# USER'S MANUAL

## City of Tacoma Watershed Planning Project

*Prepared for*

## City of Tacoma

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# Contents

# 1 Introduction

This manual describes how to use the Tacoma Watershed Insights web application. This application lets users track stormwater infrastructure, assess performance, and make informed decisions regarding stormwater and water quality in Tacoma.

## 1.1 Purpose

The purpose of this manual is to provide a guide for users who want to learn how to navigate and use the Tacoma Watershed Insights web application. The manual covers the following topics:

- How to access and log in to the application
- How to view and explore the map and data layers
- How to use the tools and features of the application
- How to export and share data and reports

This manual is focused on the usability of the web application. It does not provide technical details about the methodology behind calculations or modeling assumptions. For information regarding these aspects, please refer to the Technical Methodology Report [1].

The manual assumes that users have a basic familiarity with web browsers and GIS concepts. The manual also provides links to external resources for further information and learning.

## 1.2 Key Concepts

Before using the Tacoma Watershed Insights web application, it is helpful to understand some key concepts that are used in the tool. These concepts are also referred to throughout this manual.

[1] *Technical Methods and Approach Document - City of Tacoma Watershed Planning Project.* Geosyntec Consultants, June 2023.

### 1.2.1 Climate Epochs

Stormwater facility results are calculated based on continuous rainfall-runoff simulation using a regional precipitation data set.[2]

Four scenarios or *climate epochs* have been developed as shown in Table 1.1.

**Table 1.1:** Climate Epochs

| Scenario | Begin | End |
|---|---|---|
| 1980s (Historic) | January 1, 1970 | December 31, 1999 |
| 2030s | January 1, 2000 | December 31, 2039 |
| 2050s | January 1, 2040 | December 31, 2069 |
| 2080s | January 1, 2070 | December 31, 2099 |

### 1.2.2 Facility Types

Water quality and hydrology calculations are specific to each facility type. *Facility Type* refers to stormwater facility names used by the City of Tacoma.

**Table 1.2:** Facility Types contained in the Tacoma Watershed Insights application

| Facility Type | Description |
|---|---|
| Filterra/Vegetated box | Manufactured devices with high-rate filtration media that support plants. |
| Media Filter | Manufactured devices with high-rate filtration media consisting of a variety of inert and sorptive media types and configurations (e.g., cartridge filters, upflow filters, membrane filters, vertical bed filters). |

[2] Salathé, E.P., Hamlet, A.F., Mass, C.F., Lee, S-Y., Stumbaugh, M., Steed, R. 2014. Estimates of Twenty-first Century flood risk in the Pacific Northwest based on regional scale climate model simulations. J. Hydrometeorology 15(5): 1881-1899, https://doi.org/10.1175/JHM-D-13-0137.1

| Facility Type | Description |
| --- | --- |
| Oil-water Separator | Manufactured devices including oil/water separators and baffle chambers designed for removing floatables and coarse solids. |
| Pervious Pavement | Full-depth pervious concrete, porous asphalt, paving stones or bricks, reinforced turf rings, and other permeable surface designed to replace traditional pavement. |
| Pond/wet vault | Surface wet pond with a permanent pool of water, may include underground wet vaults. |
| Bioretention | Shallow, vegetated basins with a variety of planting/filtration media and often including underdrains. |
| Sand Filter | Filter bed with granular media, typically sand. |
| Swale | Shallow, vegetated channel, also called bioswale or vegetated swale. |
| Swirl Separator | Manufactured devices providing gravitational settling using swirl concentrators, screens, and baffles. Also referred to as hydrodynamic separators (HDS). |
| Dry Extended Detention Basin/Tank | Dry extended detention including grass-lined and concrete lined basins that are designed to empty after a storm. |
| Trench | Filter bed with granular media, typically sand. Full infiltration |
| Vault | Concrete-lined basins that drain after a storm. |

### 1.2.3 Simple vs. Detailed Facilities

In the context of the Tacoma Watershed Insights application, facilities can be modeled as one of two types: Simple and Detailed.

The Tacoma Watershed Insights application models stormwater infrastructure as either Simple or Detailed facilities based on the availability of data and the complexity of the facility’s design and operation.

#### 1.2.3.1 Simple Facilities

By default, facilities are initially modeled as Simple Facilities unless detailed information has been entered. The Simple Facility model is used when detailed data about a facility is not available, such as the specific design parameters of the facility or the infiltration area. Simple facilities are assumed to treat or retain 91% of runoff from the effective drainage area.

#### 1.2.3.2 Detailed Facilities

If more detailed data about a facility are available, the application can model the facility as a Detailed Facility. When the Simple Facility switch is turned off, parameters specific to the facility type become editable. Detailed Facilities provide a more accurate and comprehensive model of a facility's performance.

### 1.2.4 Pollutants

The Tacoma Watershed Insights application models 8 different stormwater pollutants. These are shown below.

**Table 1.3:** Stormwater Pollutants

| Parameter | Group | EIM Parameter CAS |
|---|---|---|
| Bis(2-ethylhexyl) phthalate | Phthalate | 117-81-7 |
| Copper | Metal | 7440-50-8 |
| Phenanthrene | LPAH | 85-01-8 |
| Pyrene | HPAH | 129-00-0 |
| Total Nitrogen | Nutrient | None |
| Total Phosphorus | Nutrient | 7723-14-0 |
| Total Suspended Solids | Conventional | None |
| Zinc | Metal | 7440-66-6 |

### 1.2.5 Subbasins

A Subbasin is a geographical area that drains into a particular receiving water or collection system node. In addition to reporting facility performance, the tool reports metrics on a subbasin level.

The subbasins used in this tool have been developed by the City of Tacoma. They are summarized in Table 1.4. Subbasins are referenced by a unique subbasin code using the subbasin code prefix shown in Table 1.4. For example, the first subbasin that is part of the Flett Creek Basin would be `FL_01`.

**Table 1.4:** City of Tacoma Subbasins

| Basin | Number of Subbasins | Subbasin Code prefix |
|---|---|---|
| Flett Creek | 10 | `FL_` |
| Foss Waterway | 15 | `FS_` |
| Joes Creek | 3 | `JC_` |
| Leach Creek | 6 | `LC_` |
| Lower Puyallup | 6 | `LP_` |
| North Tacoma | 11 | `NT_` |
| Northeast Tacoma | 6 | `NE_` |
| Tideflats | 6 | `TF_` |
| Western Slopes | 4 | `WS_` |

# 2 System Administration

## 2.1 Sign Up as a New User

You must register and be approved as a new user before using the site. To sign up, click **Login** in the upper right hand corner of the site. At the login page, click **Register** to be taken to the registration page. After entering the required details, click **Submit** to create your account. An email will be sent to your provided email address for verification.

Before you can access the site, your account must be approved by a User Admin. See the Modifying User Roles section for information on approving new users.

## 2.2 User Roles

Users can have one of the following roles associated with their account.

Only a User Admin or System Admin may edit user roles.

**Table 2.1:** Roles and Permissions

| Role | Permissions |
|---|---|
| **Public** | None |
| **Read-only** | Read access to data via site and via token |
| **User/Editor** | All of the above, plus<br>• access to scenarios and editing data |
| **User Admin** | All of the above, plus<br>• access to user manager<br>• access to application settings |
| **System Admin** | All of the above, plus<br>• direct api access |

## 2.3 Managing Users

Only a User Admin or System Admin may edit user roles. To approve new users and to update user roles, follow these steps.

1. Click on your profile avatar in the upper left-hand corner of the screen.
2. Select **Manage Users** from the menu.

You will be taken to the Manage Users page, where you can edit and save user role information.

# 3 Viewing Results with the Map Explorer

The map explorer module is the main access point for all the spatial resources that can be used to view existing infrastructure and water quality conditions.

## 3.1 Viewing Layers

By default, the following layers are enabled:

- Stormwater facilities
- Stormwater facility delineations
- Stormwater subbasins

To view other layers select the layer icon on the left-hand menu. A new panel will display with available layers.

Other layers that can be viewed are shown below.

**Table 3.1:** Map Data Layers

| Category | Layer Name |
|---|---|
| **Conveyances** | Catchbasin Leads<br>Regional Facility Model: Manholes<br>Surfacewater Inlet<br>Surfacewater Main<br>Surfacewater Trunk |
| **Landcover & Landuse** | Land Cover Category<br>Imperviousness<br>Contours<br>Runoff<br>Terrain |

| Category | Layer Name |
|---|---|
| **Pollutants** | Total Copper Concentration<br>Total Nitrogen Concentration<br>Total Suspended Solids Concentration<br>Total Zinc Concentration |

## 3.2 Viewing Facility Overview Information

You can view summary information for a particular BMP by clicking on it from the Map Explorer. The map will zoom to the selected facility and a panel will be displayed showing information on a facility.

## 3.3 Viewing Facility Details

Click on **View Facility Details** from the Facility Overview Panel to see and edit particular facility attributes. In addition to the overview information displayed on the Map Explorer, you can view water quality parameters, cost analysis parameters, and detailed performance data.

## 3.4 Exporting Facility Details

To export detailed facility data, click on **Export Results** from the Facility Detail Page. This will export a `.csv` file with all facility attributes and performance results.

## 3.5 Searching for a Facility

To search for a particular facility, select the search icon on the left-hand toolbar. A panel will appear with search options. You may search by the following categories:

- **altid/node_id** - Refers to the facility id.
- **Facility Type** - Refers to the City designated facility type
- **Facility Type (WQ Modeling)** - Refers to the facility type designation used for water quality modeling

# 4 Results Viewer

## 4.1 Using the BMP Facility Results View

The BMP Facility Results View can be used to view a summary of the performance of existing BMP's. To access the viewer, select **WQ Results Viewer** from the dropdown menu at the top menu bar, or from the homepage.

You can view individual BMP results by selecting the **BMP Facility Results View** card or by selecting the icon on the left-hand menu bar. Results are summarized by climate epoch.

## 4.2 Using the Subbasins Results View

The water quality results viewer can be used to view the conditions of each stormwater subbasin. To access the viewer, select it from the dropdown menu at the top menu bar, or the homepage.

You can view aggregated results by subbasin by selecting the **Subbasin Results View** card or by selecting the icon on the left-hand menu bar. To view a chloropleth map of results, select the parameter to visualize from the menu next to the map.

## 4.3 Exporting Results

To export results from the Subbasin Results View, click the **Export** button on the table below the map. This will download a CSV file of all results. To export a selection of data, select the rows you want to export on the table, then click **Export**.

# 5 Editing Facility Data

## 5.1 Editing Water Quality Parameters

You can edit the parameters used to model facilities in the **Facility Details** view. There are several ways to navigate to this view:

- From the Map Explorer map, click on a facility to open the Facility Overview panel. Then, click on **View Facility Details** to be taken to the detail page.
- From the **Water Quality Results Viewer,** click on a BMP name in the table.

## 5.2 Updating from Simple to Detailed Facility

By default, most facilities are modeled as simple facilities, meaning only two parameters are used: Captured Percentage, and Retained Percentage. The Simple Facility type should be used when detailed data about a facility are not available (e.g. the facility's infiltration area).

If more detailed data are available, turn off the Simple Facility switch, and parameters specific to the facility type will be editable.

## 5.3 Editing Facility Type

If a Facility Type needs to be updated, select the Facility Type dropdown menu, and choose the appropriate facility type. Click **Save** to save your edits.

**Warning** Saving your edits does not recalculate results. To recalculate, click the **Refresh Results** button on the Facility Details Page.

## 5.4 Editing Life Cost Analysis Parameters

By default, facilities will not have cost parameters unless users provide cost analysis parameters. Facilities without cost data will show the following message under the Lifecycle Cost Analysis Heading:

> *Lifecycle costs are unavailable for this facility. This usually means that the "Cost Analysis Parameters" are incomplete.*

To edit lifecycle cost parameters, select the dropdown menu titled **Cost Analysis Parameters.** There, you can enter the cost analysis parameters directly for a facility. See the Cost Analysis Parameters section for descriptions of parameters.

### 5.4.1 Cost Estimator Tool

To assist with selection of cost analysis parameters, a cost estimator tool is available; it uses cost curves and methodology developed by King County to provide high-level cost estimates for various facilities. To use this tool, select a BMP to view the BMP facility details page. Next, click on the cost analysis parameters drop down and then click on the **King County Cost Estimator Tool.** This will open a dialog box to select and apply data from King County cost curves.

First, select the appropriate facility type under the **BMP Type** dropdown menu. This will preselect an appropriate BMP Cost Curve used by King County (**KC BMP Variation** in the tool). You can refine or change the selected cost curve under the **KC BMP Variation** menu. Cost curves that match the selected **BMP Type** will be shown in **bold**.

In order to calculate the cost parameters, you must enter a sizing parameter in the next dialog box. Depending on the cost curve selected, the dialog box will display either *area (sqft)* or *each (count).* Here, *area* refers to the footprint area of a facility (e.g. the total area of pervious pavement), or the number of facilities to be installed (e.g. number of UIC wells).

After entering the number denoting the area or number of facilities, the Capital Cost and O&M Costs will be calculated. Click *Apply to BMP Form* to apply the calculated costs to the facility. To calculate the final lifecycle cost, you will need to enter data for the following:

**Install Year** - The year of installation, denoting what year to apply the capital costs.

**Replacement Cost** - The cost to replace a facility. This cost is intended to reflect costs related to major replacement of facility components, such as replacement of soil after multiple years of use.

**Lifespan Yrs** - How long the facility would be operated before replacement would be necessary.

### 5.4.2 Global Cost Settings

In order to calculate lifecycle costs the same way for every facility, the tool uses four global cost parameters (*discount rate*, *inflation rate*, *planning horizon*, and *cost basis year*). These parameters apply to all facilities analyzed, instead of a particular facility.

To edit these global parameters, select *Settings* under your user profile in the top left portion of the screen. Individual cost parameters can be edited by clicking the edit tool to the left of each parameter name.

# 6 Using the Prioritization Module

The watershed prioritization module allows users to identify and prioritize areas for actions to meet watershed planning goals related to water quality, habitat, and social equity.

## 6.1 Selecting Project Type

The *Project Type* dialog denotes what type of project is being considered. The two choices are:

- **Retrofit** - Projects that are intended to improve water quality or hydrology. This choice gives a higher priority to subbasins that have a higher pollutant load, or do not have adequate stormwater infrastructure.
- **Preservation** - Projects that are intended to preserve an area in a subbasin with better water quality or already have adequate stormwater infrastructure.

## 6.2 Setting Priority Weights

The prioritization tool allows users to weight watershed management goals based on their relative importance. Weights are positive numbers

Weights can be zero or any positive number, and reflect a decision maker or stakeholders preferences. The higher the weight, the more important the criterion. Numerically, this represents a factor of preference. For example if Goal A has a weight of 1 and Goal B has a weight of 2, Goal B will be treated as twice as important as Goal A.

No constraints have been set on the scale of weights, however, it is common practice to set a total number of weighting points (e.g. 10 points) and assign weights so that the sum of weights is equal to this predetermined total.

Priority weights are assigned for each major watershed goal. Goals are comprised of subgoals and numeric metrics as described in Table 6.1:

**Table 6.1:** Watershed Planning Goals used in the Prioritization Module.

| Goals | Sub-goals | Criteria |
|---|---|---|
| **Goal 1: Improve Water Quality Outcomes (Clean Water Goal)** | 1.1 Prioritize areas based on pollutant concentrations | Total Nitrogen Concentration, TSS Concentration, Annual Runoff, Imperviousness |
| | 1.2 Improve infrastructure in areas with inadequate stormwater management | Percent of Area Treated, Age of Development |
| **Goal 2: Increase Resilience to Climate Change Impacts (Resilient Community Goal)** | 2.1 Target areas most vulnerable to and at risk for climate change impacts | Urban Heat Island, Capacity Issues Layer |
| **Goal 3: Preserve and Restore Critical and Sensitive Habitat (Healthy Ecosystems)** | 3.1 Preserve and Improve Natural Spaces | ES Open Space/Natural Resource Areas, Biodiversity Corridors |
| **Goal 4: Implement Equity and Social Justice (Healthy Neighborhoods; Equity)** | 4.1 Prioritize areas of overlapping equity needs as identified by other Tacoma programs | Equity Index Score, Livability Index |
| | 4.2 Improve access to safe, high-quality roadway infrastructure (green infrastructure recommendation) | Pavement Condition Index |

## 6.3 Viewing Prioritization Results

After selecting and submitting priority weights, results will be shown on the chloropleth map and in the *Subbasin Prioritization Results* table.

Subbasins with higher priority scores reflect a higher preference for new projects based on user weighting. Clicking on a row will highlight the selected subbasin on the map.

## 6.4 Downloading Prioritization Results

To understand the breakdown of attributes and weights from the prioritization module, download the results by clicking on the *Export* button. This will download a .CSV file listing subgoals, criteria, weights, direction of criteria (whether a criterion should be minimized or maximized), as well as the criterion-specific results.

# 7 Using the Scenario Designer

The Scenario Designer is used to create and evaluate potential new facilities or groups of facilities. It can be used to assess the potential performance of a new action, or compare various alternative actions.

## 7.1 Creating a New Scenario

To create a new scenario, click **Create New Scenario** in the Scenario Designer page. A new window will open with a multi-step form where you can enter information about your scenario. The first step asks for basic information about your scenario. Enter this information, then click **Next.**

### 7.1.1 Creating a New Delineation.

The next step is to create a new delineation. The new delineation represents the area that drains to a new facility. Enter a name for this new delineation and then click the **edit icon** on the map window.

Use the stormwater upstream trace tool in Tacoma's GIS system (AccessES) to identify the approximate upstream drainage area to the node where you plan to install the new facility. Draw the new delineation on the map. Double-click to complete the delineation. To delete a delineation after it has been completed, click the **delete icon** on the map window.

Once you have finished creating the delineation, click **Next.**

### 7.1.2 Creating a new facility

The final step is to create a new BMP facility. Under the **Create a BMP** section, add water quality parameters and cost analysis parameters. See the section on Editing Facility Data for instructions.

Use the map to indicate the location for the new facility. Click the **Edit Icon** in the map window and then click on your desired location on the map. Save your location by clicking on the **Accept Edits** icon. Then click **Next** under the **Create a BMP** form.

The new scenario will be summarized on the next screen. If everything looks good, click **Create Scenario** to save your scenario. On the next screen, be sure to click **Calculate Scenario WQ Results** to generate results.

**Caution** You must click **Calculate Scenario WQ Results** to generate performance results for your scenario.

# 8 Data Integrations

Facility data, subbasin data, and results can be easily integrated into other tools and applications through the **Data Integration Module.** Navigate to the module by clicking on **Profile** under the user menu in the top left corner of the application. The **Data Integration** panel is displayed below your profile information.

Data integration is performed through a REST API, which uses HTTP methods to read data from the tool.

## 8.1 Obtaining a read-only token

Each user is assigned a unique read-only token. This token allows the API server to identify and authorize your requests. Your read-only token will be displayed beneath your user profile.

## 8.2 Token Rotation

It is good practice to change your token at regular intervals, or in the event of your token being compromised. To rotate your token, click the **Rotate Token** button next to your token.

## 8.3 Making API Calls

All API calls are GET requests and are made in the following format:

> `https://www.tacomawatersheds.com/api/rest/{resource}/ {resource_id}/token/{toke`

In the above URL structure, `{resource}` is the data type you are requesting, `{resource_id}` is the specific ID of the resource (optional and depends on the endpoint), and `{token}` is your unique read-only token.

### 8.3.1 API Endpoints

This API is organized around several endpoints representing different types of resources: `tmnt_facility`, `tmnt_delineation`, `subbasin`, and `results`. All responses are provided in JSON format unless otherwise specified.

**Common Parameters:**

- `f`: (optional, default=json, [json, geojson]) Format of response data
- `limit`: (optional, default=1e6) Number of records to return
- `offset`: (optional, default=0) Start from index
- `epoch`: (optional, default=1980s, [all, 1980s, 2030s, 2050s, 2080s]) Climate epoch filter

**Get attributes for all treatment facilities:**

> `/api/rest/tmnt_facility/token/{token}?f={f}&limit={limit} &offset={offset}`

**Get attributes for a specific treatment facility:**

> `/api/rest/tmnt_facility/{altid}/token/{token}`

Replace `{altid}` with the specific facility id.

**Get attributes for all delineations:**

> `/api/rest/tmnt_delineation/token/{token}?f={f}&limit= {limit}&offset={offset}`

**Get attributes for a specific delineation:**

> `/api/rest/tmnt_delineation/ {altid}/token/{token}?f={f}`

Replace `{altid}` with the specific delineation id.

**Get attributes for all subbasins:**

> `/api/rest/subbasin/token/{token}?f={f}&limit={limit}& offset={offset}`

**Get attributes for a specific subbasin:**

> `/api/rest/subbasin/{subbasin_id}/token/{token}`

Replace `{subbasin_id}` with the specific subbasin id.

**Get water quality results for a specific subbasin:**

> `/api/rest/subbasin/wq/{subbasin_id}/token/{token}?epoch={epoch}`

Replace `{subbasin_id}` with the specific subbasin id.

**Get water quality results for all subbasins:**

> `/api/rest/subbasin/wq/token/{token}?f={f}&limit={limit}&offset=`
> `{offset}&epoch={epoch}`

**Get results:**

> `/api/rest/results/token/{token}?ntype={ntype}&limit= {limit}&offset={offset}epo`

The `ntype` parameter is optional and filters the data by node type (land_surface, tmnt_facility).

## 8.4 How to connect Excel with Tacoma Watersheds Results

Power Query is a powerful tool within Microsoft Excel that allows you to import data from various external data sources, including RESTful APIs. This tutorial will guide you on how to connect Excel Power Query with the Tacoma Watersheds `results` API.

Before starting, make sure you have your unique read-only token from the Tacoma Watersheds API.

### 8.4.1 Step 1: Open Power Query

1. Open Excel, and go to the **Data** tab in the Ribbon.
2. Click on **Get Data** in the left corner of the Ribbon.
3. In the dropdown menu, select **From Other Sources**, then **From Web**.

### 8.4.2 Step 2: Connect to the API

1. A pop-up window will appear prompting you to enter a URL.
2. In this field, enter the following API endpoint URL:

> `https://www.tacomawatersheds.com/api/rest/results/token/{token}?`
> `ntype={ntype}limit={limit}& offset={offset}&epoch={epoch}`

Replace `{token}` with your unique read-only token and fill in the `{ntype}`, `{limit}`, `{offset}`, and `{epoch}` as per your requirements. For example, if you want to get all results for `land_surface` node type and for the `1980s` climate epoch, your URL would be:

> ```
> https://www.tacomawatersheds.com/api/rest/results/token/ your_token?ntype=land_
> ```
>
> Click **OK**

#### 8.4.3 Step 3: Parse the Response

1. A new window named **Power Query Editor** will open, and Excel will show you a preview of the data.
2. If the data appears as a single column of records, click on **List** to convert it to a table. Then click on the button with two arrows on the right side of the header of the column to expand the data into a tabular format.
3. If the data is in nested JSON format, you may need to click on the double-arrow button again to fully expand the data.

#### 8.4.4 Step 4: Load the Data

1. Once you are satisfied with the preview of the data, click on **Close & Load** in the **Home** tab.
2. Excel will create a new worksheet and load the data into a table.

# 9 Source Code and Deployment

## 9.1 Source Code Information

Source code is available for the public at the project github repository: github.com/Geosyntec/StormPiper.

The source code is licensed under the Mozilla Public License 2.0 (MPL 2.0).

### 9.1.1 About the MPL 2.0

The MPL 2.0 is a free and open-source software license that allows the software to be freely used, modified, and shared under specific terms. Key highlights of the MPL 2.0 include:

- **Copyleft:** Modified files must be released under the same license, but linking is allowed without affecting the rest of the project.
- **Distribution:** You can distribute the code in both source and compiled form, provided you include the license file.
- **Attribution:** The original copyright notices must be retained in redistributed code.
- **Warranty Disclaimers and Liability Limitations:** The license includes standard provisions to protect contributors from legal claims.

You can view the full text of the MPL 2.0 license and specific details regarding the StormPiper project in the GitHub repository at:

https://github.com/Geosyntec/StormPiper/blob/main/LICENSE

Please refer to the `LICENSE` file within the repository for the complete terms and conditions governing the use of the StormPiper source code.

## 9.2 Local Development

### 9.2.1 Pre-requisites

Ensure you have Git, Python, Conda, and Docker installed on your system.

### 9.2.2 Getting Started

Follow the steps below to get the app up and running on your system:

#### 9.2.2.1 Clone the Repository

First, clone the StormPiper repository:

```
git clone git@github.com:Geosyntec/StormPiper.git
```

#### 9.2.2.2 Build and Activate a Virtual Environment

Next, create a virtual environment using Conda and activate it:

```
conda create -n stormpiper python=3.11
conda activate stormpiper
```

#### 9.2.2.3 Install the Required Dependencies

Navigate to the StormPiper directory and install the necessary dependencies:

```
cd StormPiper
pip install -r stormpiper/requirements.txt
pip install -r stormpiper/requirements_test.txt
```

### 9.2.3 Running the Development Server

Run the development server with the following command:

```
uvicorn stormpiper.main:app --reload --port 8000
```

You can access the documentation at `localhost:8000/docs`.

### 9.2.4 Making Changes and Maintenance

#### 9.2.4.1 Running Tests

Run the tests using:

```
pytest
```

To check test coverage:

```
coverage run --branch -m pytest
coverage report -m
```

#### 9.2.4.2 Code Formatting and Type Checks

Use the provided script to check code formatting and type declarations:

```
bash scripts/lint.sh
```

### 9.2.5 Docker Deployment

#### 9.2.5.1 Building the Container

Use the following command to build the container. It runs `make clean`, `make stack`, and then `make build`:

```
make develop
```

#### 9.2.5.2 Running the Container

Start the container with:

```
make up
```

You can access the development server at `localhost:8080`.

To silence the logs, run the container in `daemon` mode:

```
make up-d
```

#### 9.2.5.3 Stopping the Container

Stop the container by using:

```
make down
```

## 9.3 Deployment

Deploying the applicaiton on your own server requires knowledge of Kubernetes. Kubernetes is an open-source container orchestration platform that automates the deployment, scaling, and management of containerized applications. It provides mechanisms for deploying and managing applications across multiple servers, ensuring high availability and scalability.

See the Kubernetes documentation on Google Cloud Plaform for more information.

## 9.4 Deployment configuration

See the deployment scripts on the github repo for examples on how this applicaiton was deployed: https://github.com/Geosyntec/StormPiper/tree/main/.github/workflows

# 10 Parameter Definitions

## 10.1 Facility Parameters

**Table 10.1:** Facility Input Data

| Parameter | Description |
|---|---|
| area_sqft | The footprint area of the facility in square feet. |
| captured_pct | The average annual percent of stormwater captured by the facility. |
| depth_ft | The depth of ponding for the facility in feet. |
| hsg | Hydrologic Soil Group classification for native infiltration. Valid Options: A B C D |
| inf_rate_inhr | The infiltration rate at the facility location in inches per hour. |
| media_filtration_rate_inhr | The media filtration rate at the facility in inches per hour. |
| retained_pct | The percent of stormwater retained or infiltrated by the facility. |
| retention_volume_cuft | The design retention volume of the facility in cubic feet. |
| treatment_rate_cfs | The treatment rate of the facility in cubic feet per second. |

**Table 10.2:** Facility Water Quality Result Parameters

| Parameter | Description |
|---|---|
| DEHP_conc_mg/l_effluent | Mean annual concentration of Bis(2-ethylhexyl) phthalate (DEHP) discharged from a facility (mg/l) |
| DEHP_conc_mg/l_influent | Mean annual concentration of Bis(2-ethylhexyl) phthalate (DEHP) flowing to a facility (mg/l) |
| DEHP_load_lbs_inflow | Mean annual load of Bis(2-ethylhexyl) phthalate (DEHP) entering a facility (lbs) |
| DEHP_load_lbs_removed | Mean annual load of Bis(2-ethylhexyl) phthalate (DEHP) removed by a facility (lbs) |
| DEHP_load_lbs_total_discharged | Mean annual load of Bis(2-ethylhexyl) phthalate (DEHP) exiting a facility (lbs) |
| PHE_conc_mg/l_effluent | Mean annual concentration of Phenanthrene discharged from a facility (mg/l) |
| PHE_conc_mg/l_influent | Mean annual concentration of Phenanthrene flowing to a facility (mg/l) |
| PHE_load_lbs_inflow | Mean annual load of Phenanthrene entering a facility (lbs) |
| PHE_load_lbs_removed | Mean annual load of Phenanthrene removed by a facility (lbs) |
| PHE_load_lbs_total_discharged | Mean annual load of Phenanthrene exiting a facility (lbs) |
| PYR_conc_mg/l_effluent | Mean annual concentration of Pyrene discharged from a facility (mg/l) |
| PYR_conc_mg/l_influent | Mean annual concentration of Pyrene flowing to a facility (mg/l) |

| Parameter | Description |
| --- | --- |
| PYR_load_lbs_inflow | Mean annual load of Pyrene entering a facility (lbs) |
| PYR_load_lbs_removed | Mean annual load of Pyrene removed by a facility (lbs) |
| PYR_load_lbs_total_discharged | Mean annual load of Pyrene exiting a facility (lbs) |
| TCu_conc_ug/l_effluent | Mean annual concentration of Total Copper discharged from a facility (ug/l) |
| TCu_conc_ug/l_influent | Mean annual concentration of Total Copper flowing to a facility (ug/l) |
| TCu_load_lbs_inflow | Mean annual load of Total Copper entering a facility (lbs) |
| TCu_load_lbs_removed | Mean annual load of Total Copper removed by a facility (lbs) |
| TCu_load_lbs_total_discharged | Mean annual load of Total Copper exiting a facility (lbs) |
| TN_conc_mg/l_effluent | Mean annual concentration of Total Nitrogen discharged from a facility (mg/l) |
| TN_conc_mg/l_influent | Mean annual concentration of Total Nitrogen flowing to a facility (mg/l) |
| TN_load_lbs_inflow | Mean annual load of Total Nitrogen entering a facility (lbs) |
| TN_load_lbs_removed | Mean annual load of Total Nitrogen removed by a facility (lbs) |
| TN_load_lbs_total_discharged | Mean annual load of Total Nitrogen exiting a facility (lbs) |
| TP_conc_mg/l_effluent | Mean annual concentration of Total Phosphorus discharged from a facility (mg/l) |
| TP_conc_mg/l_influent | Mean annual concentration of Total Phosphorus flowing to a facility (mg/l) |
| TP_load_lbs_inflow | Mean annual load of Total Phosphorus entering a facility (lbs) |

| Parameter | Description |
| --- | --- |
| TP_load_lbs_removed | Mean annual load of Total Phosphorus removed by a facility (lbs) |
| TP_load_lbs_total_discharged | Mean annual load of Total Phosphorus exiting a facility (lbs) |
| TSS_conc_mg/l_effluent | Mean annual concentration of Total Suspended Solids discharged from a facility (mg/l) |
| TSS_conc_mg/l_influent | Mean annual concentration of Total Suspended Solids flowing to a facility (mg/l) |
| TSS_load_lbs_inflow | Mean annual load of Total Suspended Solids entering a facility (lbs) |
| TSS_load_lbs_removed | Mean annual load of Total Suspended Solids removed by a facility (lbs) |
| TSS_load_lbs_total_discharged | Mean annual load of Total Suspended Solids exiting a facility (lbs) |
| TZn_conc_ug/l_effluent | Mean annual concentration of Total Zinc discharged from a facility (ug/l) |
| TZn_conc_ug/l_influent | Mean annual concentration of Total Zinc flowing to a facility (ug/l) |
| TZn_load_lbs_inflow | Mean annual load of Total Zinc entering a facility (lbs) |
| TZn_load_lbs_removed | Mean annual load of Total Zinc removed by a facility (lbs) |
| TZn_load_lbs_total_discharged | Mean annual load of Total Zinc exiting a facility (lbs) |

**Table 10.3:** Facility Hydrology Result Parameters

| Parameter | Description |
| --- | --- |
| bypassed_pct | Percent of mean annual runoff bypassed by a facility |

| Parameter | Description |
|---|---|
| design_intensity_inhr | Design storm intensity for a flow-based facility (in/hour) |
| design_volume_cuft_cumul | design volume for a volume-based facility (cubic feet) |
| ro_coeff | Design runoff coefficient for a facility |
| runoff_volume_cuft_bypassed | Mean annual runoff volume bypassed by a facility (cubic feet) |
| runoff_volume_cuft_captured | Mean annual runoff volume captured by a facility (cubic feet) |
| runoff_volume_cuft_inflow | Mean annual runoff volume entering a facility (cubic feet) |
| runoff_volume_cuft_retained | Mean annual runoff volume retained by a facility (cubic feet) |
| runoff_volume_cuft_total_discharged | Mean annual runoff volume exiting a facility (cubic feet) |
| runoff_volume_cuft_treated | Mean annual runoff volume treated by a facility (cubic feet) |

## 10.2 Cost Data Parameters

**Table 10.4:** Global Cost Parameters

| Parameter | Description |
|---|---|
| cost_basis_year | The base year for the cost calculation. |
| discount_rate | The rate used for discounting future cash flows. |
| inflation_rate | The rate of inflation considered in the cost calculation. |
| planning_horizon_yrs | The planning horizon in years for cost calculation. |

**Table 10.5:** Facility Cost Parameters

| Parameter | Description |
|---|---|
| capital_cost | The total capital cost for the facility. |
| capital_cost_basis_year | The base year for the calculation of the capital cost of the facility. |
| install_year | The year when a facility was or will be installed. |
| lifespan_yrs | The expected lifespan of a facility in years. |
| om_cost_basis_year | The base year for the calculation of the operation and maintenance cost of the facility. |
| om_cost_per_yr | The operation and maintenance cost of a facility per year. |
| present_value_capital_cost | The present value of the capital cost of the facility. |
| present_value_chart_table | The present value chart table related to the facility. |
| present_value_cost_table | The present value cost table related to the facility. |
| present_value_om_cost | The present value of the operation and maintenance cost of the facility. |
| present_value_total_cost | The total present value cost of the facility. |
| replacement_cost | The cost to replace or perform major upgrade to the facility. |

## 10.3 Subbasin Parameters

**Table 10.6:** Landcover parameters

| Parameter | Description |
|---|---|
| lc_pasture_pct | Landcover Pasture (pct) |

| Parameter | Description |
|---|---|
| lc_grass_pct | Landcover Grass (pct) |
| lc_water_pct | Landcover Water (pct) |
| lc_imp_roof_pct | Landcover Impervious-roof (pct) |
| lc_imp_nonroof_pct | Landcover Impervious-nonRoof (pct) |
| lc_imp_total_pct | Landcover Impervious-total (pct) |

**Table 10.7:** Land Use parameters

| Parameter | Description |
|---|---|
| lu_resair_pct | Landuse Airport Compatibility Residential (pct) |
| lu_commcmu_pct | Landuse Crossroads Mixed-Use Center (pct) |
| lu_rgcd_pct | Landuse Downtown Regional Growth Center (pct) |
| lu_com_pct | Landuse General Commercial (pct) |
| lu_indh_pct | Landuse Heavy Industrial (pct) |
| lu_indl_pct | Landuse Light Industrial (pct) |
| lu_resl_pct | Landuse Low-Scale Residential (pct) |
| lu_ins_pct | Landuse Major Institutional Campus (pct) |
| lu_resm_pct | Landuse Mid-Scale Residential (pct) |
| lu_resmfhd_pct | Landuse Multi-Family (High Density) (pct) |
| lu_comn_pct | Landuse Neighborhood Commercial (pct) |
| lu_comnmu_pct | Landuse Neighborhood Mixed-Use Center (pct) |
| lu_os_pct | Landuse Parks and Open Space (pct) |
| lu_shore_pct | Landuse Shoreline (pct) |
| lu_rgctm_pct | Landuse Tacoma Mall Regional Growth Center (pct) |

**Table 10.8:** Subbasin Parameters

| Parameter | Description |
| --- | --- |
| area_acres | The total subbasin area in acres. |
| basicwq_area_acres | The area in acres allocated for basic water quality. |
| basicwq_area_pct | The percentage of total area allocated for basic water quality. |
| eff_area_acres | The effective impervious area within a subbasin in acres. |
| eff_area_pct | The percentage of total area that is effective impervious area. |
| enhwq_area_acres | The area in acres treated by enhanced water quality facilities. |
| enhwq_area_pct | The percentage of total subbasin area treated by enhanced water quality facilities. |
| fc_area_acres | The area in a subbasin in acres treated by flow control facilities. |
| fc_area_pct | The percentage of total subbasin area treated by flow control facilities. |
| runoff_depth_inches | Depth of runoff in inches. |
| runoff_volume_cuft | Volume of runoff in cubic feet. |
| runoff_volume_cuft_generated | Volume of runoff generated in cubic feet. |
| runoff_volume_cuft_reduced | Volume of runoff reduced in cubic feet. |
| runoff_volume_pct_reduced | The percentage of runoff volume reduced. |
| tmnt_facility_count | Total number of treatment facilities within a subbasin |
| treated_area_acres | The area in acres that has been treated by stormwater facilities |
| treated_area_pct | The percentage of total area that has been treated by stormwater facilities |

# 11 Appendix A - Technical Methodology

Geosyntec consultants

engineers | scientists | innovators

# TECHNICAL METHODS AND APPROACH DOCUMENT

## City of Tacoma Watershed Planning Project

*Prepared for*

**City of Tacoma**
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## TABLE OF CONTENTS

# CHAPTER 1. INTRODUCTION

The Tacoma Watershed Insights web application (also referred to as Tacoma watershed tool, or tool) allows for City of Tacoma users to assess and plan stormwater best management practices (BMPs) across the city. It consists of components to explore existing BMPs, view water quality and flow-control performance of BMPs under different climate conditions, help prioritize locations for new facilities, and investigate scenarios for new BMP locations.

This report describes the technical basis and methods used to develop the tool. It is organized into the following chapters.

1. Introduction
2. Best Management Practice (BMP) Performance Module – Module for predicting the performance of BMP strategies. Includes documentation on pollutant loading, hydrology calculations, and influent-effluent relationships.
3. Cost Module - a lifecycle cost calculator that analyzes capital costs, operations and maintenance costs, with facility lifespan providing the net present costs of different facility types.
4. Watershed Prioritization Module – A graphic multi-criteria decision analysis (MCDA) interface that assists users in identifying and prioritizing areas of high priority for stormwater actions.
5. System Architecture

These components represent the core technical features of the tool. The chapters below document the assumptions and technical methods used to develop these features.

# CHAPTER 2. BMP PERFORMANCE

## 2.1 Introduction

This section describes the technical basis and assumptions to be used for the Best Management Practice (BMP) Performance Module of the Tacoma Watershed Planning Project tool.

### 2.1.1 Components

#### *2.1.1.1 Chemicals of Concern*

Eight chemicals of concern (COCs) have been selected for this study as summarized in Table 2-1. Chemicals of Concern below.

**Table 2-1. Chemicals of Concern**

| Parameter | Group | EIM Parameter CAS |
|---|---|---|
| Bis(2-ethylhexyl)phthalate- Water - Total | Phthalate | 117-81-7 |
| Copper - Water - Total | Metal | 7440-50-8 |
| Phenanthrene - Water - Total | LPAH | 85-01-8 |
| Pyrene - Water - Total | HPAH | 129-00-0 |
| Total Nitrogen - Water - Total | Nutrient | NA |
| Total Phosphorus - Water - Total | Nutrient | 7723-14-0 |
| Total Suspended Solids - Water - Total | Conventional | NA |
| Zinc - Water - Total | Metal | 7440-66-6 |

#### *2.1.1.2 BMPs*

Best management practices (BMPs) to be evaluated include both structural and non-structural BMPs. These are described below.

Structural BMPs refer to BMPs that capture stormwater and improve water quality or hydrology. Facility type names shown in Table 2 conform with the names used in their asset management database.

**Table 2-2. Structural BMP Definitions**

| Facility Type | Description |
|---|---|
| **Filterra/Vegetated box** | Manufactured devices with high rate filtration media that support plants. |
| **Media Filter** | Manufactured devices with high-rate filtration media consisting of a variety of inert and sorptive media types and configurations (e.g., cartridge filters, upflow filters, membrane filters, vertical bed filters). |
| **Oil-water Separator** | Manufactured devices including oil/water separators and baffle chambers designed for removing floatables and coarse solids. |
| **Pervious Pavement** | Full-depth pervious concrete, porous asphalt, paving stones or bricks, reinforced turf rings, and other permeable surface designed to replace traditional pavement. |
| **Pond/wet vault** | Surface wet pond with a permanent pool of water, may include underground wet vaults. |
| **Bioretention** | Shallow, vegetated basins with a variety of planting/filtration media and often including underdrains. |
| **Sand Filter** | Filter bed with granular media, typically sand. |
| **Swale** | Shallow, vegetated channel, also called bioswale or vegetated swale. |
| **Swirl Separator** | Manufactured devices providing gravitational settling using swirl concentrators, screens, and baffles. Also referred to as hydrodynamic separators (HDS). |
| **Dry Extended Detention Basin/Tank** | Dry extended detention including grass-lined and concrete lined basins that are designed to empty after a storm. |
| **Trench** | Filter bed with granular media, typically sand. Full infiltration |
| **Vault** | Concrete-lined basins that drain after a storm. |

In addition to the structural BMPs shown in Table 2, non-structural BMPs will be included as described in Section 6 of this document.

## 2.2 Hydrologic Simulation

Continuous hydrologic simulation will be performed for historic and future climate scenarios. The results of these simulations will be used to calculate inflow to BMPs as well as annual runoff rates.

### 2.2.1 Data Sources

#### *2.2.1.1 Precipitation*

The tool will use a region-wide, simulated precipitation dataset developed by the University of Washington Climate Impacts Group (Mauger et al., 2018). This dataset contains modeled hourly precipitation using the Geophysical Fluid Dynamics Laboratory (GFDL) Climate Model version 3 (CM3) and the Representative Concentration Pathways (RCP) 8.5 scenario. This is the regional climate model dataset that was used by King County for their most recent update of intensity-duration-frequency curves for design of stormwater facilities.

The GFDL model was chosen by CIG due to its ability to accurately model winter storm drivers, important for stormwater applications. Combined with the higher emissions scenario, this modeling scenario represents the upper end of expected future climate changes effects.

CIG downscaled climate model results using a statistical-dynamical approach to capture the expected changes in extreme events as well as the different drivers of rainfall that affect the Puget Sound Region. Regional simulations were performed using the Weather Research and Forecasting community mesoscale model. This resulted in hourly rainfall predictions at an approximately 12 km grid size across Puget Sound. Predictions were bias-corrected on a quantile-mapping basis (individual mean bias corrections for precipitation in each quantile range) using the historic (1970-2005) WRF data. Four runoff scenarios/epochs will be developed as shown in Table 3.

**Table 2-3. Historic and Future Climate Precipitation Scenarios**

| Scenario | Begin | End |
|---|---|---|
| Historic | January 1, 1970 | December 31, 1999 |
| 2030s | January 1, 2000 | December 31, 2039 |
| 2050s | January 1, 2040 | December 31, 2069 |
| 2080s | January 1, 2070 | December 31, 2099 |

#### *2.2.1.2 Potential Evapotranspiration*

Evapotranspiration includes evaporation directly from soil layers and vegetation as well as transpiration through plants. For runoff calculations, evapotranspiration is used to account for direct loss of water from stored water and loss of water from transpiration.

For this modeling effort, monthly values of potential evapotranspiration (PET) from the TerraClimate long-term monthly dataset. PET values were calculated for the study area for the period 1970-2000 as shown in Table 4.

**Table 2-4. Terra Climate Monthly Potential Evapotranspiration, Tacoma, Washington**

| Month | Monthly PET *(mm)* | Monthly PET *(in)* |
|---|---|---|
| **Jan** | 185 | 7.3 |
| **Feb** | 278 | 11.0 |
| **Mar** | 496 | 19.5 |
| **Apr** | 720 | 28.4 |
| **May** | 1000 | 39.4 |
| **Jun** | 1148 | 45.2 |
| **Jul** | 1334 | 52.5 |
| **Aug** | 1198 | 47.2 |
| **Sep** | 795 | 31.3 |
| **Oct** | 425 | 16.7 |
| **Nov** | 233 | 9.2 |
| **Dec** | 163 | 6.4 |

#### *2.2.1.3 Hydrologic Response Units*

Modeling will be performed on discretized landscape units based on common soils, land cover, and slope characteristics known as hydrologic response units (HRUs). The HRU approach provides a computationally efficient method of pre-computing hydrologic response for later use. Results for a particular watershed can be calculated by summing or averaging the results for individual HRUs.

Each combination of parameters was modeled in separate batched simulations. HRUs were designated by a three-digit number according to the following convention:

- First digit: Hydrologic Soil Group Number (0 = A/B, 1 = C, 2 = Saturated)
- Second digit: Land cover (0=Forest, 1=Pasture, 2=Lawn, 5=Impervious)
- Third Digit: Slope (0=Flat, 1=Mod, 2=Steep)

For example, a site with Type C soils, with forested land cover, on a moderate slope would be represented by 101. This schema allowed for HRUs to be stored as an eight-bit unsigned integer on a raster image, minimizing storage size.

#### *2.2.1.4 HSPF Parameters*

A set of regional HSPF regional calibration factors for the Puget Lowlands Ecoregion were developed the USGS in the 1990s (Dinicola, 1990) and updated by Clear Creek Solutions for use within WWHM (Department of Ecology, 2014). These parameters, referred to as the 'default parameters' by Ecology will be used in this study. Parameters are provided in Appendix A

## 2.3 Hydrologic Performance

### 2.3.1 Long-Term Volume Capture Performance

Hydrologic performance refers to: (1) the long-term volume captured and retained by a BMP (i.e., lost to infiltration, ET, harvesting, diversion, or another pathway), (2) long-term volume captured and treated by a BMP, and (3) long-term volume bypassed or overflowing (not captured). To complete the water balance, the sum of these three pathways equals the total inflow volume to the BMP.

The approach uses long-term capture nomographs to determine the estimated hydrologic performance. A nomograph is a chart that relates BMP design attributes like volume, drawdown time, and design flowrate, with pre-computed values for long-term hydrologic performance. Each point on these charts is the result of a continuous simulation model run for 20-30 years.

The Modeling Engine supports two primary BMP sizing and design paradigms:

- Volume-based nomographs. The capture efficiency is a function of the normalized BMP storage volume and the drawdown time for the stored water to be fully drained or otherwise treated.

- Flow-based nomographs. The capture efficiency is a function of the flow-through capacity for providing treatment and the time of concentration of the tributary area.

The modeling approach allows for separate sets of nomographs to be consulted for any given climate scenario depending on the sizing paradigm for a given facility type. These nomographs are created by running batches of long-term continuous simulations for BMPs with various storage volumes and drawdown times (for volume-based BMPs) or various flow rates and watershed time of concentration (Tc) values (for flow-based BMPs).

This methodology for determining long-term percent capture was previously used for the Puget Sound Partnership BMP Performance tool (Nilsen and Koryto, 2017). It was first developed and technically vetted for the National Cooperative Highway Research Program (Taylor et. al, 2016).

This approach is intended to facilitate the rapid estimation of long-term volume capture performance of structural stormwater BMP facilities, it is not intended to assess adequacy of design or to perform detailed BMP sizing.

#### 2.3.1.1 Nomograph Preparation

***Volume-Based Nomographs***

Volume-based nomographs encode three pieces of information about the BMP facility:

1. Ratio of the volume capacity provided by the BMP design to the Design Capture Volume (DCV) for the tributary area. This value is a unitless ratio. The equation for the DCV of the tributary area is:

$$V_{dc} = \sum A_n \cdot Q_{91,n}$$

Where: $V_{dc}$ = Design Capture Volume *($ft^3$)*

$A_n$ = Watershed area comprised of a particular HRU *($ft^2$)*

$Q_{91,n}$ = 91st percentile, 24-hour runoff depth for a particular HRU *(ft)*

The ratio is the actual volume of the BMP divided by the DCV of the tributary area. So, if a BMP is designed exactly to the DCV then it would have a ratio of 1.0, and a BMP sized to smaller than the DCV would have a ratio of less than 1.

2. Drawdown time of the facility. This is computed differently for different types of BMPs. In general, this is computed as the volume divided by the relevant discharge rate. The units for this value are hours.

3. Long-term capture efficiency resulting from many years of continuous simulation for a given facility relative size and drawdown time.

The three dimensions of data can be represented in a nomograph plot as shown below in Error! Reference source not found..

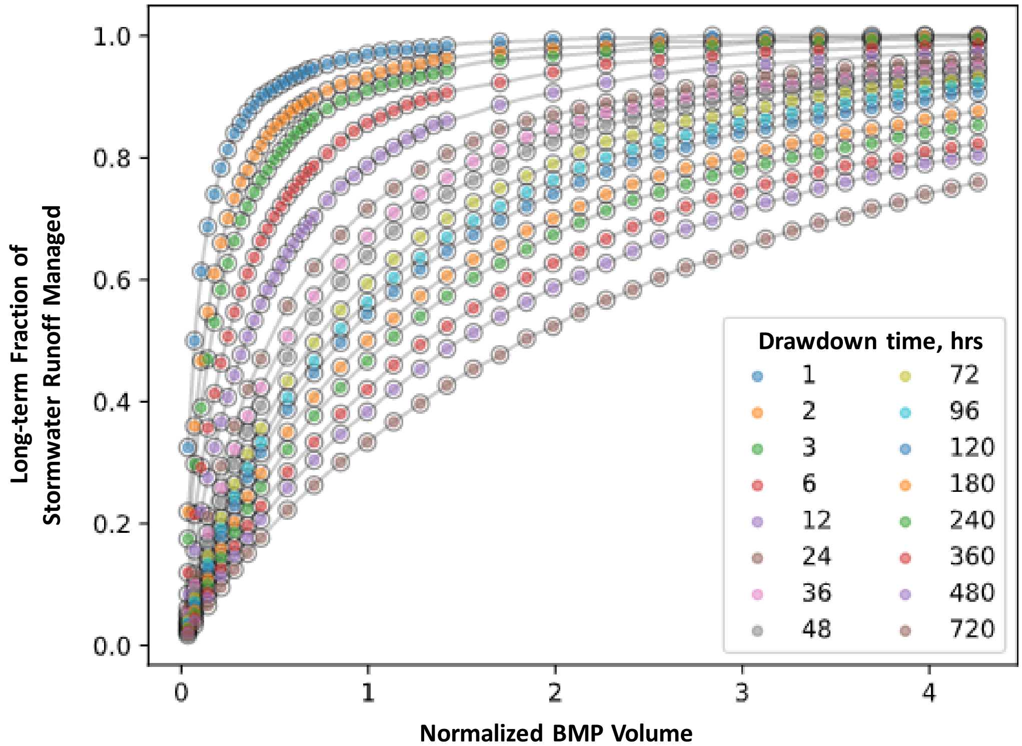



**Figure 2-1. Example of a capture efficiency nomograph for a volume-based BMP with a constant drawdown time.**

The process for nomograph development for each climate scenario includes:

1. Define a representative unit tributary area (typically one acre). Determine the DCV produced from this tributary area for each impervious HRU.

2. Produce a continuous timeseries of discharge from this area over a long-term period.

3. Perform batch simulations consisting of relevant combinations of BMP volume and drawdown time, representing the range of expected values (one simulation for each combination of HRU, drawdown time, and BMP volume). Produce a continuous timeseries of BMP storage and discharge using the same long-term period as in Step 2.

4. Extract the long-term capture efficiency from each run. Load these results into a standard data table to support lookups and interpolation.

**Flow-Based Nomographs** This nomograph type encodes two pieces of information about facilities designed with a flow-based sizing approach:

1. Effective design intensity of the facility. This value relates the treatment rate provided by the facility to the effective area of the tributary area it is meant to treat. The units for this value are inches per hour. The equation for the design intensity is:

$$I_d = \frac{\sum(A_n \cdot q_{91,n})}{\sum \mathrm{A_n}}$$

Where: $I_d$ = Design intensity *(in/hr)*

$q_{91,n}$ = 91st percentile discharge for a particular HRU *(in/hr)*

$A_n$ = Watershed area comprised of a particular HRU *($ft^2$)*

2. Long-term capture efficiency resulting from continuous simulation for a given facility design intensity and its adjacent land surface Tc.

The three dimensions of data can be represented in a nomograph plot as shown below in Figure 2-2.

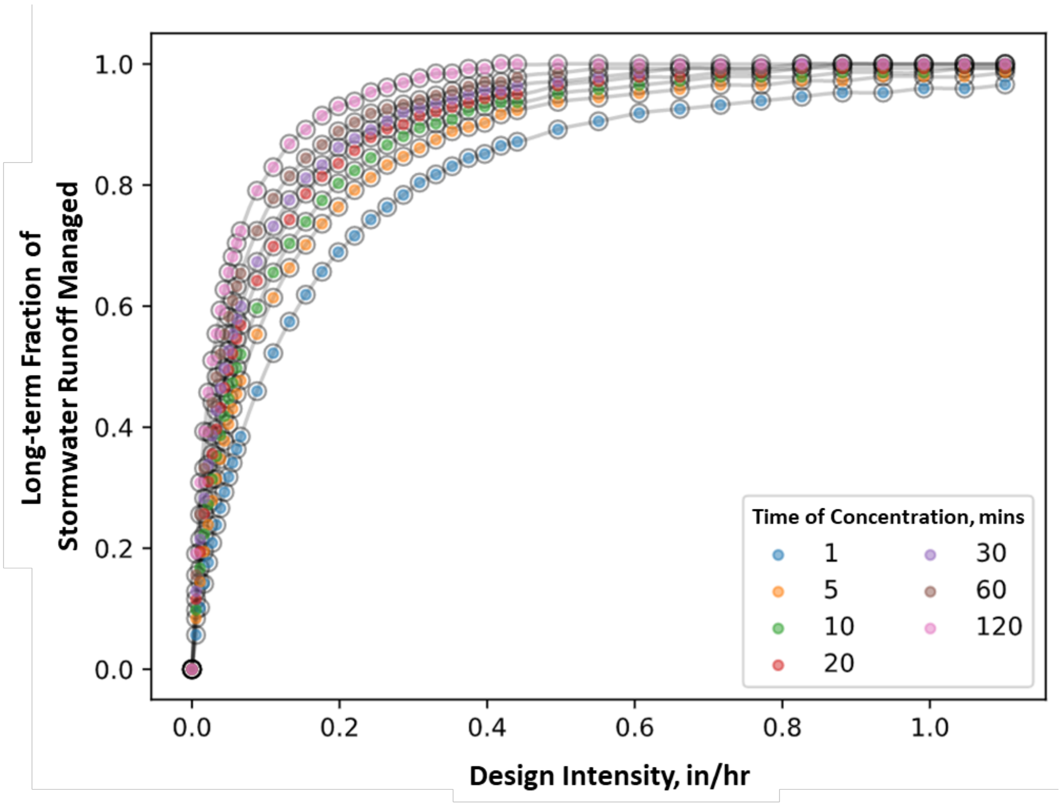



**Figure 2-2. Capture efficiency nomograph for a flow-based BMP.**

### *2.3.1.2 Nomograph Solution Approaches*

The nomograph solution approach relies on the definition of distinct ‘compartments’ within a BMP. Each facility may be composed of one or two compartments, and the volume managed by each compartment is either counted as 'treated/detained' and discharged downstream or it is counted as infiltrated and is eliminated from the water balance.

This compartment-based approach allows the Modeling Engine to calculate BMP capture for a wide variety of facility configurations. **Table 2-5** shows the modeled BMP types mapped to their respective treatment solution approaches. The table indicates whether the facility has one or two-compartments and which nomograph type is being used to calculate wet-weather volume capture performance.

**Table 2-5. Structural facility types & solution approach table**

| Modeled BMP Name | Pseudocode Mapping to Tacoma Asset Management Type | No. of Compartments | Volume-based Compartments | Flow-based Compartments |
|---|---|---|---|---|
| **Bioretention with raised underdrain** | FACILITYTYPE == "Bioretention" AND<br>INFILTRATED ≠ "FULL" | 2 | Infiltration &<br>Treatment | -- |
| **Dry Extended Detention Basin/Tank** | FACILITYTYPE == "Tank" AND FLOWCONTROL ≠ true | 2 | Infiltration &<br>Treatment/Detention | -- |
| **Flow Duration Control Tank** | FACILITYTYPE == "Tank" AND<br>FLOWCONTROL == true | 2 | Infiltration &<br>Treatment/Detention | -- |
| **Bioretention with no Underdrain** | FACILITYTYPE == "Bioretention" AND<br>INFILTRATED == "FULL" | 1 | Infiltration | -- |
| **Infiltration Basin/Trench** | FACILITYTYPE == "Trench" | 1 | Infiltration | -- |
| **Permeable Pavement** | FACILITYTYPE == "Pervious Pavement" | 1 | Infiltration | -- |
| **Sand Filter** | FACILITYTYPE == "Sand Filter" | 1 | Treatment | -- |
| **Filterra /Vegetated box** | FACILITYTYPE == "Vegetated Box" | 1 | -- | Treatment |

| | | | | |
|---|---|---|---|---|
| **Media Filter** | FACILITYTYPE == "Media Filter" | 1 | -- | Treatment |
| **Oil-water Separator** | FACILITYTYPE == "Oil Water Separator" | 1 | -- | Treatment |
| **Hydrodynamic Separator** | FACILITYTYPE == "Swirl Separator" | 1 | -- | Treatment |
| **Vegetated Swale** | FACILITYTYPE == "Swale" | 2 | Infiltration[1] | Treatment |
| **Wet Pond** | FACILITYTYPE == "Pond" | 1 | Treatment | -- |

1 Vegetated Swales and Filter Strips perform 'incidental infiltration' due to their un-lined design. This is discussed further in the 'hybrid flow and infiltration' discussion below.

**Single-Compartment Volume-Based Nomograph Traversal.** This is the simplest case for volume-based facilities, such as an infiltration basin, lined bioretention, bioretention with no underdrain, permeable pavement, and several other types. For a single compartment BMP, the normalized BMP volume is determined as the ratio of the facility's total volume to the DCV of the tributary area. BMP input parameters are structured so that the drawdown time can be inferred from available design information such as facility depth, total volume, and underlying infiltration rate so that the correct curve can be chosen from the nomograph.

Figure 2-3 illustrates an example solution for an infiltration facility with a six-hour draw-down time whose total volume is equal to the DCV of the tributary area. In this case, the modeling module would estimate that the facility achieves approximately 85% of long-term runoff volume infiltration.

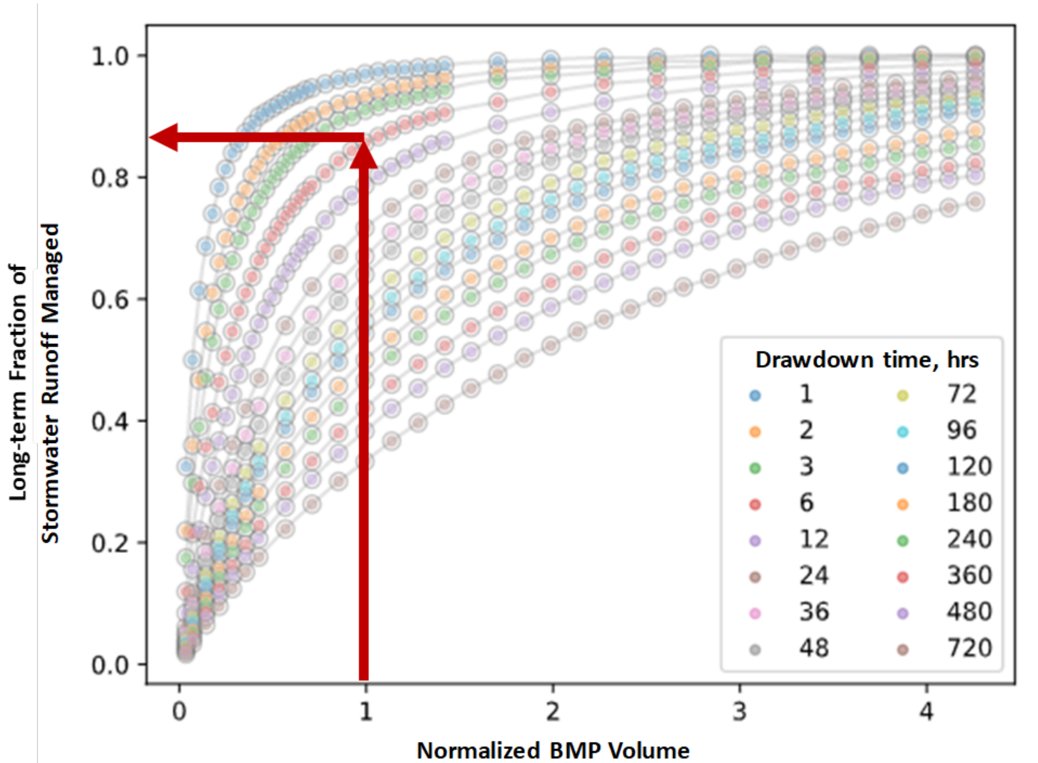



**Figure 2-3. Single compartment volume-based nomograph solution example**

**Two-Compartment Volume-Based Nomograph Traversal.** This type of BMP solution is used for volume-based facilities that are capable of both infiltration and treatment of inflowing stormwater. Common examples of this type of BMP include bioretention facilities with a raised underdrain and extended dry detention facilities. These facility types may perform volume infiltration via infiltration into the native soil and may discharge treated flow via elevated underdrains or outlet structures.

The first nomograph traversal is for the infiltration compartment since these facilities fill from the bottom and infiltration typically begins to occur before treated discharge. The following figure illustrates the traversal process for a two-compartment facility in which each compartment is sized to be 50% of the design volume. In this case, the drawdown time is 24 hours for the infiltration compartment and 3 hours for the treatment compartment. The following steps demonstrate the traversal process which is illustrated below in **Figure 2-4**.

Determine the infiltration capture performance by traversing 0.5 units along the x-axis and locate the correct trace for the 24-hour drawdown time of the infiltration compartment. The value is approximately 48% of long-term capture. This is shown in brown in the figure below.

Translate horizontally to the trace for the next compartment which draws down in 3 hours. The second compartment trace is shown in green in the figure below.

Follow the green 3-hour drawdown trace up the nomograph for 0.5 units of x-axis distance.

In this example, about 83% of long-term capture is achieved by both compartments working in concert. Infiltration accounts for 48% (from step 1), treatment accounts for 35% (83% - 48%), and 17% is bypassed (100% - 83%).

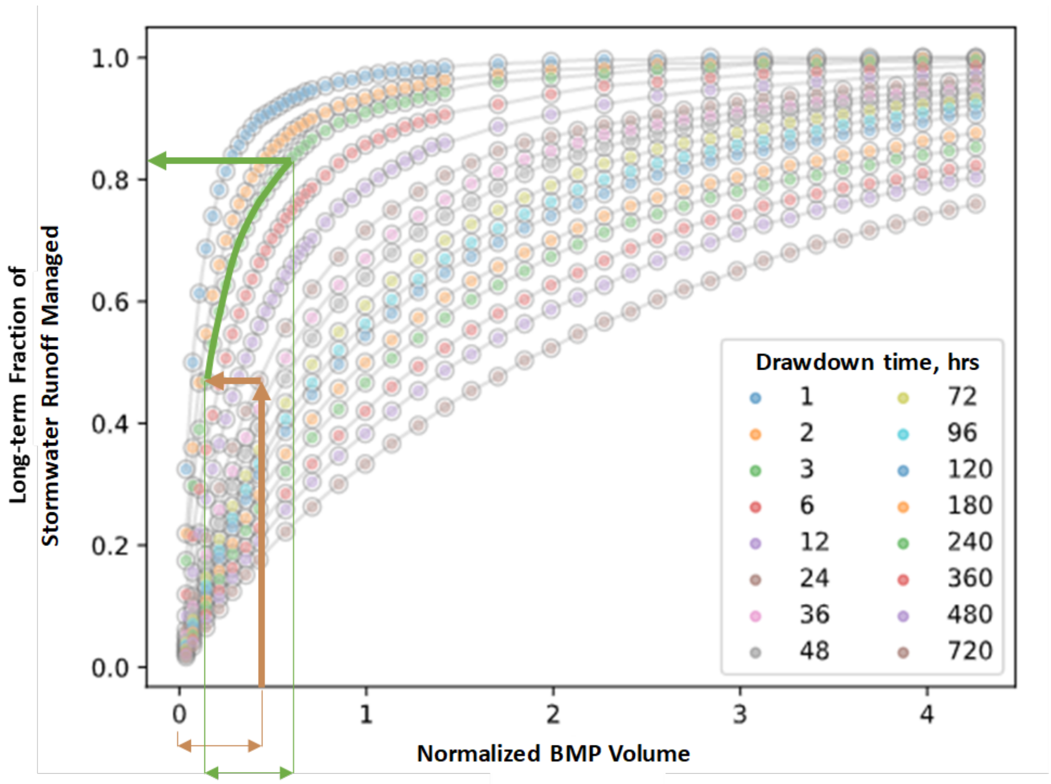



**Figure 2-4: Two-compartment nomograph traversal. In this case both compartments have the same volume capture capacity (0.5 Design Volumes) but they have different drawdown times.**

For some BMP types, such as extended detention with permeable bottoms, there is not a defined infiltration compartment. Instead, infiltration occurs simultaneously with treatment. For these BMPs, the facility is divided into two parallel compartments with equal drawdown time. The volume in each compartment is prorated based on the ratio of the discharge rate from each compartment. For example, a hypothetical detention basin with a DCV ratio of 1.0 has a treated surface discharge rate of 0.35 cfs and an infiltration discharge rate of 0.15 cfs. The basin is divided into two parallel compartments, a treatment compartment with a DCV ratio of 0.7 and 0.35 cfs discharge rate and a infiltration compartment with a DCV ratio of 0.3 and 0.15 cfs discharge rate. Each compartment is analyzed individually (in parallel) and then the results are summed.

**Single-Compartment Flow-Based Nomograph Traversal.** This is the simplest case for flow-based BMPs. It is based on the flow rate of the facility. This nomograph is useful for modeling facilities such as an HDS unit or a proprietary flow-through biofilter since these facilities do not perform stormwater volume infiltration. In the example nomograph below (Figure 2-5) a facility with a design treatment intensity of 0.2 inches per hour is expected to manage 83% of long-term runoff.

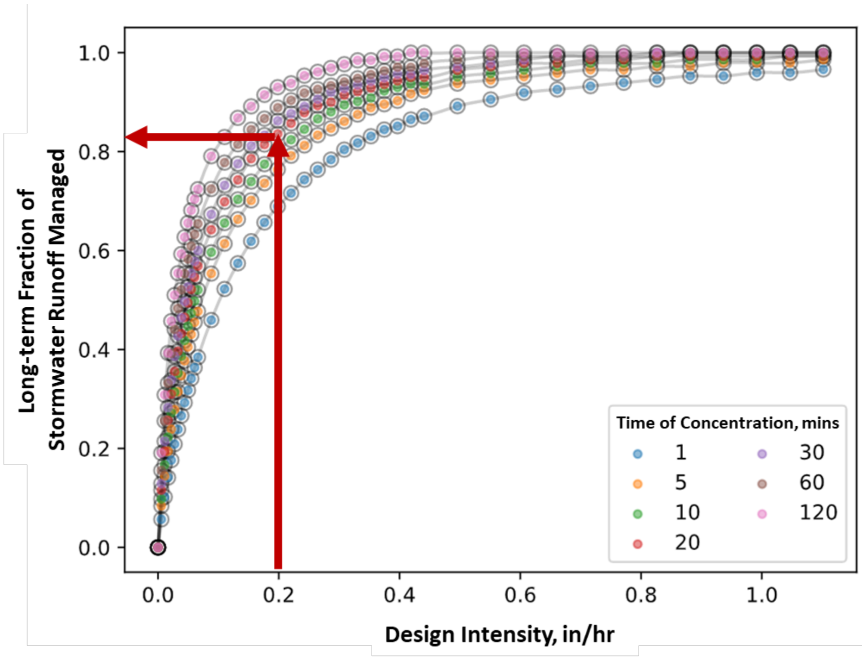



**Figure 2-5. Single compartment flow-based nomograph solution**

**Hybrid Flow-Based Nomograph Traversal.** This volume capture solution applies only to facilities that are both unlined and flow-based facilities like a typical vegetated swale. These facilities are often sized and designed as flow-based facilities, but they may provide incidental volume reduction via infiltration depending on underlying soil conditions. For these facilities, the nomograph solution for capture is:

1. Consult the relevant flow-based nomograph to compute the total long-term capture volume.
2. Utilize the facility volume, depth, and underlying soil group to estimate the total storage volume and drawdown time for the facility.
3. Consult the relevant volume-based nomograph to calculate the long-term retained volume.
4. Calculate the treated and discharged volume as the difference between the total long-term capture volume and the retained volume.

This approach helps ensure that the overall long-term volume capture is consistent with the flow-based nomograph traversal result but allows for a portion of the capture volume to be counted as infiltration to better represent the incidental infiltration performance of these facilities.

**Nested BMPs.** The nomograph solution supports regional BMPs that receive discharge from BMPs in their upstream catchments. This means that upstream facilities that achieve long-term volume capture and attenuation will affect the potential volume capture performance of downstream facilities since that volume, or a portion of that volume, was removed from the system. It should be noted that in practice BMPs are typically only nested once, such as in a distributed

BMP upstream of a centralized BMP, and more deeply nested facility configurations are uncommon.

This approach implements a corrective algorithm to track and correct the impacts of upstream infiltration and detention when applying nomograph traversal capture solutions in nested BMP configurations. This effectively treats upstream BMPs similarly to the first compartment in a two compartment BMP, described above. Therefore, the downstream BMP traverses the nomograph curve further to the right, where the slopes are lower (somewhat less capture per unit of volume provided). Comparisons between this algorithm and an explicit continuous simulation analysis in EPA SWMM 5.1 are within 5% of long-term capture efficiency, long-term volume infiltration performance, and long-term treatment performance for equivalent BMP configurations.

### 2.3.2 Simplified Treatment Volume Capture Performance

The approach allows for a simplified method to model catchments with many treatment facilities for which individual facility delineations are not available, or to model facilities where specific design parameters are unknown. The user can enter the fractions of the site treated by given types of BMP and enter the long-term fraction of runoff volume retained and treated by the facility. This method requires the user to delineate the overall site treated area, but uses the user-entered values for percent of volume treated and retained rather than nomographs.

## 2.4 Water Quality Performance

### 2.4.1 Statistical Analysis Approach

Water quality performance estimates will be derived from the International Stormwater BMP Database (http://bmpdatabase.org/), version 2021 or later. Analysis will be based on the distribution of paired influent and effluent water quality concentrations for individual events by BMP category as reported in the database. This approach follows a similar study performed for the Puget Sound Partnership, evaluating the performance of water quality BMPs (Nilsen and Koryto 2017). Analysis steps are described below.

#### *2.4.1.1 Data Sufficiency*

In order to be used in this study, a minimum of 20 paired results must be reported with at least three distinct studies.

#### *2.4.1.2 Paired difference test*

For each BMP-pollutant combination, a parried difference test will be performed to test whether influent and effluent data represent statistically distinct populations. The Wilcoxon signed-ranked test, which is a non-parametric hypothesis test will be used. Only relationships that show a statistically distinct difference between influent and effluent will be used.

#### *2.4.1.3 Monotonicity test*

Next, data will be tested for monotonicity (e.g. a nondecreasing function) using the non-parametric Spearman’s Rho test. Only monotonic relationships will be used.

#### *2.4.1.4 Regression*

Finally, a regression relationship between influent and effluent concentrations will be developed using the non-parametric Kendall-Theil Robust Line regression. This approach was chosen to handle data outliers better than other regression methods, such as ordinary least-squares regression.

### 2.4.2 Influent - Effluent performance curves

The pollutant load entering a BMP is estimated by calculating the product of the average annual influent volume and the mean COC concentration in the watershed. The BMP pollutant load reduction is calculated by the sum of:

1. **Infiltration** - The load reduced by infiltration is calculated as the watershed pollutant concentration multiplied by the volume lost to infiltration by the facility.

2. **Treatment** - The load reduced by treatment is calculated as the product of the volume treated and the reduction in concentration achieved by the facility between the influent and treated effluent.

To calculate the concentration reduction for treated water, this approach uses as input a set of influent-versus-effluent concentration curves. These define the best estimate of average effluent quality based on the average influent quality. These curves were developed based on monitoring studies in the International Stormwater BMP Database (http://bmpdatabase.org/), as prepared for the San Diego WQE (2018). An example plot representing the functional relationship between influent and effluent TSS concentration for several BMP types is shown below in Figure 2-6.

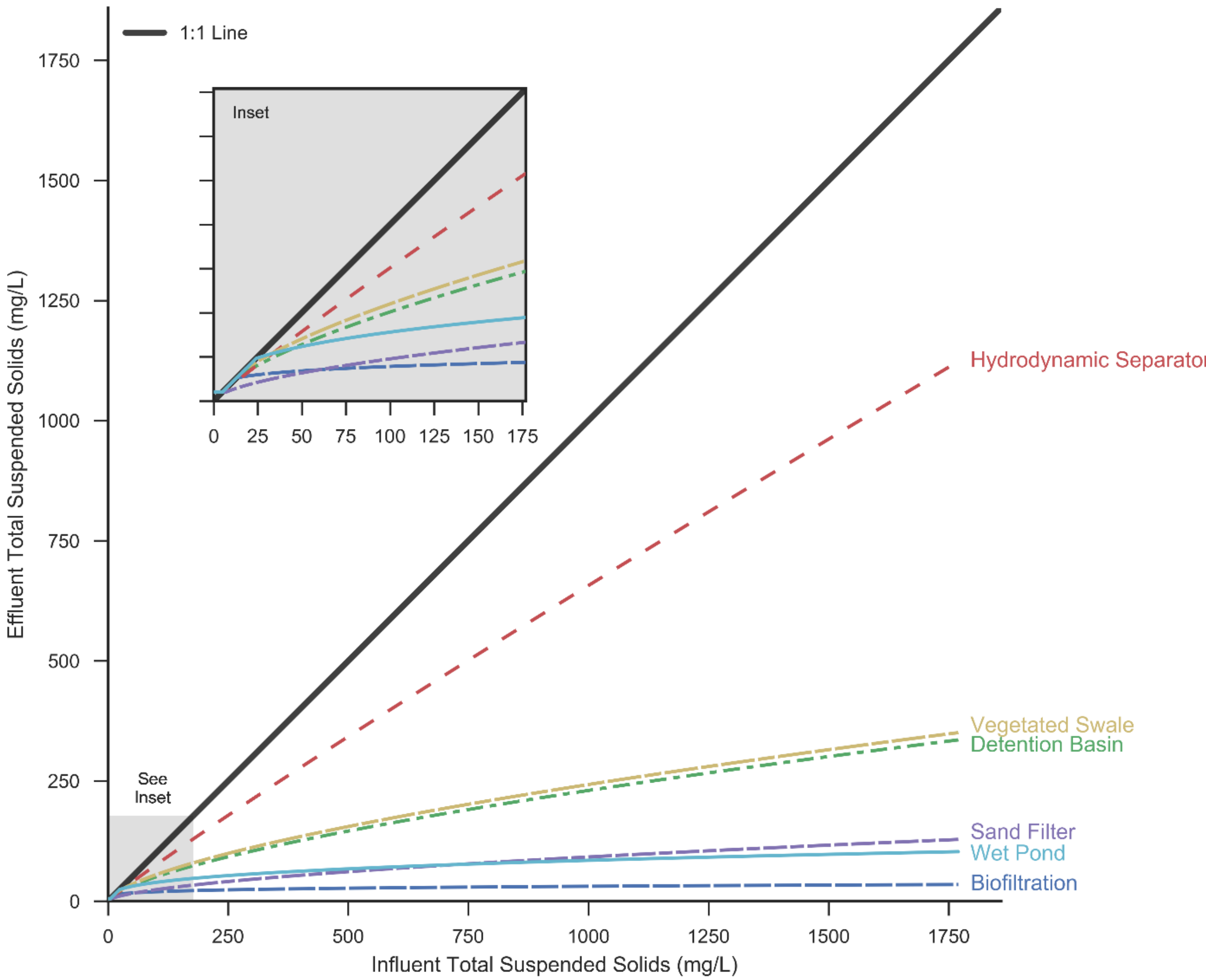



**Figure 2-6. Influent vs effluent curve for TSS removal by BMP type**

The load reduction mechanism(s) for each of BMP types are listed below in Table 2-6.

**Table 2-6. Load reduction calculation approach for BMP types**

| Water Quality BMP Types | Eliminates Load (Infiltrated / diverted) | Treatment & Discharge Influent-Effluent Curve |
|---|---|---|
| **Garden with no Underdrain** | Infiltration | No treatment assumed (infiltration only) |
| **Infiltration Basin/Trench** | Infiltration | No treatment assumed (infiltration only) |
| **Drywell** | Infiltration | No treatment assumed (infiltration only) |
| **Permeable Pavement** | Infiltration | No treatment assumed (infiltration only) |
| **Underground Infiltration** | Infiltration | No treatment assumed (infiltration only) |
| **Cisterns for Harvest and Use** | Infiltration | No treatment assumed (infiltration only) |
| **Rain Garden (bioretention with raised underdrain)** | Infiltration | Biofiltration/Bioretention |
| **Dry Extended Detention Basin/Tank** | Infiltration | Detention Basin |
| **Flow Duration Control Basin/Tank** | Infiltration | Detention Basin |
| **Vegetated Swale** | Infiltration | Vegetated Swale |
| **Rain Garden with Underdrain and Liner** | No infiltration assumed | Biofiltration/Bioretention |
| **Filterra /Vegetated box** | No infiltration assumed | High Rate Biofiltration |
| **Media Filter** | No infiltration assumed | High Rate Media Filter |
| **Other Proprietary Biotreatment** | No infiltration assumed | High Rate Biofiltration |
| **Oil-water Separator** | No infiltration assumed | Oil-water separator |
| **Sand Filters** | No infiltration assumed | Sand Filter |
| **Hydrodynamic Separator** | No infiltration assumed | Hydrodynamic Separator |
| **Wet Pond** | No infiltration assumed | Wet Pond/Wetland Basin |

The overall load reduction is calculated as the sum of the load removed via infiltration and the load removed via treatment. The load downstream of a BMP is calculated as the influent load minus these two components of load reduction. The effluent concentration is calculated as the load divided by the effluent volume. Bypass volume is assumed to be untreated and is assigned the contributing catchment concentration.

## 2.5 Performance of Source Control BMPs

### 2.5.1 Street Sweeping

#### *2.5.1.1 Performance Data*

Tacoma performs enhanced street sweeping across the city using regenerative air machines. Currently, all areas of the city are swept at least twice a year, with more frequent sweeping occurring for major arterials and business districts (City of Tacoma, 2017).

Tacoma has been monitoring sweeping performance in the Thea Foss watershed since 2012. A summary of monitoring results is shown in Table 7. For most COCs, the trend in removal efficiencies are relatively steady, although values fluctuate from year-to-year.

***Table* 2-7. Summary of Reduction in COC Concentrations for Street Sweeping in the Thea Foss Watershed, 2012-2021**

| COC | 2012 | 2013 | 2014 | 2015 | 2016 | 2017* | 2018* | 2019* | 2020† | 2021† | Mean Value (Tool Default) | Trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bis(2EH)phthalate** | 47% | 50% | 53% | 55% | 55% | 34% | 37% | 42% | 35% | 36% | **44%** | |
| **Indeno(1,2,3-c,d)pyrene** | 66% | 64% | 67% | 68% | 67% | 50% | 49% | 49% | 39% | 33% | **55%** | |
| **Phenanthrene** | 65% | 68% | 70% | 70% | 71% | 51% | 50% | 51% | 41% | 41% | **58%** | |
| **Pyrene** | 61% | 69% | 71% | 73% | 73% | 54% | 54% | 54% | 44% | 43% | **60%** | |
| **TSS** | 18% | 20% | 21% | 22% | 24% | 18% | 18% | 18% | 27% | 26% | **21%** | |
| **Zinc** | 19% | 23% | 27% | 29% | 32% | 29% | 30% | 30% | 36% | 36% | **29%** | |

* includes enhanced sweeping for outfalls 243, and 245

† includes enhanced sweeping for outfalls 243, 245, and 254

#### *2.5.1.2 Tool assumptions*

To calculate pollutant removal attributable to street sweeping, the tool will employ the following assumptions.

- Default removal for each COC will be set at the mean value as shown in Table 7.
- Pollutant reduction will be calculated prior to influent concentrations draining to BMPs.
- Street sweeping will be assumed to apply evenly to an entire watershed.

### 2.5.2 Storm Line Cleaning

Similar to Street Sweeping, Anchor QEA (2012) evaluated performance of basin-wide storm-line cleaning.

**Table 2-8. Summary of Storm Line Cleaning Monitoring in the Thea Foss Watershed, 2012-2021**

| COC | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | Mean Value (Tool Default) | Trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bis(2EH)phthalate** | 40% | 52% | 54% | 57% | 58% | 56% | 54% | 54% | 54% | 55% | 56% | **54%** | |
| **Indeno(1,2,3-c,d)pyrene** | 76% | 78% | 79% | 81% | 80% | 79% | 76% | 75% | 74% | 74% | 74% | **77%** | |
| **Phenanthrene** | 72% | 73% | 75% | 77% | 77% | 77% | 75% | 74% | 74% | 74% | 74% | **75%** | |
| **Pyrene** | 77% | 79% | 81% | 83% | 83% | 82% | 80% | 79% | 79% | 79% | 79% | **80%** | |
| **TSS** | 21% | 21% | 25% | 28% | 30% | 32% | 30% | 30% | 29% | 30% | 31% | **28%** | |
| **Zinc** | 20% | 22% | 26% | 28% | 30% | 32% | 32% | 33% | 34% | 36% | 37% | **30%** | |

#### *2.5.2.1 Tool assumptions*

To calculate pollutant removal attributable to line cleaning, the tool will employ the following assumptions.

- Default removal for each COC will be set at the mean value as shown in Table 8.
- Pollutant reduction will occur after to effluent concentrations discharging from BMPs.
- Storm line cleaning will be assumed to apply evenly to an entire watershed.

# CHAPTER 3. COST MODULE

## 3.1 Introduction

This section describes the development of a lifecycle module for selected stormwater facilityy types. This module incorporates capital costs, operations and maintenance costs, and lifespan, to provide the present costs of various facility types.

## 3.2 Parameters

The cost module contains parameters that can be adjusted by the user. Global parameters are set for the tool as a whole and apply to all cost calculations. Asset specific parameters are used to calculate costs for a specific asset and should be based on the specific attributes of an asset.

### 3.2.1 Global Parameters

The following parameters apply to all cost calculations in the tool. These are adjusted at a global level so costs of specific assets can be compared to one another.

- **Cost Basis Year**: The reference year for inflation adjustment (i.e. what year should dollar values be reported in).
- **Discount Rate:** The interest rate used to determine the present value of future cash flows. The discount rate in the tool has been initialized with the 30-year rate published in the White House Office of Management and Budget (OMB) Circular A-94 (OMB, 2023) This rate corresponds to the long-term nominal interest rate on US Treasury notes and bonds.
- **Inflation Rate**: This is the annual inflation rate to be applied to purchases and services. The inflation rate has been initialized with the long-term inflation rate published by the Congressional Budget Office (2023)
- **Planning Horizon**: This is the total time-period in years over which future cash flows will be considered.

### 3.2.2 Asset Specific Parameters

The following parameters apply to a specific asset. These are adjusted on a per asset basis, based on that asset's characteristics.

- **Capital Costs**: These are the initial costs required for constructing and installing an asset. Capital costs may include property acquisition costs depending on the scenario.
- **Capital Cost Basis Year**: This refers to the reference year used to express the capital costs. For example, if capital costs were calculated in 2020 dollars, the user would input 2020 for the Capital Cost Basis Year.
- **Install Year**: The year when the asset was constructed.

- **Lifespan**: The expected duration of facility service before it requires replacement or significant overhaul.
- **O&M Cost Basis Year**: This is the base year from which the annual operation and maintenance costs are calculated.
- **O&M Costs per Year:** The reference year used to express operation and maintenance costs.
- **Replacement Cost**: The cost to replace or significantly overhaul an asset beyond routine maintenance (e.g., media replacement in a bioretention facility).

### 3.2.3 Reference Costs

To assist with estimation of costs, unit costs for facilities were adapted from the King County Water Quality Benefit Evaluation (WQBE) program (Hadler and others, 2022). This study used data from a number of sources including King County Wastewater Treatment Division and the Washington State Department of Ecology to create cost curves, which are based on the predicted costs of different water quality actions. Unit cost curves were developed for both capital and operations and maintenance costs.

Cost curves were mapped to Tacoma's facility type definitions as shown in Table 3-1.

**Table 3-1. Facility types and corresponding unit cost curves**

| Facility Type | Corresponding King County Unit Cost Curves |
|---|---|
| Bioretention | WQBE_03A_Bioretention Underdrain on Property |
| | WQBE_03Aa_Bioretention Underdrain with Property Cost |
| | WQBE_03B_Bioretention No Underdrain on Property |
| | WQBE_03Bb_Bioretention No Underdrain with Property Cost |
| | WQBE_03C_Bioretention Underdrain in ROW |
| | WQBE_03D_Bioretention No Underdrain in ROW |
| Holding Basin | WQBE_12A_Detention Pond on Public Property |
| | WQBE_12B_Detention Pond with Property Cost |
| Media Filter | WQBE_05A_Media Filter Drain Underdrain |
| | WQBE_05B_Media Filter Drain No Underdrain |
| Pervious Pavement | WQBE_08A_Pervious Concrete Sidewalk (no sand layer) |
| | WQBE_08B_Porous Asphalt Driveway (with sand layer) |
| | WQBE_08C_Permeable Paver Driveway (with sand layer) |
| | WQBE_08D_Permeable Paver Plaza (no sand layer) |
| Pond | WQBE_13A_Infiltration Pond Till Soil on Public Property |
| | WQBE_13B_Infiltration Pond Outwash Soil on Public Property |
| | WQBE_13C_Infiltration Pond Till Soil with Property Cost |
| | WQBE_13D_Infiltration Pond Outwash Soil with Property Cost |
| | WQBE_13E_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Public Property |
| Swale | WQBE_04A_Bioswale in ROW |
| | WQBE_04B_Bioswale on Public Property |
| | WQBE_04C_Bioswale with Property Cost |

| | |
|---|---|
| Tank | WQBE_11A_Detention Vault on Public Property |
| Tank | WQBE_11B_Detention Vault in ROW |
| Tank | WQBE_11C_Detention Vault with Property Cost |
| | WQBE_16_Cistern on Property |
| Vault | WQBE_14A_Infiltration Vault Till Soil on Public Property |
| | WQBE_14B_Infiltration Vault Outwash Soil on Public Property |
| | WQBE_14C_Infiltration Vault Till Soil in ROW |
| | WQBE_14D_Infiltration Vault Outwash Soil in ROW |
| | WQBE_14E_Infiltration Vault Till Soil with Property Cost |
| | WQBE_14F_Infiltration Vault Outwash Soil with Property Cost |
| | WQBE_14G_Infiltration Vault Outwash Soil with High Rate Underground Filter System in ROW |
| Vegetated Box | WQBE 02A_Bioretention Planter on Property |
| | WQBE_02B_Bioretention Planter in ROW |
| | WQBE_02C_Bioretention Planter with Property Cost |

### 3.2.4 Cost Calculations

#### *3.2.4.1 Net present value*

Costs are calculated as the net present value (NPV) of all capital and operations and maintenance costs. NPV is the value of a stream of benefits or costs when discounted back to a single time. The formula for calculating NPV of future outlays is:

$$NPV(i,N) = \sum_{t=0}^{N} \frac{R_t}{(1+i)^t}$$

where

NPV = net present value of costs
$R_t$ = Annual regular costs
i = discount rate
N = Number of years (planning horizon).

#### *3.2.4.2 Inflation adjustments*

Users can input capital costs and operations and maintenance costs derived in different basis years from each other. This functionality permits the user to incorporate cost estimates or actual expenditures from prior years and still be able make a comparative analysis using the tool. Costs are adjusted for inflation using the formula below:

$$V_0(1+r)^n = V_n$$

where

$V_0$ = Value from previous time period
$V_n$ = Current value
r = inflation rate
n = Number of years between periods

Capital costs are costs are adjusted for inflation by this formula directly. Operation and maintenance costs are first translated to the whole life-cycle value corresponding to the previous period, and then adjusted using this formula.

# CHAPTER 4. WATERSHED PRIORITIZATION MODULE

## 4.1 Introduction

The watershed prioritization module allows users to identify and prioritize areas that are a high priority for actions to meet watershed planning goals related to water quality, habitat, and social equity. By developing a structured decision support process, decisions can be made that better allocate resources, plan for new facilities, and identify areas for preservation.

This chapter presents the methodology used to develop the watershed prioritization module. The module leverages GIS data, water quality modeling, BMP performance modeling, and multi-criteria decision analysis (MCDA). The approach presented below reconciles the complexities of watershed planning with the need for practical, science-driven decision making.

## 4.2 Methodology

This section described the process used to incorporate the PROMETHEE II (Preference Ranking Organization Method for Enrichment Evaluation) MCDA methodology with available spatial data. It provides an overview of the MCDA framework, development of critieria, and methods for calculating watershed metrics.

### 4.2.1 PROMETHEE II MCDA Overview

The PROMETHEE II is a widely used Multi-Criteria Decision Analysis (MCDA) methodology developed by Brans and Vincke (1985). This approach is primarily designed to aid decision-makers in handling complex decision problems involving multiple, often conflicting, criteria. It offers an organized framework to compare and rank various alternatives based on the decision-maker's preferences.

PROMETHEE II works by converting criteria into a comparable scale, which allows for the evaluation of alternatives based on different aspects. The methodology consists of several steps:

1. Formation of a decision matrix that contains all the alternatives and their performance on each criterion.
2. Assignment of weights to the criteria reflecting their relative importance.
3. Application of a preference function to each pair of alternatives to establish their pairwise comparison.
4. Calculation of outranking flows (positive "leaving flow" and negative "entering flow").
5. Generation of a complete or partial ranking of alternatives based on the net outranking flow (difference between positive and negative flows).

One of the primary benefits of PROMETHEE II over other MCDA methodologies is its transparency and ease of interpretation. The method uses straightforward mathematical calculations, and the decision-maker's preferences are clearly reflected in the process through weights and preference functions. This visibility of decision parameters contributes to the method's acceptability among decision-makers.

PROMETHEE II MCDA methodology has been successfully used in a wide array of fields, including environmental management, healthcare, finance, and logistics. In the context of watershed prioritization, it provides a systematic for evaluating and ranking watersheds based on multiple environmental and socio-economic criteria.

### 4.2.2 Decision Matrix

#### *4.2.2.1 Criteria*

The MCDA methodology in the tool uses several criteria to meet the goals of improving water quality, increasing resilience to climate change impacts, preserving and restoring critical and sensitive habitats, and implementing equity and social justice.

Watershed Planning staff identified four prioritization goals that align with the goals of the City's Watershed Plan. Goal 1 addresses water quality outcomes, focusing on pollutant concentrations and stormwater management infrastructure improvement. Goal 2 aims to increase resilience to climate change impacts by targeting areas most vulnerable to these impacts. Goal 3 centers around preserving and restoring critical and sensitive habitats. Goal 4 seeks to implement equity and social justice, with a focus on areas identified as having overlapping equity needs by other Tacoma programs. Table Table 4-1summarizes the subgoals, critieria, and sources of data for each goal.

**Table 4-1 Watershed Planning Goals and associated Subgoals and Criteria**

| **Goal 1: Improve Water Quality Outcomes (Clean Water Goal)** | | |
|---|---|---|
| **Sub-goal** | **Criteria** | **Data Source** |
| 1.1 Prioritize areas based on pollutant concentrations | Total Nitrogen Concentration | TNC Stormwater Heatmap |
| | TSS Concentration | TNC Stormwater Heatmap |
| | Annual Runoff | TNC Stormwater Heatmap |
| | Imperviousness | TNC Stormwater Heatmap |
| 1.2 Improve infrastructure in areas with inadequate stormwater management | Percent of Area Treated | Calculated in tool |
| | Age of Development | TNC Stormwater Heatmap |

| **Goal 2: Increase Resilience to Climate Change Impacts (Resilient Community Goal)** | | |
|---|---|---|
| **Sub-goal** | **Criteria** | **Source** |
| 2.1 Target areas most vulnerable to and at risk for climate change impacts | Urban Heat Island | City of Tacoma |
| | Capacity Issues Layer | City of Tacoma |

| **Goal 3: Preserve and Restore Critical and Sensitive Habitat (Healthy Ecosystems)** | | |
|---|---|---|
| **Sub-goal** | **Criteria** | **Source** |
| 3.1 Preserve and improve Natural Spaces | ES Open Space/Natural Resource Areas | City of Tacoma |

| | | |
|---|---|---|
| | Biodiversity Corridors | City of Tacoma |

| Goal 4: Implement Equity and Social Justice (Healthy Neighborhoods; Equity) | | |
|---|---|---|
| **Sub-goal** | **Criteria** | **Source** |
| 4.1 Prioritize areas of overlapping equity needs as identified by other Tacoma programs | Equity Index Score | City of Tacoma |
| | Livability Index | City of Tacoma |
| 4.2 Improve access to safe, high-quality roadway infrastructure (green infrastructure recommendation) | Pavement Condition Index | City of Tacoma |

#### *4.2.2.2 Direction of Criteria*

The direction of the criteria—whether they are minimized or maximized—depends on the nature of the criterion itself.

For Goal 1, pollutant concentrations such as Total Nitrogen Concentration and TSS Concentration are to be minimized to improve water quality. Conversely, the Annual Runoff and the Percent of Area Treated are criteria aimed to be maximized for better stormwater management.

Under Goal 2, the Urban Heat Island effect is a criterion to be minimized to enhance climate resilience, whereas the capacity to handle climate change impacts is to be maximized.

For Goal 3, the preservation and improvement of Natural Spaces, Salmon Streams, and Biodiversity Corridors are all maximized to ensure healthy ecosystems.

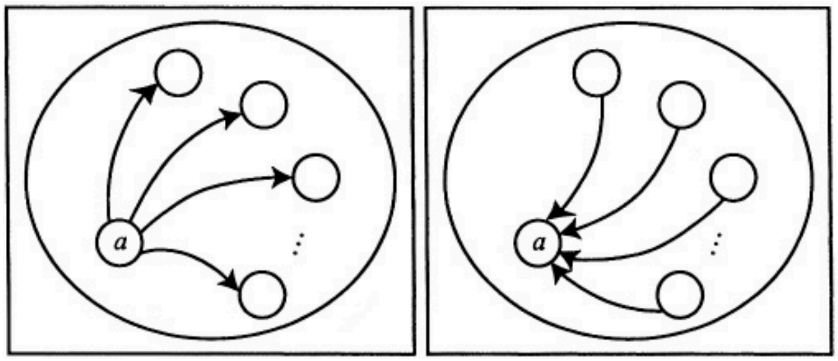
Finally, in Goal 4, the Equity Index Score and Livability Index are maximized to enhance social justice and improve the quality of life in neighborhoods. In contrast, pavement condition, indicative of needed infrastructure work, is minimized to reflect improved roadway conditions. Sidewalk density is maximized to reflect better access to safe, high-quality roadway infrastructure.

#### *4.2.2.3 Preference Function*

PROMETHEE II can use several preference functions (Brans and Vincke, 1985) representing different thresholds for criteria indifferences and preferences. The decision support module uses the “Usual” preference function representing the simplest case for user preferences, whereby any difference in criteria results in a strict preference. In other words if a criterion value for one watershed exceeds another, the preference value is 1 (indicating a clear preference). If not, the preference value is 0 (indicating no preference).

#### *4.2.2.4 Calculation of Outranking flows*

Watersheds are compared to each other on a pairwise basis. A given watershed is compared to every other watershed with respect to each criterion. For each comparison, a binary (i.e. 0 or 1) value is assigned and multiplied by the weight of the criterion. This represents the positive outranking flow. This process is then repeated by comparing every other watershed back to the initial watershed. For each of these comparisons, a binary value of 0 or -1 is assigned representing whether or not another watershed is preferred to the selected watershed. This is the negative outranking flow. Positive and negative outranking flows are illustrated in **Figure 4-1**.



(a) The $\phi^+(a)$ outranking flow. (b) The $\phi^-(a)$ outranking flow.

**Figure 4-1 Illustration of positive and negative outranking flows (Brans and De Smet, 2016)**

The positive and negative outranking flows are then summed independently for each watershed, resulting in a partial ranking of watersheds. The positive and negative outranking flows are then summed together to arrive at the final full ranking of watersheds.

## 4.3 Example

For example, assume a comparison of three watersheds: Watershed A, Watershed B, and Watershed C. For simplicity, assume three criteria: Total Nitrogen Concentration, Urban Heat Island, and Equity Index Score. Assume the weights of these criteria are 3, 4, and 5 respectively (as input by the user).

The preference values for Watershed A over Watershed B, calculated using the usual preference function, are as follows:

Total Nitrogen Concentration: 1 (A is better than B)

Urban Heat Island: 0 (A is equivalent to B)

Equity Index Score: 1 (A is better than B)

The positive outranking flow for Watershed A over Watershed B is:

$$(1 * 3) + (0 * 4) + (1 * 5) = 8$$

The positive outranking flow for Watershed B over Watershed A is:

$$(0 * 3) + (0 * 4) + (0 * 5) = 0$$

This would then be repeated for the watershed pairs of (A,C), (B,C), (C,A) and (C,B).

The negative outranking flow for Watershed A over Watershed B is:

$$(0 * 3) + (0 * 4) + (0 * 5) = 0$$

The negative outranking flow for Watershed B over Watershed A is:

$$(-1 * 3) + (0 * 4) + (-1 * 5) = -8$$

This would then be repeated for the watershed pairs of (A,C), (B,C), (C,A) and (C,B).

The positive and negative outranking flows are then summed, representing the net outranking flow for each watershed. Finally, watersheds are ranked based on their net outranking flows. The watershed with the highest net outranking flow is considered the best option according to the chosen criteria and weights.

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# APPENDIX A

HSPF IMPLND and PERLND Factors

*Table A-1 HSPF PERLND Factors*

| HRU | Soil | Land Cover | | Slope | LZSN | INFILT | LSUR | SLSUR | KVARY | AGWRC | INFEXP | INFILD | BASETP | AGWETP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 000 | A/B | Forest | | Flat | 5 | 2 | 400 | 0.05 | 0.3 | 0.996 | 2 | 2 | 0 | 0 |
| 001 | A/B | Forest | | Mod | 5 | 2 | 400 | 0.1 | 0.3 | 0.996 | 2 | 2 | 0 | 0 |
| 002 | A/B | Forest | | Steep | 5 | 2 | 400 | 0.15 | 0.3 | 0.996 | 2 | 2 | 0 | 0 |
| 010 | A/B | Pasture | | Flat | 5 | 1.5 | 400 | 0.05 | 0.3 | 0.996 | 2 | 2 | 0 | 0 |
| 011 | A/B | Pasture | | Mod | 5 | 1.5 | 400 | 0.1 | 0.3 | 0.996 | 2 | 2 | 0 | 0 |
| 012 | A/B | Pasture | | Steep | 5 | 1.5 | 400 | 0.15 | 0.3 | 0.996 | 2 | 2 | 0 | 0 |
| 020 | A/B | Lawn | | Flat | 5 | 0.8 | 400 | 0.05 | 0.3 | 0.996 | 2 | 2 | 0 | 0 |
| 021 | A/B | Lawn | | Mod | 5 | 0.8 | 400 | 0.1 | 0.3 | 0.996 | 2 | 2 | 0 | 0 |
| 022 | A/B | Lawn | | Steep | 5 | 0.8 | 400 | 0.15 | 0.3 | 0.996 | 2 | 2 | 0 | 0 |
| 100 | C | Forest | | Flat | 4.5 | 0.08 | 400 | 0.05 | 0.5 | 0.996 | 2 | 2 | 0 | 0 |
| 101 | C | Forest | | Mod | 4.5 | 0.08 | 400 | 0.1 | 0.5 | 0.996 | 2 | 2 | 0 | 0 |
| 102 | C | Forest | | Steep | 4.5 | 0.08 | 400 | 0.15 | 0.5 | 0.996 | 2 | 2 | 0 | 0 |
| 110 | C | Pasture | | Flat | 4.5 | 0.06 | 400 | 0.05 | 0.5 | 0.996 | 2 | 2 | 0 | 0 |
| 111 | C | Pasture | | Mod | 4.5 | 0.06 | 400 | 0.1 | 0.5 | 0.996 | 2 | 2 | 0 | 0 |
| 112 | C | Pasture | | Steep | 4.5 | 0.06 | 400 | 0.15 | 0.5 | 0.996 | 2 | 2 | 0 | 0 |
| 120 | C | Lawn | | Flat | 4.5 | 0.03 | 400 | 0.05 | 0.5 | 0.996 | 2 | 2 | 0 | 0 |
| 121 | C | Lawn | | Mod | 4.5 | 0.03 | 400 | 0.1 | 0.5 | 0.996 | 2 | 2 | 0 | 0 |
| 122 | C | Lawn | | Steep | 4.5 | 0.03 | 400 | 0.15 | 0.5 | 0.996 | 2 | 2 | 0 | 0 |
| 200 | SAT | Forest | | Flat | 4 | 2 | 100 | 0.001 | 0.5 | 0.996 | 10 | 2 | 0 | 0.7 |
| 201 | SAT | Forest | | Mod | 4 | 2 | 100 | 0.01 | 0.5 | 0.996 | 10 | 2 | 0 | 0.7 |
| 202 | SAT | Forest | | Steep | 4 | 2 | 100 | 0.1 | 0.5 | 0.996 | 10 | 2 | 0 | 0.7 |
| 210 | SAT | Pasture | | Flat | 4 | 1.8 | 100 | 0.001 | 0.5 | 0.996 | 10 | 2 | 0 | 0.5 |
| 211 | SAT | Pasture | | Mod | 4 | 1.8 | 100 | 0.01 | 0.5 | 0.996 | 10 | 2 | 0 | 0.5 |
| 212 | SAT | Pasture | | Steep | 4 | 1.8 | 100 | 0.1 | 0.5 | 0.996 | 10 | 2 | 0 | 0.5 |
| 220 | SAT | Lawn | | Flat | 4 | 1 | 100 | 0.001 | 0.5 | 0.996 | 10 | 2 | 0 | 0.35 |
| 221 | SAT | Lawn | | Mod | 4 | 1 | 100 | 0.01 | 0.5 | 0.996 | 10 | 2 | 0 | 0.35 |
| 222 | SAT | Lawn | | Steep | 4 | 1 | 100 | 0.1 | 0.5 | 0.996 | 10 | 2 | 0 | 0.35 |

## Table A-2 HSPF IMPLND Factors

| HRU | Land Cover | Slope | LSUR | SLSUR | NSUR | RETSC |
|---|---|---|---|---|---|---|
| 250 | Impervious | Flat | 400 | 0.01 | 0.1 | 0.1 |
| 251 | Impervious | Moderate | 400 | 0.05 | 0.1 | 0.08 |
| 252 | Impervious | Steep | 400 | 0.1 | 0.1 | 0.05 |

# 12 Appendix B - King County Unit Cost Basis

# TECHNICAL MEMORANDUM

Date: October 4, 2024

To: Carly Greyell, King County Water and Land Resources Division
Jim Simmonds, King County Wastewater Treatment Division

From: Olivia Wright, Herrera Environmental Consultants, Inc.
John Lenth, Herrera Environmental Consultants, Inc.

Subject: WQBE – Phase 3 Action and Program Fact Sheet Development (439-TM1)

# Contents



# Appendices

# Figures

# Introduction

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes for selecting cost-effective water quality investments, reducing pollutant load and improving ecological and human health outcomes. The WQBE Toolkit will include a set of computational models:

- Integrated pollutant loading models, which estimate pollutant loads for major King County waterbodies taking into account major pollutant pathways and sources.
- System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) models, which identify cost-effective combinations of potential water quality improvement investments for reduction of pollutant loads or stormwater volumes.
- Qualitative causal models, which define relationships between potential water quality projects and programs and five ecological/human health endpoints (southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches).

The WQBE Toolkit provides information that will be used in planning and prioritization of water quality investments. However, it is not the only information that informs these decisions. These efforts will also consider information not provided by the WQBE Toolkit, including how well different actions would advance equity and social justice, meet regulatory requirements, impact the cost of wastewater rates, and reflect other regional priorities (e.g., sustainability, community well-being, and more).

Part of this effort has involved the development of model inputs for “Actions” composed of structural or nonstructural stormwater controls that improve water quality and/or provide flow control. These Actions provide the unit building blocks (or “unit Actions”) that are aggregated and combined to develop "Programs,” or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. SUSTAIN models are then developed for each Program to evaluate cost effectiveness combinations of Actions, or “Packages,” for improving water quality or providing flow control.

The WQBE Toolkit is being developed in three phases over a period extending from 2020 through 2024.

- Phase 1 (2020): Assumptions for a preliminary set of nineteen Actions and three Programs focused on improving water quality were developed to be modeled with the WQBE Toolkit.
- Phase 2 (2021-2022): Preliminary Actions and Programs from Phase 1 were refined to improve their representation in SUSTAIN (Herrera 2022). The three water quality Programs from Phase 1 were subsequently modeled with SUSTAIN (Paradigm and Herrera 2022).
- Phase 3 (2023-2024): An additional four Actions and four Programs focused on providing flow control were developed and the Phase 2 Action costs were refined using a simplified approach that allows for more direct comparison to similar planning level cost estimates in the region.

This memorandum documents the process used to develop the Phase 3 Action and Program Fact Sheets for the WQBE toolkit. It begins with a general overview of the Fact Sheet development process and guidance for their interpretation. Detailed supporting documentation on the technical basis for the Fact Sheet content is then provided in a series of appendices.

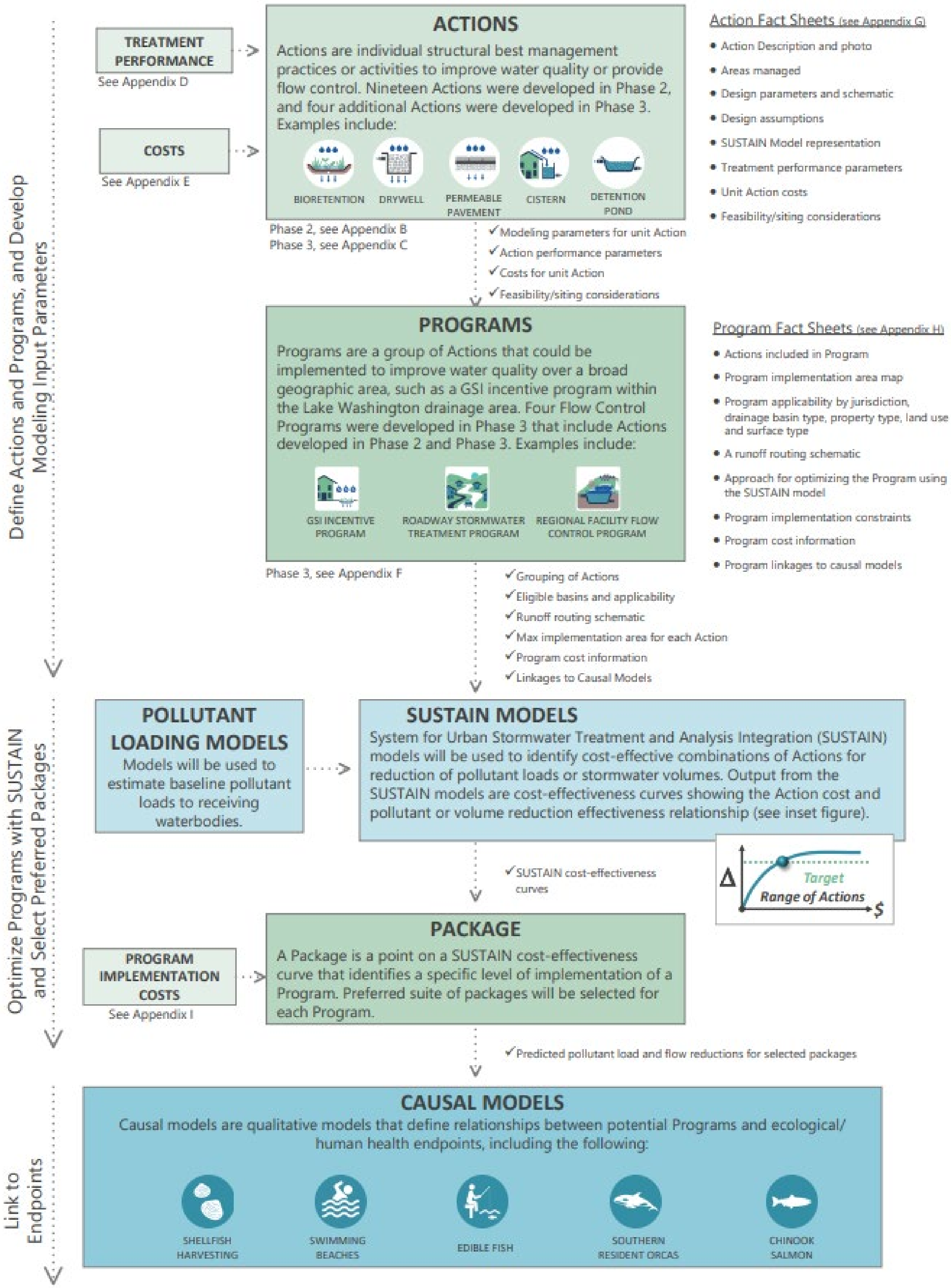
# Action and Program Development Process

An overview of the process used to develop the Actions and Programs is provided in Figure 1. The graphic depicts the interrelationship between the WQBE elements (Actions, Programs, and computational models).

Supporting technical documentation for the development of the Phase 3 Action and Program Fact Sheets is provided in a series of appendices to this memorandum:

- WQBE terminology (Appendix A) – Provides key terminology that is used in the WQBE Toolkit.
- Phase 2 Action design assumptions (Appendix B) – Documents the design assumptions for the original nineteen Actions that were developed in Phase 2. A subset of these Actions are included in Flow Control Programs developed in Phase 3. Note the cost information in the Fact Sheets from this memorandum were update in Phase 3 as described below.
- Phase 3 Action design assumptions (Appendix C) – Documents the design assumptions for the four new Actions that were developed in Phase 3.
- Phase 3 Action performance assumptions (Appendix D) – Documents the water quality treatment assumptions for the original nineteen Actions developed in Phase 2 and the four new Actions developed in Phase 3.
- Phase 3 Action costs (Appendix E) – Documents the simplified costing approach that was developed in Phase 3. Included is a summary of the revised costs for the nineteen original Actions developed in Phase 2 and the four new Actions developed in Phase 3.
- Phase 3 Flow Control Program development (Appendix F) – Documents the assumptions for four Programs focused on flow control developed in Phase 3.
- Phase 3 Action Fact Sheets (Appendix G) – Fact Sheets for the original nineteen Actions that have updated costs from the simplified costing approach that was developed in Phase 3 and summarized in Appendix E. Also included are Fact Sheets for the four new Actions that were developed in Phase 3. These fact sheets supersede those developed during Phase 2 and included in Appendix B.
- Phase 3 Water Quality and Flow Control Program Fact Sheets (Appendix H) – Fact Sheets for four new Programs focused on flow control that were developed in Phase 3.
- Program Implementation delivery models and costing approach (Appendix I) – Provides example costs for Program implementation models that could be applied outside of SUSTAIN.

Figure 1. WQBE Elements.



# Action Fact Sheet Content and Interpretation Guidance

Nineteen Actions were developed in Phase 2 and an additional four Actions were developed in Phase 3. Action fact sheets were developed to compile Action descriptions and design details to support Program development and SUSTAIN modeling. The key design assumptions and technical basis for information included in the Action Fact Sheets for the Actions developed in Phase 2 and Phase 3 can be found in the Appendices B and C, respectively. The associated Action Fact Sheets can be found in Appendix G and include the following:

- Description and a representative photo of the Action
- Potential areas managed, including land uses, land cover types, and property types
- SUSTAIN model parameters for unit Action, including footprint area, drainage area, and design section
- Schematic for unit Action, illustrating section and dimensions
- Design assumptions, including basis for sizing
- Representation of hydrologic and treatment performance in the SUSTAIN model
- Action treatment performance parameters, including median percent removal and median effluent concentration
- Planning-level cost estimates for unit Action
- Programmatic feasibility and siting considerations

Figures 2 and 3 provide an annotated Action Fact Sheet to guide the user in interpreting the content.

Figure 2. Annotated Action Fact Sheet – Bioretention HPBSM Example (page 1 of 2).

Action name

# BIORETENTION HPBSM

## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

Action icon

10/1/2024

General description of the Action including major assumptions and benefits provided

### ACTION DESCRIPTION

City of Redmond Overlake Village LID Retrofit Project
Photo courtesy of RKI

Photo depicting real-world application

Shallow earthen depressions with a designed high-performance bioretention soil media (HPBSM) and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system. Provides volume and peak flow reduction and water quality treatment.

### AREAS MANAGED

Summary of where the Action can be applied, informing cost estimates and SUSTAIN model assumptions on implementation

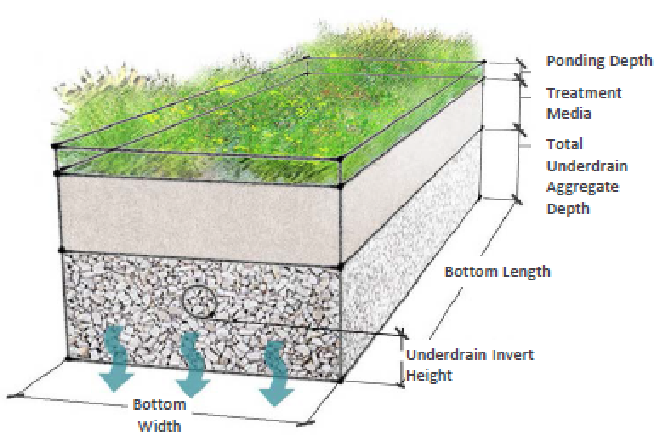
**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Driveways
- Parking Lots
- Sidewalk
- Plazas
- Local Roads
- Arterial Roads
- Highways

Parameters used to inform the Action representation in SUSTAIN

### UNIT ACTION SCHEMATIC




Schematic illustration to inform the Action representation in SUSTAIN

### DESIGN PARAMETERS

| Parameter | Soil Type: Till | Soil Type: Outwash |
|---|---|---|
| Unit Footprint Area | 85 SF | 85 SF |
| Unit Drainage Area | 12,148 SF | 9,570 SF |
| Ponding Depth | 6 in | 6 in |
| Bottom Length | 16 ft | 16 ft |
| Bottom Width | 5.33 ft | 5.33 ft |
| Side Slope | 3H : 1V | 3H : 1V |
| Treatment Media Depth | 18 in | 18 in |
| Treatment Media Porosity | 30% | 30% |
| Treatment Media Infiltration Rate | 6 in/hr | 6 in/hr |
| Total Underdrain Aggregate Depth | 26 in | N/A |
| Underdrain Invert Height | 12 in | N/A |
| Underdrain Diameter | 8 in | N/A |
| Underdrain Aggregate Porosity | 40% | N/A |
| Native Soil Design Infiltration Rate | 0.3 in/hr | 2.5 in/hr |

N/A: Not Applicable

Note: For Actions with side slopes, see SUSTAIN representation in 439-TM1 Appendix B.

### DESIGN ASSUMPTIONS

Basis of design summary

- Design is based on *2016 King County Surface Water Design Manual (KCSWDM)* Section C.2.6.1.
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Although not listed in the Basic or Enhanced Water Quality Treatment Menu in the KCSWDM, this project assumes the Action, including the HPBSM, provides Enhanced Water Quality Treatment.
- The HPBSM is a low phosphorus media composed of 70% sand, 20% coir and 10% high carbon wood ash (biochar). No polishing layer is included.
- For bioretention installed in till soils, an elevated underdrain promotes infiltration. Design includes 6” cover, 8” underdrain pipe, and 12” bedding.
- For bioretention installed on outwash soils, no underdrain is included.

Page 1 of 2

Visit kingcounty.gov/WQBE for more information.

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Figure 3. Annotated Action Fact Sheet – Bioretention HPBSM Example (page 2 of 2).

# BIORETENTION HPBSM
Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

Summary of SUSTAIN modeling processes

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Model explicitly represents ponding, infiltration, underdrain flow, and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

**Treatment:**
- Water that infiltrates is lost to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

Median percent removal and median effluent concentrations for target pollutants analyzed in SUSTAIN

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal [a] | 25th Percentile Effluent Concentration [a] |
|---|---|---|
| Total Copper | 62.3% | 7.1 µg/L |
| Dissolved Copper | 57.6% | 4.6 µg/L |
| Total Zinc | 91.0% | 5.0 µg/L |
| Dissolved Zinc | 86.2% | <4.0 µg/L [b] |
| Total Phosphorus | 54.9% | 0.024 mg/L |
| Total Nitrogen | 51.3% | 1.2 mg/L |
| Total Suspended Solids | 78.0% | 13.5 mg/L |
| Total PCBs | 78.0%[c] | 358 pg/L[c] |
| Total PBDEs | 67.1%[c] | 0.034 ng/L[c] |
| Total PAHs | 95.1% | <0.01 µg/L [b] |
| Bis(2-ethylhexyl)phthalate | 63.2%[c] | 0.044 µg/L[c] |
| Fecal Coliform | 61.5 % | 31.5 CFU/100 mL |

a. Performance based on the low phosphorus alternative bioretention soil media with 70% sand/20% coconut coir/10% high carbon wood ash
b. Method detection limit
c. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | With Underdrain | | No Underdrain | |
|---|---|---|---|---|
| | On Property without Acquisition | In Right of Way/ Highway | On Property without Acquisition | In Right of Way/ Highway |
| Total Project | $50,100 | $90,300 | $46,500 | $90,000 |
| Total Direct Construction | $35,400 | $63,900 | $32,800 | $63,700 |
| Total Indirect Non-Construction | $14,700 | $26,400 | $13,700 | $26,300 |
| Operation and Maintenance | $3,100/year | $3,100/year | $3,100/year | $3,100/year |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

Total project, operation and maintenance, and property acquisition cost estimates for various model configurations

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Site must have sufficient space (e.g., right-of-way applications typically require minimum planter width of 12 feet)
- Locate away from traveled areas on individual lots to prevent soil compaction and damage to vegetation
- No discharge towards existing basements, erosion hazard areas, or landslide hazard areas
- Meet infiltration siting restrictions, including setbacks:
  - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
  - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
  - 100 feet away from proposed or existing septic system drainfields
- See comprehensive list of infeasibility criteria in Section C.2.6 of *the 2016 King County Surface Water Design Manual*

Considerations for program implementation and siting of individual Actions in SUSTAIN

Page 2 of 2 Visit kingcounty.gov/WQBE for more information.

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# Program Fact Sheet Content and Interpretation Guidance

Three Programs were developed under Phase 1 and subsequently refined in Phase 2 that focused on providing water quality improvements. Herrera (2022) provides the key assumptions and technical basis for these Programs.

- Green Stormwater Infrastructure (GSI) Incentive Program,
- Roadway Stormwater Treatment Program
- Regional Stormwater Treatment Program.

In Phase 3, four additional Programs were developed that focused on providing flow control:

- GSI Incentive Flow Control Program
- Roadway Retrofit Flow Control Program
- Regional Facility Flow Control Program
- Greening Flow Control Program

This technical memorandum focuses on the Programs developed in Phase 3. The key assumptions and technical basis for these Programs can be found in Appendix F. The associated Program Fact Sheets are provided in Appendix H. These Fact Sheets were developed to compile Program descriptions and implementation rules to support Program optimization using the SUSTAIN model. They include the following:

- Detailed description of the Program
- Actions developed in Phase 2 and Phase 3 that could be included in the Program
- Program implementation area, including a map showing eligible basins
- Program applicability by jurisdiction, drainage basin type, property type, land use and surface type
- A runoff routing schematic showing how flow is routed through Actions in the SUSTAIN model
- Program implementation constraints that are used to quantify the maximum area that could be treated by each Action
- Program cost information
- Approach for optimizing the Program using the SUSTAIN model
- Program linkages to causal models

Figures 4 through 7 provide an annotated Program Fact Sheet to guide the user in interpreting the content.

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Figure 4. Program Fact Sheet – GSI Incentive Flow Control Program Example (page 1 of 4).

Program name

Provides high-level description of Program

Shows Actions that could be included in Program. The most cost-effective combination of Actions would be identified using the SUSTAIN model. Also indicates if pretreatment is required. Refer to companion Action Fact Sheets and Appendix B and C for detailed descriptions of Actions. Icons shown here are included in upper right corner of Action Fact Sheets.

# GSI INCENTIVE FLOW CONTROL PROGRAM

## Water Quality Benefits Evaluation Program Fact Sheet

Phase 3

10/1/2024

## PROGRAM OVERVIEW

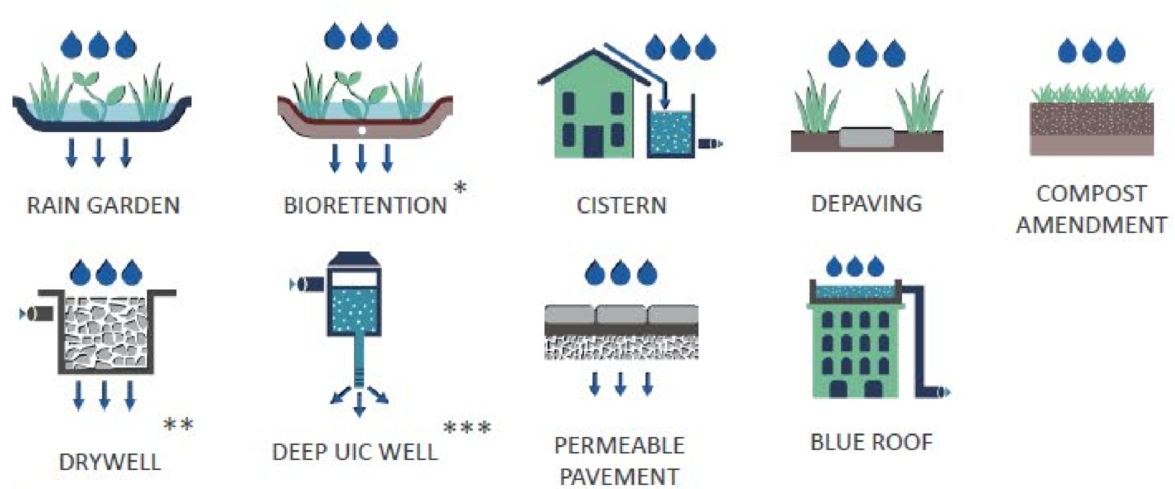
The GSI Incentive Flow Control Program would provide incentives for property owners to install small scale green stormwater infrastructure (GSI) practices to help manage the rain that falls on their roofs and other impervious surfaces, such as parking lots and driveways. The Program would provide grants, rebates, or other financial incentives to eligible property owners for installing and maintaining GSI on their properties.

The objective of the Program would be to provide flow control for stormwater runoff in separated drainage basins to more closely mimic predeveloped hydrology for receiving waterbodies in Puget Sound Nearshore, Elliott Bay, Green/Duwamish, Lake Union/Ship Canal, and Lake Washington basins. The Program could be adapted for combined drainage basins with the objective to reduce combined sewer overflows.

The Program could include the GSI practices ("Actions") listed below. The most cost-effective combinations of Actions for this Program could be identified using the SUSTAIN model. Modeling inputs for the Actions, including design, performance, and cost assumptions, are provided in companion Action Fact Sheets.

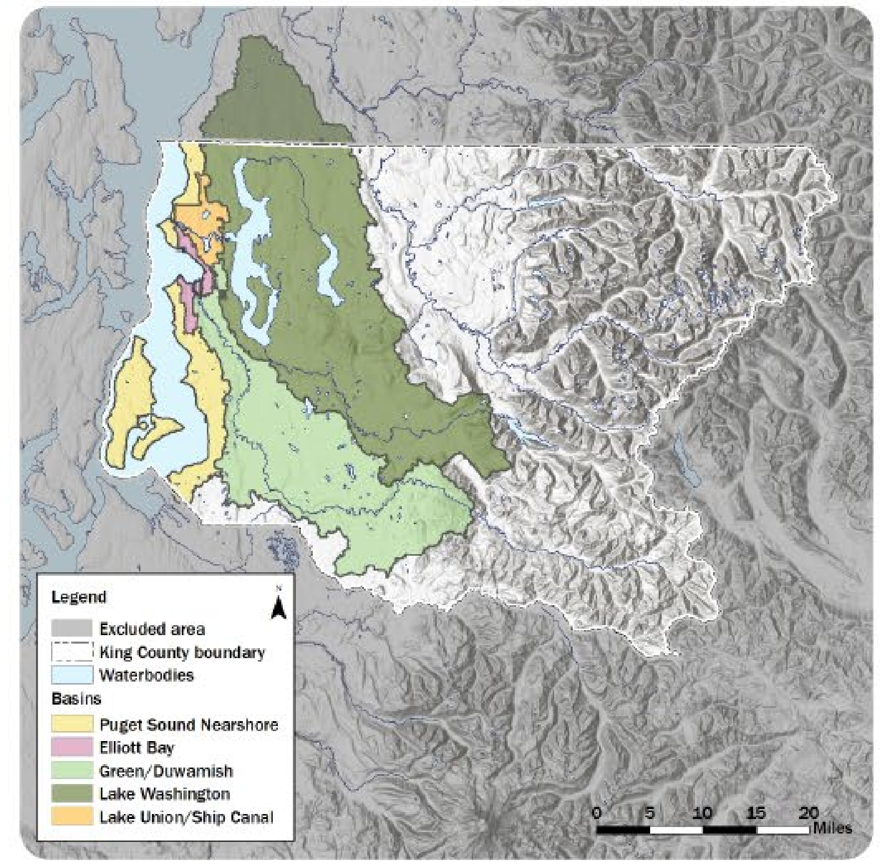
The following pages include key assumptions and an overview the Program. See 439-TM1 Appendix F for more detailed information regarding the methods used.

## ACTIONS INCLUDED IN PROGRAM




* Not including bioretention facilities with underdrains on till soil due to minimal flow control benefits
** Paired with upstream bioretention planter for pre-treatment
*** Paired with upstream high-rate filter for pre-treatment

## PROGRAM IMPLEMENTATION AREA




## PROGRAM APPLICABILITY

- Basins in implementation area (see map above)
- Unincorporated King County and cities
- Separated drainage basins
- Residential, commercial, industrial land uses
- Private and public parcels

Page 1 of 4 Visit kingcounty.gov/WQBE for more information.

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Program icon

Map shows King County basins eligible for Program. Map also shows excluded areas, if applicable (e.g., basin areas outside of County)

Lists where Program could apply, including jurisdiction type, drainage basin type, land use, and property ownership.

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Figure 5. Program Fact Sheet – GSI Incentive Flow Control Program Example (page 2 of 4).

# GSI INCENTIVE FLOW CONTROL PROGRAM

## Water Quality Benefits Evaluation Program Fact Sheet

Phase 3

10/1/2024

### SUSTAIN MODELING APPROACH

Describes diagram below

**Runoff routing:**
This diagram shows how stormwater runoff is routed through GSI Actions in the SUSTAIN model. The arrows characterize the routing of runoff from each land use and surface type to the Actions or Action treatment trains. The compost amendment and depave Actions are represented in the model by converting the modeled surface type. Some Actions are only applied to certain soil and slope conditions (see the Implementation Constraints Table on page 3). Overflow from the Actions and unmanaged runoff is routed to the catchment outlet. SUSTAIN provides an assessment of the most cost-effective combination of Actions within a treatment train to achieve different levels of flow control.

Describes how SUSTAIN will be used to optimize the Program

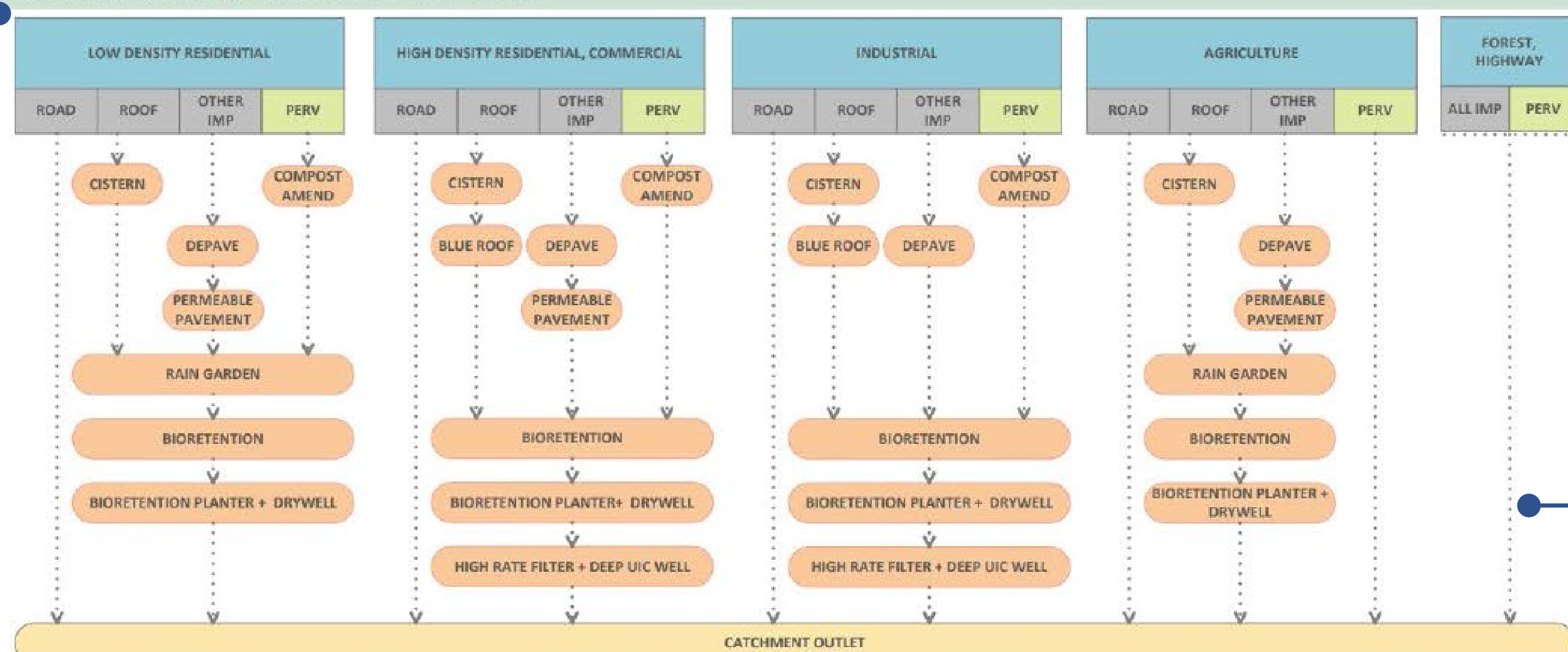
**SUSTAIN Program optimization:**
SUSTAIN could be used to evaluate and optimize the most cost-effective Actions for this Program.

- For performance, Actions can be optimized for runoff volume reduction on days in the timeseries where runoff exceeds a threshold that represents an unnatural hydrograph. The associated pollutant load reduction provided by the optimized Actions can be estimated.
- For costs, optimization can be based on Action lifecycle costs. Program development and implementation costs can be scaled and applied to modeling results.
- SUSTAIN models these Actions as a lumped representation at the bottom of each catchment. The cost-effective Actions identified by SUSTAIN are assumed to be distributed throughout the defined drainage area.

LEGEND

- HIGHWAY Land use
- Impervious surface
- Pervious surface
- BIORETENTION Action
- SUSTAIN will select best option in box
- Runoff routing

Diagram shows how stormwater is routed in the SUSTAIN model.




Land use in blue box

Surface type (gray is impervious surface and green is pervious surface)

* Not including bioretention facilities with underdrains on till soil due to minimal flow control benefits

** Compost amendment is only applied for lawn surfaces

Arrow indicates runoff routing

Outlet of model catchment

Page 2 of 4 Visit kingcounty.gov/WQBE for more information.

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Figure 6. Program Fact Sheet – GSI Incentive Flow Control Program Example (page 3 of 4).

# GSI INCENTIVE FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet

Phase 3

10/1/2024

Provides a detailed description of the Program including Program elements, key assumptions, and risks.

## PROGRAM DESCRIPTION/ASSUMPTIONS

**Program description:**

- The GSI Flow Control Incentive Program would provide financial incentives in the form of rebates, grants, or other forms of funding to property owners to install GSI practices (Actions) to provide flow control for currently unmanaged stormwater runoff from roofs and other impervious surfaces, such as parking lots and driveways.
- The Program would be applicable to private parcels in residential, commercial, and industrial, agricultural areas with separated drainage systems. Eligible areas would include unincorporated King County and cities in the implementation area. GSI Actions would be implemented across the eligible areas based on the assumed technical and participation factors shown in the table to the right.
- The Program would be administered by King County in partnership with other jurisdictions and nongovernmental agencies.
- Program elements would include:
  - Public outreach
  - Website with eligibility maps, design tools, and incentive calculator
  - Application processing and site/construction inspection
  - Contractor recruitment/trainings
  - Annual inspections and maintenance
- Modeling will determine full costs of design, construction, maintenance and replacement. A separate evaluation will determine rebates/grants for incentivizing participation. Costs of Program development and administration, would be borne by the County, or potentially shared with other partners.

**Key assumptions:**

- Factors influencing technical feasibility and participation are based on professional judgement and assumed to be the same across all eligible areas.
- Because this is a retrofit Program, Action sizing is not based on redevelopment requirements (i.e., contributing drainage area to each unit Action is not constrained).

**Key risks and challenges:**

- Relies, in part, on cooperation between King County and partners
- Relies on interested property owners
- Requires alignment with varied local codes
- Requires development of qualified contractor base
- Requires ongoing maintenance efforts and costs

## PROGRAM IMPLEMENTATION CONSTRAINTS

Max Drainage Area = Total Implementation Area (reduced by infeasible areas) x "Technical Factor" x "Participation Factor"
= Total Implementation Area (reduced by infeasible areas) x "Composite Factor"

| GSI Action | Infeasible Areas [1] | Technical Factor [2] | | | | | | | | Participation Factor [3] | Composite Factor (Technical x Participation) [4] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Low Density Residential | | | High Density Residential, Commercial, and Industrial | | | Agricultural | | | |
| | | Roof | Other Imp | Perv | Roof | Other Imp | Perv | Roof | Other Imp | | |
| Rain garden on till | Outwash soil, slopes > 10% | 30% | 30% | 30% | | | | 30% | 30% | 20% | 6.0% |
| Rain garden on outwash | Till soil, slopes > 10% | 50% | 50% | 50% | | | | 50% | 50% | 20% | 10.0% |
| Bioretention on outwash | Till soil, slopes > 10% | 50% | 50% | 50% | 40% | 40% | 40% | 50% | 50% | 20% | 8.0% - 10.0% |
| Cisterns | -- | 50% | | | 50% | | | 50% | | 25% | 12.5% |
| Bioretention planter to drywell | Till soil | 30% | 30% | 30% | 30% | 30% | 30% | 30% | 30% | 15% | 4.5% |
| High rate filter to deep UIC well | Outwash soil, gw protection areas | | | | 20% | 20% | 20% | | | 5% | 1.0% |
| Depaving | -- | | 20% | | | 10% | | | 20% | 5% | 0.5% - 1.0% |
| Permeable pavement | Slopes > 3% | | 30% | | | 30%[5] | | | 10% | 2% | 0.2% - 0.6% |
| Blue roof | | | | | 20% | | | | | 2% | 0.4% |
| Compost amendment | | | | 80% | | | 80% | | | 30% | 24% |

1. "Infeasible Areas" are areas where the Action will not be applied.
2. "Technical Factor" represents the estimated fraction of the implementation area that could feasibly be managed based on technical considerations like space constraints, utility conflicts, existing runoff patterns, and site uses.
3. "Participation Factor" represents the anticipated participation in the Program.
4. "Composite Factor" is the combined factor applied to estimate the maximum drainage area.
5. Not applied to industrial land use.

LEGEND

| | |
|---|---|
| Action not applied | |
| High Implementation | ≥30% |
| Medium Implementation | 15 to <30% |
| Low Implementation | ≤15% |

Only a portion of the drainage area routed to Actions in the schematic on page 2 can be feasibly treated due to technical and social constraints. To address this, the total drainage area was reduced to eliminate "infeasible areas" and apply "technical factor" and "participation factor" from this table. Technical and participation factors are based on professional judgement.

 Visit kingcounty.gov/WQBE for more information.

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Figure 7. Program Fact Sheet – GSI Incentive Flow Control Program Example (page 4 of 4).

# GSI INCENTIVE FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet

Phase 3

10/1/2024

Provides description of Program cost elements and how they will be used in SUSTAIN optimizations.

## PROGRAM COSTS

Program costs include:

- Lifecycle costs for Actions sited on private property (see table below).
- Upfront Program development costs (develop website, standards, requirements)
- Average annual Program administration costs (outreach, application processing, construction inspections, maintenance education, annual inspections)

Program development and administration costs are not included in the table and can be applied separately. See 439-TM1 Appendix I for examples.

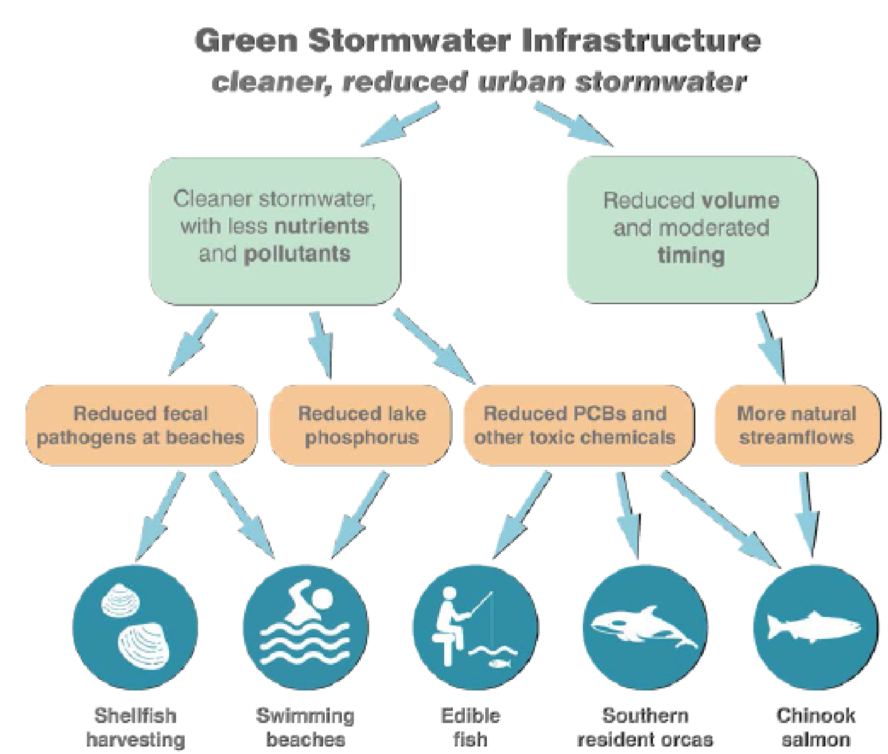
Provides lifecycle costs for Actions included in the Program. See Appendix E for basis of cost estimates.

| Unit Action | Lifecycle Cost/Unit Action[1,2,3] |
|---|---|
| Rain garden | $56,700 |
| Bioretention without underdrain | $117,900 |
| Cisterns | $46,100 |
| Bioretention planter to drywell | $76,000 |
| High-rate filter to deep UIC well | $250,000 |
| Depaving[4] | $16,800 |
| Permeable pavement[5] | $68,400 |
| Blue roof | $170,900 |
| Compost amendment | $13,400 |

1. All costs are per unit of Action installed on private property without property acquisition.
2. Costs are presented in 2023 dollars. Life-cycle include initial capital, operations and maintenance, and capital replacement costs over a 30-year life-cycle.
3. Annual O&M costs are included in the life-cycle costs with periodic replacements. For details on the total project costs and O&M cost development, see 439-TM1 Appendix E.
4. Costs based on driveway depaving with wheel strips
5. Costs based on permeable paver driveway with sand layer.

## LINKAGES TO CAUSAL MODELS

The GSI Incentive Flow Control Program could be evaluated using causal models to assess benefits to a suite of human and ecological health endpoints. The graphic below illustrates the types of factors that might be influenced by a Program and how changes in those factors might improve outcomes for shellfish harvest, swimming beaches, edible fish, Chinook salmon, and Southern Resident orcas. Causal model inputs for the evaluation would be based on the factors shown here. A detailed list of potential causal model inputs are included as an appendix to technical memorandum #420-TM1.




Provides a description and graphic showing how the Program will link to the causal models. These models will be used to evaluate the benefit of the Program for human health and ecological endpoints.

Page 4 of 4 Visit kingcounty.gov/WQBE for more information.

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# Next Steps

The information in the Program and Action Fact sheets can be used to develop SUSTAIN model inputs to accomplish the following:

- Optimize the Programs using the SUSTAIN model to identify cost-effective combinations of Actions for improving flow control and water quality.
- Identify a set of optimum Packages from the resultant SUSTAIN cost effectiveness curves.

# References

Herrera. 2022. Water Quality Benefits Evaluation – Phase 2 Action and Program Factsheet Development (431-TM1). Prepared for King County Water and Land Resources Division by Herrera Environmental Consultants. May.

Paradigm and Herrera. 2022. Water Quality Benefits Evaluation – Phase 2 SUSTAIN Model Development (821-TM1). Prepared for King County Water and Land Resources Division by Paradigm Environmental and Herrera Environmental Consultants. December.

# Appendix A

## Terminology

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Herrera
Science + Planning + Design

# TECHNICAL MEMORANDUM

**Date:** October 4, 2024

**To:** Carly Greyell, King County Water and Land Resources Division
Jim Simmonds, King County Wastewater Treatment Division

**From:** Olivia Wright, Herrera Environmental Consultants, Inc
John Lenth, Herrera Environmental Consultants, Inc.

**Subject:** WQBE Terminology (Appendix A to 439-TM1)

## Introduction

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes regarding selection of cost-effective water quality improvement investments, reducing pollutant load, and improving ecological and human health outcomes. The WQBE Toolkit will include a set of computational models:

- Integrated pollutant loading models, which estimate pollutant loads for major King County waterbodies, taking into account major pollutant pathways and sources
- System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) models, which identify cost-effective combinations of potential water quality for reduction of pollutant loads or stormwater volumes
- Qualitative causal models, which define relationships between potential water quality projects and programs and five ecological/human health endpoints (southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches)

The WQBE Toolkit provides an important set of information that will be used in planning and prioritization of water quality investments. However, it is not the only information that informs these decisions. These efforts will also consider information not provided by the WQBE Toolkit, including how well different actions would advance equity and social justice, meet regulatory requirements, impact the cost of wastewater rates, and reflect other regional priorities (e.g., sustainability, community well-being, and more).

The WQBE toolkit is being developed in several phases over a period extending from 2020 through 2024. Part of this effort has been developing "Actions" composed of structural practices that improve water quality. These Actions provide the unit building blocks (or "unit Actions") that are aggregated and combined to develop "Programs," or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. During Phase 1 (2020), a preliminary set of Actions and Programs focused on improving water quality were developed to be modeled with the WQBE toolkit. In Phase 2 (2021–2022), the water quality Actions and Programs were further refined to improve their representation in SUSTAIN. In Phase 3 (2023–2024), the project team developed additional Actions and Program that could provide flow control in the basins discharging to the Puget Sound.

This technical memorandum is provided as Appendix A to 439-TM1. It specifically documents key terminology that is used in the WQBE Toolkit.

# Program Terminology

Action: Individual structural and non-structural best management practices (BMPs) or activities to improve water quality (e.g., rain gardens, wetponds, street sweeping).

Assessment point: Location where a management objective is evaluated during optimization.

Basin: Grouping of catchments and subbasins that represent the primary discharge points and spatial scale for the Tier 2 System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) model optimization.

Basis of estimate (BOE): A document that details the premise, or basis, from which critical aspects of a project cost estimate were developed, including cost and labor estimates, material availability, any assumptions or deviations, any studies or analysis used as a reference, and any other details that impacted the cost estimates.

Catchment: Delineation of drainage areas for the LSPC baseline pollutant loading model.

Jurished: The result of intersecting the catchments and jurisdictional boundaries; serves as the scale of the individual Tier 1 SUSTAIN model cost-optimization.

Package: A point on a SUSTAIN cost-effectiveness curve that identifies a specific level of implementation of a Program (e.g., 200 unit rain gardens and 50 unit permeable pavement installations, in specified subbasins, representing a cost-effective implementation of a Green Stormwater Infrastructure [GSI] incentive program in the Lake Washington basin).

Programs will be evaluated with the SUSTAIN models by generating a Package of representative Actions optimized for stormwater volume or pollutant load reductions at an assessment point. Previously defined Projects could also be incorporated into the SUSTAIN models and included in optimization evaluations as desired.

Program: A group of unit Actions that could be implemented to improve water quality over a broad geographic area, such as a GSI incentive program within the Lake Washington basin or a roadway stormwater treatment program on County-owned roads within the Green/Duwamish basin.

Project: An individual Action or related group of Actions at a specific geographic location for which detailed, spatially-explicit characteristics are defined (e.g., a rain garden installation on a specified property or within a small defined area).

Subbasin: Grouping of catchments for which the SUSTAIN model output will be reported to inform Causal model inputs.

Unit Action: A representative vertical profile, areal footprint, and associated design-drainage area for an Action being modeled in SUSTAIN. Cost-benefit optimization is used to determine the collective sizes and/or number of unit Actions required to achieve a certain pollutant load reduction target. Each unit Action has an associated cost that is scalable during optimization to estimate total implementation costs.

Unit: Representative footprint of an Action defined so as to be compatible with the SUSTAIN model.

# Appendix B

## Phase 2 Action Design Assumptions and Modeling Parameters

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# PHASE 2
# WATER QUALITY ACTION DEVELOPMENT
# (APPENDIX B TO 431-TM1)

## WATER QUALITY BENEFITS EVALUATION

*Prepared For:*

Herrera Environmental Consultants

*and*

King County Wastewater Treatment Division

January 14, 2022

*Prepared By:*

ROBIN KIRSCHBAUM, INC. water { planning engineering

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KING COUNTY WASTEWATER TREATMENT DIVISION

# WATER QUALITY BENEFITS EVALUATION

| | |
|---|---|
| Date: | January 14, 2022 |
| To: | John Lenth / Herrera |
| Cc: | Carly Greyell / King County Water and Land Resources Division |
| From: | Robin Kirschbaum, PE, and Steven Demmer / Robin Kirschbaum, Inc. |
| Subject: | Phase 2 Water Quality Action Development (TM #431-TM1) |

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## ATTACHMENTS

# GLOSSARY

**Action:** Individual structural and non-structural best management practices (BMPs) or activities to improve water quality (e.g. rain gardens, wetponds, street sweeping).

**Basic Water Quality Treatment:** Water quality treatment standard that provides removal of 80% of the total suspended solids for flows or volumes up to and including the Water Quality design flow or volume. Also referred to as Basic Treatment (when referencing the *2019 Stormwater Management Manual for Western Washington*).

**Best Management Practice:** The schedules of activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices, that when used singly or in combination, prevent or reduce the release of pollutants and other adverse impacts to receiving waters.

**Deep Underground Injection Control (UIC) Well:** A UIC well constructed by drilling and casing a 12-inch-diameter, up to 100-foot-deep borehole intended to infiltrate pre-treated stormwater runoff into deep soil horizons.

**Design Standard:** The design standard establishes the Basis of Design and associated design parameters for a given Action. For example, Bioretention is designed based on the Enhanced Water Quality Treatment Standard (2016 King County Surface Water Design Manual, Appendix C, Section C.2.6), with design parameters such as maximum side slope, maximum ponding depth, and minimum bioretention soil mix depth defined accordingly.

**Enhanced Basic Water Quality Treatment:** Water quality treatment standard that provides greater than 30% dissolved copper removal and greater than 60% dissolved zinc removal, in addition to Basic Water Quality Treatment for flows up to and including the Water Quality design flow or volume. Also referred to as Enhanced Treatment (when referencing the *2019 Stormwater Management Manual for Western Washington*).

**Enhanced Maintenance:** Actions intended to minimize pollutant loading to the stormwater conveyance system and receiving waters while extending the useful life of stormwater management assets.

**Flow Control:** Mitigation for the impacts of increased surface and stormwater runoff flow rates generated by development. Flow control Actions are designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground, or to hold runoff for a short period of time, releasing it to the conveyance system at a controlled rate.

**Hard Surface:** An impervious surface, a permeable pavement, or a vegetated roof.

**Level 2 Flow Control Standard:** Flow control standard that provides matching developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow. Also provides matching developed peak discharge rates to predeveloped peak discharge rates for the 2- and 10-year return periods.

**Long-term Continuous Modeling:** Hydrologic modeling that includes algorithms that maintain a continuous water balance for a catchment to account for soil moisture and hydraulic conditions antecedent to each storm event.

**Modified Level 1 Flow Control Standard:** A modified version of King County's Level 1 Flow Control standard that provides matching developed peak discharge rates to the pre-developed (forested) peak discharge rates for the 2- and the 10-year recurrence intervals. By contrast to the pre-developed forest condition, the unmodified Level 1 Flow Control standard is designed to control flood flows at their current levels and to maintain peak flows within the capacity of the conveyance system for most storm events.

**Off-line Actions:** Water quality Actions to which stormwater runoff is restricted to some maximum flow rate or volume by a flow-splitter.

**Peak Control Standard:** Flow control standard from the *2017 Seattle Stormwater Manual* (Section 5.3.4) that provides:

- The post-development peak flow with 4% annual probability (25-year recurrence flow) shall not exceed 0.4 cubic feet per second per acre
- The peak flow with a 50% annual probability (2-year recurrence flow) shall not exceed 0.15 cubic feet per second per acre).

**Performance Standard:** The performance standard establishes the numerical target for water quality treatment or flow control that the Action is sized to achieve. For example, Bioretention is sized for a performance standard of filtering at least 91% of the average annual runoff based on long-term continuous hydrologic modeling.

**Pollution-generating Hard Surface:** Those hard surfaces considered to be a significant source of pollutants in stormwater runoff.

**Pre-treatment:** An Action that removes at least 50% solids, typically installed upstream of an Underground Injection Control (UIC) well or other Actions that do not provide basic water quality treatment.

**Presettling:** Catch basins or vaults located upstream of an Action intended to collect sediment, reduce the frequency of maintenance activities, and extend the useful life of the downstream Action. The *2016 King County Surface Water Design Manual* (Section 5.2.1 and Section 6.5.1) requires presettling upstream of all filtration and infiltration Actions.

**Program**: A group of Actions that could be implemented to improve water quality over a broad geographic area, such as a Green Stormwater Infrastructure incentive program within the Lake Washington drainage area or a roadway stormwater treatment program on County-owned roads within the Ship Canal drainage area.

**Restoration:** An Action that is intended to restore an area's land surface condition to its predeveloped condition.

**Sizing Factor:** Factors provided in the 2017 Seattle Stormwater Manual that represent the ratio of contributing hard surface area to the Action bottom footprint area, used in this project for rapid sizing of Actions.

**Source Control:** An Action or operation intended to prevent pollutants from coming into contact with stormwater through physical separation of areas or careful management of activities that are sources of pollutants.

**System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN):** A decision support system that assists stormwater management professions with developing and implementing plans for flow and pollution control measures to protect source waters and meet water quality goals.

**Underground Injection Control (UIC) Well:** A structure built to discharge fluids from the ground surface into the subsurface; a bored, drilled, or driven shaft whose depth is greater than the largest surface dimension; or a dug hole whose depth is greater than the largest surface dimension; or an improved sinkhole, which is a natural crevice that has been modified; or a subsurface fluid distribution system that includes an assemblage of perforated pipes, drain tiles, or other similar mechanisms intended to distribute fluids below the surface of the ground.

**Unit Action:** A single Action designed for the smallest unit contributing drainage areas included in the Program evaluation. Unit Actions are aggregated up (e.g., multiplied) by the ratio of actual contributing drainage area to unit drainage area based on Program definitions and SUSTAIN modeling assumptions. Different unit Actions can be combined to form water quality treatment trains that provide multiple benefits.

**Water Quality:** A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

**Water Quality Design Flow:** The flow rate at or below which 91% of the total runoff volume, as estimated by an approved continuous runoff model, will be treated.

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# 1 INTRODUCTION

## 1.1 Background

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes regarding selection of cost-effective water quality improvement investments, reducing pollutant load and improving ecological and human health outcomes. This toolkit will be applied to a suite of potential projects and programs that could improve water quality and could be implemented in the areas draining to the WTD service area receiving waters.

The results of the evaluation of the projects and programs will provide information about the multiple water quality benefits of potential WTD investments within the context of potential regional programs that could be implemented at a County-wide scale. This information will provide technical support for King County discussions with stakeholders, regulators and decision makers related to water quality investments and policies. The toolkit will also be adaptable and designed to respond to the values supported by the region and WTD ratepayers (including those identified by the Regional Engagement effort of the Clean Water Plan) and future strategic planning needs at the Division and Department level (including Clean Water Healthy Habitat).

## 1.2 Project Phasing

The WQBE toolkit is being developed in two phases over a period extending from 2020 through 2022. During Phase 1 (2020), a preliminary set of models was developed. In Phase 2 (2021-2022), these models are being further calibrated and refined to support County planning efforts (e.g., Clean Water Plan and CSO Long-Term Control Plan [LTCP]). Implementation of preliminary analyses using the WQBE toolkit will be performed during its development phases; once finalized, the WQBE toolkit will be used to support a wide range of future planning efforts by the County and potentially other municipalities within the County's jurisdictional borders.

To support preliminary model development in Phase 1, the Project team developed a suite of "Actions" comprised of structural practices that improve water quality. These Actions provide the unit building blocks (or "unit Actions") that were aggregated and combined to develop water quality "Programs", or groups of Actions that can be implemented to improve water quality over a broad geographic area. Fact Sheets were developed to document the defining characteristics of each Action and Program, including costs, performance, and modeling inputs. Subsequent work in Phase 1 included preliminary modeling of these Programs to identify the most cost-effective combinations of Actions or "Packages" for reducing pollutant loads or stormwater volumes as a proof of concept.

The Project team documented the process used to develop Phase 1 Actions and Programs for the WQBE toolkit in a technical memorandum (RKI 2020). The Phase 1 memorandum documented the preliminary assumptions and methods used to develop the water quality Actions, including design configuration, Action sizing, cost estimating, and water quality treatment performance.

A half-day workshop (Workshop 430-W1 Phase 2 Action Unit Cost Development) was conducted on January 29, 2021 with County staff to review the methods, assumptions, and results of Phase 1 evaluations. Potential refinements were identified and discussed regarding the cost estimating approach, Action design, and cost-benefit analysis in (System for Urban Stormwater Treatment and Analysis Integration) SUSTAIN. Shortly following the workshop, the project team agreed to the following key refinements to Action design to be implemented in Phase 2:

- Whereas Action sizing was based primarily on simplified sizing factors in Phase 1, Phase 2 would refine the sizing by use of explicit modeling in a King County-approved long-term continuous hydrologic model, such as MGSFlood. MGSFlood is a proprietary interface of Hydrological Simulation Program – FORTRAM (HSPF) used in the western Washington area for designing and sizing stormwater Best Management Practices (BMPs). This explicit modeling refinement was based on results of preliminary pre-Phase 2 modeling for bioretention, which found that the simplified sizing factors were overly conservative for purposes of this evaluation.
- Action design parameters (e.g., side slopes, ponding depths, freeboard depths, native soil infiltration rates, etc.) would generally remain unchanged from Phase 1, since the design parameters had been thoroughly vetted and agreed upon in Phase 1.
- In order to minimize re-work needed for Action cost estimating, Action bottom footprint areas would remain unchanged from Phase 1 wherever possible. Thus, while holding the bottom footprint areas constant (as well as design parameters and cost estimates), the contributing drainage areas were adjusted in MGSFlood until the Action was demonstrated to meet the applicable performance standard (e.g., water quality treatment, level 1 flow control, level 2 flow control) in the model.

In addition to the above refinements, Phase 2 also entailed development of regression equations to relate Mean Annual Precipitation (MAP) to contributing drainage area for each Action. These relationships, developed through modeling in MGSFlood, were needed to enable SUSTAIN modeling to account for variable Action performance as a result of the highly variable MAP across King County.

### 1.3 Purpose of this Memorandum

This memorandum documents the revised assumptions for Action cost-benefit evaluation that were developed for Phase 2 based on discussions during and after the January 29, 2021 workshop. Specifically, this memorandum documents the following:

- Basis of Design in accordance with the 2016 King County Surface Water Design Manual (KCSWDM) where applicable;
- Action sizing methodology and results;
- Scaling of contributing drainage area based on Mean Annual Precipitation (MAP); and
- Refined integration of unit Action sizing modeling with County-wide modeling in System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN).

## 2 ACTION DEFINITIONS

Table 1 includes a total of 24 Actions, of which 19 of the 24 Actions were defined and evaluated in Phase 1. Of these, 15 Actions were refined in Phase 2, where explicit modeling in MGSFlood was used to revise the drainage area that could be managed to the applicable design standard (Section 1.2). The remaining four Phase 1 Actions, including Media Filter Drain, Permeable Pavement, Depaving, and Cistern, were deemed satisfactory and not refined in this phase.

In addition to the 19 Actions developed and refined in Phases 1 and 2, another five Actions, including Sand Filter, Blue Roof, Creosote Wood Piling Removal, Enhanced Street Sweeping, and Urban Tree Planting, were identified for potential development in future project phases. These Actions have not yet been designed or evaluated.

*Table 1 – Summary of Action Development and Refinement by Phase.*

| Action | Phase 1 | Phase 2 Refinement | Notes |
|---|---|---|---|
| Rain Garden | X | X | |
| Bioretention | X | X | |
| Bioretention Planter | X | X | This Action was sized as both a stand-alone Action and as pre-treatment (See Section 4.5 for Pre-treatment Sizing) |
| Bioswale | X | X | |
| Media Filter Drain (MFD) | X | | No change from Phase 1 |
| Drywell | X | X | Phase 2 includes bioretention planter as pretreatment |
| Deep Underground Injection Control (UIC) Well | X | X | Phase 2 includes bioretention planter and high rate underground filter system as pretreatment |
| Permeable Pavement | X | | No change from Phase 1 |
| Depaving (Removal of Impervious Surfaces) | X | | No change from Phase 1 |
| Stormwater Treatment Wetland | X | X | |
| Detention Vault | X | X | |
| Detention Pond | X | X | |
| Infiltration Pond | X | X | Phase 2 includes high rate underground filter system as pretreatment |
| Infiltration Vault | X | X | Phase 2 includes high rate underground filter system as pretreatment |
| Cistern | X | | No change from Phase 1 |
| Wetpond | X | X | |
| Wetvault | X | X | |
| High Rate Underground Filter System | X | X | This Action was sized as both a stand-alone Action and as pre-treatment (See Section 4.5 for Pre-treatment Sizing) |
| Regional Vegetated Media Filtration Facility | X | X | |
| Sand Filter | N/A | | These Actions were identified early in Phase 1 for possible future analysis, but have not yet been advanced to design. |
| Blue Roof | | | |
| Creosote Wood Piling Removal | | | |
| Enhanced Street Sweeping | | | |
| Urban Tree Planting | | | |

**Abbreviations:**

N/A Not Applicable

## 2.1 Major Categories

The Actions were organized into the following six (6) major categories:

- Green Stormwater Infrastructure (GSI)
- Stormwater Retention/Detention/Infiltration
- Gray Stormwater Infrastructure
- Source Control
- Enhanced Maintenance
- Restoration

The feasibility and cost effectiveness of different categories of Actions are often dependent on land use type. For example, low-density residential areas are generally more conducive to GSI than high-density urban areas, while source control and gray stormwater infrastructure are often a good fit for industrial areas. Large-scale retention/detention/infiltration facilities are most often implemented in large open public spaces or in conjunction with large public redevelopment projects. Program development (see Appendix E to 431-TM1 [Herrera 2021a]) will consider the distinct characteristics of each Action in regard to targeting specific land use, land cover and property type for implementation, sequencing and funding, and creating partnerships with landowners and jurisdictional agencies.

Blue roofs, sand filters, source control (Creosote Wood Piling Removal), enhanced maintenance (Enhanced Street Sweeping), and restoration (Urban Tree Planting) Actions were identified in Phase 1 for possible future analysis, but have not yet been advanced to design (Table 1). The remainder of this memorandum focuses on GSI, stormwater retention/detention/infiltration, and gray stormwater infrastructure Actions, as summarized in Table 2.

## 2.2 Major Design Assumptions

Major assumptions related to design, siting, and cost estimating were developed based on local design manuals, design standards, manufacturer information, and recently constructed local project examples. In Phase 1, the major assumptions were collaboratively refined and agreed upon during two workshops with King County staff from relevant Department of Natural Resources and Parks (DNRP) programs conducted on May 6, 2020 and May 13, 2020. Design decisions were refined throughout Phase 2 as documented in the Decision Log in Attachment B.

In order to minimize re-work needed for Action cost estimating (Appendix D to 431-TM1 [HDR 2021]), the design assumptions were generally not modified in Phase 2. Instead, the contributing drainage areas were adjusted using explicit modeling in MGSFlood to meet the applicable design standard given the Phase 1 Action bottom footprint areas. This enabled the cost-performance relationship to be refined while using the Phase 1 cost estimates with minimal updates. See Section 4 for further detail on Phase 2 sizing methods and assumptions.

The design assumptions vary significantly among the many Actions; but the following major design assumptions were applied uniformly where applicable:

- All Actions were generally defined as off-line facilities, assuming a flow splitter or detention device will be installed upstream and that only flows up to the off-line water quality design flow rate will be routed to the Action.
- Long-term design native soil infiltration rates were assumed to be (COS 2017):
    - 0.3 inches per hour for till soils
    - 2.5 inches per hour for outwash soils
- Underdrains are included for some infiltration-based Actions (Bioretention and MFD) installed in till soils and some non-infiltration-based Actions (Bioretention Planter, High Rate Underground Filter System and Regional Vegetated Media Filtration Facility), sized as follows:
    - 8-inch-diameter, with the exception of High Rate Underground Filter System (4-inch-diameter) and Regional Vegetated Media Filtration Facility (12-inch-diameter)
    - Elevated underdrain (8-inch-diameter) for Bioretention on till soils provided to promote infiltration into underlying soils (see the Bioretention Fact Sheet in Attachment A)
- Underdrains are not included for Rain Gardens, Drywells, UIC Wells, Permeable Pavement, Infiltration Pond, or Infiltration Vault.
- Infiltration-based Actions installed in outwash soils do not include underdrains.

See Table 2 below for a more comprehensive list of Action definitions and major assumptions. Table 2 also provides additional information used for SUSTAIN modeling, including land uses managed, surface types managed, and property type. Note that the table is not all inclusive and there may be additional applications of the BMP types beyond what is listed in this table. This information is also summarized in the Fact Sheets (Attachment A).

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*Table 2 – Action Definitions, Benefits, and Major Assumptions.*

| Action | Definition | Benefits Provided | Land Uses Managed | Surface Types Managed | Property Type | Treatment Media |
|---|---|---|---|---|---|---|
| **Green Stormwater Infrastructure (GSI)** | | | | | | |
| Rain Garden | A shallow, landscaped depression with adapted plants, visually similar to bioretention but with compost-amended native soils and no underdrain. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas and to allow stormwater to pass through the amended soil profile. | Volume and Peak Flow Reduction, Water Quality Treatment | • Residential<br>• Commercial | • Roofs<br>• Lawns<br>• Driveways<br>• Sidewalks<br>• Parking Lots | • Private Parcel<br>• Public Parcel | • 3" compost tilled in to 8" depth |
| Bioretention Planter | Similar to bioretention, this Action includes a designed high-performance bioretention soil media (HPBSM) and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants. This Action varies from bioretention in that the sides are vertically contained by walls constructed from formed concrete. These designs are often used in highly-urbanized settings. For this analysis, the Action is assumed to have an underdrain and closed bottom. | Peak Flow Reduction, Water Quality Treatment | • Residential<br>• Commercial<br>• Industrial | • Roofs<br>• Driveways<br>• Parking Lots<br>• Sidewalks<br>• Plazas<br>• Local Roads<br>• Arterial Roads | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way | • 70% sand<br>• 20% coir<br>• 10% high carbon wood ash (biochar)<br>• No polishing layer required |
| Bioretention | Shallow earthen depressions with a designed high-performance bioretention soil media (HPBSM) and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system. | Volume and Peak Flow Reduction, Water Quality Treatment | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural | • Roofs<br>• Lawn<br>• Driveways<br>• Parking Lots<br>• Sidewalks<br>• Plazas<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way | • 70% sand<br>• 20% coir<br>• 10% high carbon wood ash (biochar)<br>• No polishing layer required |
| Bioswale | An open, gently sloped, vegetated channel designed for treatment of stormwater. Grass is most common vegetation, but wetland vegetation can be used if soil is saturated. These are designed to “filter” water as it is conveyed through a vegetated swale. While this Action may provide incidental infiltration, that is not the primary treatment mechanism. | Peak Flow Reduction, Water Quality Treatment | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural | • Parking Lots<br>• Arterial Roads<br>• Local Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way | N/A |

| Action | Definition | Benefits Provided | Land Uses Managed | Surface Types Managed | Property Type | Treatment Media |
|---|---|---|---|---|---|---|
| Media Filter Drain (MFD) | A linear flow-through stormwater treatment device that can be sited along roadway side slopes (conventional design) and medians, borrow ditches, or other linear depressions. Cut-slope applications may also be considered. MFDs have four basic components: a gravel no-vegetation zone, a vegetated filter strip, the MFD mix bed, and an optional gravel-filled underdrain trench or layer of crushed surfacing base course. Treated water is either infiltrated into the underlying soil or collected by an underdrain and discharged to the drainage system. | Volume and Peak Flow Reduction, Water Quality Treatment | • Highway<br>• Agricultural | • Arterial Roads<br>• Local Roads<br>• Highways | • Public Right-of-Way | • Mix of crushed rock, dolomite, gypsum, and perlite (see Table V-6.4, Volume V, Chapter 6 of the Ecology Manual) |
| Drywell | A gravel filled hole that conveys stormwater runoff into the soil matrix. | Volume and Peak Flow Reduction | • Residential<br>• Commercial<br>• Industrial<br>• Agricultural | • Roofs<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Lawns | • Private Parcel<br>• Public Parcel | N/A |
| Deep UIC Well | A well that extends below an upper confining layer and discharges into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below. This analysis assumes a water-well style UIC downstream of a pre-treatment Action. | Volume and Peak Flow Reduction | • Residential<br>• Commercial | • Roofs<br>• Sidewalks<br>• Lawns<br>• Local Roads<br>• Arterial Roads | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way | N/A |
| Permeable Pavement | Includes pervious concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material. Intended to allow passage of water through pavement. Provides water quality treatment when sand treatment layer is provided. | Volume and Peak Flow Reduction, Water Quality Treatment | • Residential<br>• Commercial | • Low Volume Residential Driveways<br>• Sidewalks<br>• Plazas<br>• Trails<br>• Pedestrian and Bike Paths<br>• Parking Lots | • Private Parcel<br>• Public Parcel | • Sand (Driveways)<br>• No Treatment (All other surface types) |
| Depaving (Removal of Impervious Surfaces) | Depaving, or removal of impervious surfaces down to bare soil. The area is amended with soil and planted with low lying ground cover. To allow continued site use, the area is retrofit with an alternative treatment (e.g., wheel strip driveways) per King County Surface Water Design Manual, "Reduced Impervious Surface Credit". | Volume and Peak Flow Reduction | • Residential<br>• Commercial<br>• Industrial | • Driveways<br>• Sidewalks<br>• Parking Lots | • Private Parcel<br>• Public Parcel | • 4” of well-decomposed compost tilled into broken up soil as deeply as possible (≤18”) |

| Action | Definition | Benefits Provided | Land Uses Managed | Surface Types Managed | Property Type | Treatment Media |
|---|---|---|---|---|---|---|
| Stormwater Treatment Wetland | Similar to a wetpond but also provides a shallow marsh area to allow the establishment of emergent wetland aquatic plants, which improves pollutant removal. | Peak Flow Reduction, Water Quality Treatment | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way | N/A |
| **Stormwater Retention/Detention/Infiltration** | | | | | | |
| Detention Vault | A box-shaped underground facility that provides temporary storage of stormwater runoff. The stored stormwater runoff is then released through a control structure at an attenuated rate. | Peak Flow Reduction | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Plazas<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way | N/A |
| Detention Pond | A surface basin that provides temporary storage of stormwater runoff. The stored stormwater runoff is then released through a control structure at an attenuated rate, allowing the basin to dry out between storm events. | Volume and Peak Flow Reduction | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way | N/A |

| Action | Definition | Benefits Provided | Land Uses Managed | Surface Types Managed | Property Type | Treatment Media |
|---|---|---|---|---|---|---|
| Infiltration Pond | A surface basin that temporarily stores stormwater runoff similar to a detention pond, but also provides infiltration. | Volume and Peak Flow Reduction | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way | N/A |
| Infiltration Vault | An open bottomed, box-shaped underground facility that stores stormwater runoff similar to detention vaults, but also provides infiltration via an open bottom. | Peak Flow Reduction | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Plazas<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way | N/A |
| Cistern | A tank designed to provide temporary storage and slow release of rooftop stormwater runoff. | Peak Flow Reduction | • Residential<br>• Commercial<br>• Industrial | • Roofs | • Private Parcel<br>• Public Parcel | N/A |
| **Gray Stormwater Treatment** | | | | | | |
| Wetpond | A constructed stormwater pond that retains a permanent pool of water ("wetpool"), at least during the wet season, for settling of particulate pollutants. | Peak Flow Reduction, Water Quality Treatment | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way | N/A |

| Action | Definition | Benefits Provided | Land Uses Managed | Surface Types Managed | Property Type | Treatment Media |
|---|---|---|---|---|---|---|
| Wetvault | An underground structure similar to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants. | Peak Flow Reduction, Water Quality Treatment | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Plazas<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way | N/A |
| High Rate Underground Filter System | An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in highly urbanized settings and may be proprietary. | Water Quality Treatment | • Commercial<br>• Industrial<br>• Highway | • Roofs<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Plazas<br>• Local Roads<br>• Arterial Roads | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way | Filterra ® (Proprietary) Media |
| Regional Vegetated Media Filtration Facility | A large-scale vegetated media filtration facility designed to treat stormwater runoff from a large drainage area. | Water Quality Treatment | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural<br>• Forest | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Plazas<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel | Filterra ® (Proprietary) Media |

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# 3 BASIS OF DESIGN

## 3.1 Design Manuals and References

### 3.1.1 Applicable Stormwater Design Manuals

For non-proprietary and standard Actions, designs were generally based on the 2016 *King County Surface Water Design Manual* (KCSWDM; DNR 2016) when that manual provided sufficient information to formulate the basis of design consistent with the assumptions for this project. The 2017 Seattle Stormwater Manual (SPU 2017) and the 2019 *Washington State Department of Ecology (Ecology) Stormwater Management Manual for Western Washington* (SWMMWW; Ecology 2019) were used for supplemental guidance when needed to support the basis of design, as summarized in Table 3.

### 3.1.2 Other Design Guidance and References

For proprietary or non-standard Action designs, the following additional references from manufacturers and recently constructed projects in the region were used to supplement the basis of design as follows:

- **High Rate Underground Filter System Installation:** Design was based on a standard 4’X4’ Contech Filterra® Bioscape External Bypass system (see Attachment B). These Actions were designed to meet requirements provided in Ecology’s General Use Level Designation (GULD) for Enhanced Treatment (see Attachment C). This system was used as the basis of design for this Action because of the relatively high approved infiltration rate for Enhanced Treatment (175 inches per hour), readily available design and cost information, and track record of successful installation on numerous local projects.
- **Regional Vegetated Media Filtration Facility Installation:** Design was based on the *Kitsap County Manchester Stormwater Retrofit Drainage Report* (*Manchester*; Parametrix 2014), which provides enhanced water quality treatment for approximately 73 acres of contributing drainage area. See Section 4.4 for discussion of how the basis of design for Manchester was applied to this project.
- **Deep Underground Injection Control (UIC) Wells:** Design was based on King County’s *Barton Basin Combined Sewer Overflow Project with Green Stormwater Infrastructure* (*Barton*; AESI 2013). *Barton* provides enhanced water quality treatment for approximately 200 acres of contributing drainage area, with a conservatively rounded average design discharge flow rate from the UICs into native soils of approximately 50 gallons per minute (0.111 cubic feet per second).

See Table 3 for a summary of the Basis of Design for each Action.

## 3.2 Design Standards

Phase 2 Actions were designed to meet Basic Water Quality Treatment, Enhanced Basic Water Quality Treatment, Modified Level 1 Flow Control, Level 2 Flow Control, or Peak Control Standards, as discussed further in this section and summarized in Table 3. Infiltration-based Actions that do not provide Basic Water Quality Treatment are preceded by pre-treatment facilities designed to provide at least 50% removal of solids (KCSWDM Section 6.5.1). For further information on pairing of pre-treatment facilities with Actions, see Section 4.5.

### 3.2.1 Basic Water Quality Treatment

The goal of Basic Water Quality Treatment is 80% removal of Total Suspended Solids (TSS) for flows or volumes up to and including the off-line water quality design flow rate or volume. As shown in Table 3, the following WQBE Actions are designated in the KCSWDM as Basic Water Quality Treatment Facilities (Section 6.1.1) and were designed in accordance with the KCSWDM:

- Bioswale (KCSWDM Section 6.3.1, Basic Bioswales)
- Wetpond (KCSWDM Section 6.4.1, Wetponds)
- Wetvault (KCSWDM Section 6.4.2, Wetvaults)
- Stormwater Treatment Wetland (KCSWDM Section 6.4.3, Stormwater Wetland)

While Permeable Pavement is not included in the KCSWDM Basic Water Quality Treatment Menu, Ecology recognizes Permeable Pavement as a basic treatment BMP if the design includes a 6" layer of sand that meets the size gradation (by weight) given in Table V-6.1: Sand Medium Specification of the SWMMWW.

This project proposes to use standard Permeable Pavements for low volume residential driveways, sidewalks, plazas, trails, and pedestrian and bike paths. For applications in pollution-generating areas (i.e. low volume residential driveways), the proposed design for Permeable Pavement includes a 6” layer of sand as required for water quality treatment (see Table 2). Although the Fact Sheets in Appendix A provide information for configurations with and without the sand layer, only the version with the sand layer was incorporated in the programs developed and evaluated by the project team (Herrera 2021a). Permeable pavement without a sand layer may be evaluated for flow control benefits in future phases of study (see Section 8: Summary and Recommended Next Steps).

Rain Gardens are not included in the KCSWDM Basic Water Quality Treatment Menu; however, for the purposes of this project, Rain Gardens are sized per *2017 Seattle Stormwater Manual* to meet Basic Water Quality Treatment (Volume 3, Table 5.19). See Section 4 for more information on sizing methodology.

### 3.2.2 Enhanced Basic Water Quality Treatment

The Enhanced Basic Water Quality menu (KCSWDM Section 6.1.2) is designed to achieve greater than 30% dissolved copper removal and greater than 60% dissolved zinc removal, in addition to Basic treatment (80% TSS removal) for flows up to and including the water quality design flow or volume (defined in Section 6.2.1 of the KCSWDM). The goal assumes that dissolved copper concentrations for untreated runoff are between 5 and 20 micrograms per liter (μg/L), and that dissolved zinc concentrations for untreated runoff are between 20 and 300 micrograms per liter (μg/L).

The High Rate Underground Filter System and Regional Vegetated Media Filtration Facility were designed to provide enhanced basic water quality treatment in accordance with the KCSWDM Section 6.7 (Proprietary Facility Designs).

The KCSWDM does not include Bioretention, Bioretention Planters, nor MFDs in the basic or enhanced basic water quality treatment menus. However, the SWMMWW (Figure III-1.1: Runoff Treatment BMP Selection Flow Chart) lists these Actions as enhanced water quality treatment facilities, and they were regarded as such for the purposes of this project.

For Bioretention and Bioretention planters, a specialized low phosphorus high-performance bioretention soil media (HPBSM) with 70% sand, 20% coir and 10% high carbon wood ash (biochar) is included for improved water quality treatment performance (Herrera 2020). Modified Level 1 Flow Control

The Level 1 Flow Control Standard is as follows (KCSWDM, Section 1.2.3.1):

> *Match the developed peak discharge rates to existing site conditions peak discharge rates for 2- and 10-year return periods.*

The standard was modified for this project to match developed peak discharge rates to the pre-developed forested site condition, rather than to the existing site condition. See the Decision Log in Attachment B for additional information.

This Modified Level 1 Flow Control Standard was evaluated for Cisterns and Drywells but was ultimately only used for Drywells in Phase 2. The standard was found to be impractical for Cisterns given their small size and orifice diameter limitations. Therefore, the Phase 1 Peak Control Standard was maintained for Cisterns in Phase 2 (Section 3.2.5).

### 3.2.3 Level 2 Flow Control

The Level 2 Flow Control Standard is as follows (DNR 2016, Section 1.2.3.1):

> *Match developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow. Also match developed peak discharge rates to predeveloped peak discharge rates for the 2- and 10-year return periods.*

A forested historic site condition was assumed for this project.

The following actions were sized based on the Level 2 Flow Control standard:

- Detention Pond (KCSWDM Section 5.1.1, Detention Ponds)
- Detention Vault (KCSWDM Section 5.1.3, Detention Vaults)
- Infiltration Pond (KCSWDM Section 5.2.2, Infiltration Ponds)
- Infiltration Vault (KCSWDM Section 5.2.4, Infiltration Vaults)

See Section 4.1 for a detailed summary of modeling methods used to size these Actions.

### 3.2.4 Peak Control Standard

In Phase 1, both Drywells and Cisterns were sized based on sizing factors provided in the *2017 Seattle Stormwater Manual* (*Seattle)* for the Peak Control Standard (Section 5.3.4 in the 2017 Seattle Stormwater Manual). The Peak Control Standard provides the following:

- The post-development peak flow with 4% annual probability (25-year recurrence flow) shall not exceed 0.4 cubic feet per second per acre; and
- The peak flow with a 50% annual probability (2-year recurrence flow) shall not exceed 0.15 cubic feet per second per acre).

Although the intention in Phase 2 was to explicitly model both Drywells and Cisterns in MGSFlood based on the Modified Level 1 Flow Control Standard (Section 3.2.3), preliminary modeling showed that the standard could not be reasonably met for Cisterns due to their small size and orifice diameter limitations. Therefore, the Phase 1 Peak Control Standard remained unchanged for Cisterns in Phase 2. No other Phase 2 Actions use this standard. See the Decision Log (Attachment B) for additional information.

#### 3.2.5 Other

Depaving was designed in accordance with the KCSWDM (Appendix C, Section C.2.9), with no associated numerical standard for water quality treatment or flow control. See the Fact Sheets in Attachment A for additional design information.

*Table 3 – Basis of Design.*

| Action | Basis of Design | Listed in KCSWDM Basic Water Quality Treatment Menu? (Y/N) | Applicable Treatment or Flow Control Standard | Pre-treatment Required for PGIS? (Y/N) |
|---|---|---|---|---|
| **Green Stormwater Infrastructure (GSI)** | | | | |
| Rain Garden [a] | 2017 Seattle SW Manual, "Rain Garden" (Volume 3, Section 5.4.5) | N | Basic Water Quality Treatment | N |
| Bioretention Planter [b] | 2017 Seattle SW Manual, "Non-Infiltrating Bioretention" (Volume 3, Section 5.8.2) | N | Enhanced Water Quality Treatment | N |
| Bioretention [b] | 2016 KCSWDM, "Bioretention 'Cell' or 'Swale'" (Appendix C, Section C.2.6) | N | Enhanced Water Quality Treatment | N |
| Bioswale | KCSWDM, "Basic Bioswales" (Section 6.3.1) | Y | Basic Water Quality Treatment | N |
| Media Filter Drains [b] | 2019 Ecology SMMWW, “Media Filter Drain” (Volume V, Chapter 6, BMP T8.40) | N | Enhanced Water Quality Treatment | N |
| Drywell [c] | 2017 Seattle SW Manual, “Drywells” (Volume 3, Section 5.4.3) | N | Modified Level 1 Flow Control | Y |
| Deep UIC Well [c] | 2019 Ecology SMMWW, “Deep UIC Wells” (Volume I, Chapter 4, Section I-4.15) | N | N/A | Y |
| Permeable Pavement [d] | 2016 KCSWDM, “Permeable Pavement” (Appendix C, Section C.2.7) | N | Basic Water Quality Treatment | N |
| Depaving (Removal of Impervious Surfaces) | 2016 KCSWDM, "Reduced Impervious Surface Credit" (Appendix C, Section C.2.9). | N | N/A | N |
| Stormwater Treatment Wetland | 2016 KCSWDM, "Stormwater Wetlands" (Chapter 6, Section 6.4.3) | Y | Basic Water Quality Treatment | N |

| Action | Basis of Design | Listed in KCSWDM Basic Water Quality Treatment Menu? (Y/N) | Applicable Treatment or Flow Control Standard | Pre-treatment Required for PGIS? (Y/N) |
|---|---|---|---|---|
| **Stormwater Retention/Detention/Infiltration** | | | | |
| Detention Vault | 2016 KCSWDM, "Detention Vaults" (Chapter 5, Section 5.1.3) | N | Level 2 Flow Control | N |
| Detention Pond | 2016 KCSWDM, "Detention Ponds" (Chapter 5, Section 5.1.1) | N | Level 2 Flow Control | N |
| Infiltration Pond [c] | 2016 KCSWDM, "Infiltration Ponds" (Chapter 5, Section 5.2.2) | N | Level 2 Flow Control | Y |
| Infiltration Vault [c] | 2016 KCSWDM, "Infiltration Vaults" (Chapter 5, Section 5.2.4) | N | Level 2 Flow Control | Y |
| Cistern | 2017 Seattle SW Manual, “Single-family Residential (SFR) Cisterns” (Volume 3, Section 5.5.2.5) | N | Peak Control Standard | N |
| **Gray Stormwater Treatment** | | | | |
| Wetpond | 2016 KCSWDM, "Wetponds - Basic and Large" (Chapter 6, Section 6.4.1) | Y | Basic Water Quality Treatment | N |
| Wetvault | 2016 KCSWDM, "Wetvaults" (Chapter 6, Section 6.4.2) | Y | Basic Water Quality Treatment | N |
| High Rate Underground Filter System | Filterra ® - Ecology GULD Approval for Enhanced Water Quality Treatment | Y | Enhanced Water Quality Treatment | N |
| Regional Vegetated Media Filtration Facility | Kitsap County Manchester Stormwater Retrofit Drainage Report (April 2014) | Y | Enhanced Water Quality Treatment | N |

**Abbreviations:**

| | |
|---|---|
| KCSWDM | 2016 King County Surface Water Design Manual |
| GULD | General Use Level Designation |
| N/A | Not Applicable |
| PGIS | Pollution-generating Impervious Surface |
| SMMWW | 2019 Stormwater Management Manual for Western Washington |
| SW | Stormwater |
| UIC | Underground Injection Control |

**Notes:**

a. Rain gardens are not included in the KCSWDM Basic Water Quality Treatment Menu; however, they were designed to provide basic water quality treatment in accordance with the 2017 Seattle Stormwater Manual (Volume 3, Table 5.19).
b. Bioretention planter, bioretention and media filter drain are not included in the KCSWDM Basic Water Quality Treatment Menu; however they were designed to provide enhanced water quality treatment in accordance with SWMMWW (Figure III 1.1: Runoff Treatment BMP Selection Flow Chart).
c. Drywell, deep UIC well, infiltration pond, and infiltration vault are paired with upstream pre-treatment Actions (see Section 4.5).
d. Permeable pavements are not included in the KCSWDM Basic Water Quality Treatment Menu; however, they were designed to include a 6” sand treatment layer to provide basic water quality treatment in accordance with the BMP T5.15 in the SWMMW when used in PGIS applications (low volume driveways).

# 4 ACTION SIZING METHODOLOGY

As discussed in Section 1.2, the following key refinements to Action sizing were implemented in Phase 2:

- Whereas Action sizing was based on simplified sizing factors in Phase 1, Phase 2 refined the sizing by use of explicit modeling in MGSFlood where applicable.
- Action design parameters (e.g., side slopes, ponding depths, freeboard depths, native soil infiltration rates, etc.) generally remained unchanged from Phase 1, since the design parameters had been thoroughly vetted and agreed upon in Phase 1.
- In order to minimize re-work needed for Action cost estimating, the Action bottom footprint areas remained unchanged from Phase 1 wherever possible. Thus, while holding the bottom footprint areas constant, the contributing drainage areas were adjusted in MGSFlood until the Action was demonstrated to meet the applicable performance standard.
- For some Actions, the Basis of Sizing was revised from Phase 1 to better align with King County standards (see Table 4).

In addition to MGSFlood modeling, a combination of resources, including KCSWDM sizing worksheets, sizing factors from the 2017 Seattle Stormwater Manual (City of Seattle 2017), manufacturer standard specifications, and available design information from recently constructed local projects, were used where available or appropriate, as shown in Table 4.

Columns 2 through 7 of Table 4 summarize how the Action bottom footprint areas and contributing drainage areas were developed in Phase 1. For additional documentation of Phase 1 evaluations, see the *Phase I Water Quality Action Development; Water Quality Benefits Evaluation* Technical Memorandum (RKI 2020). The last 3 columns in Table 4 (Columns 8 through 10) summarize how the drainage areas were refined in Phase 2 using explicit modeling in MGSFlood where applicable. These Phase 2 refinements are the result of the explicit modeling conducted and the updated methodology for sizing Actions with side slopes (Section 7).

The Phase 2 Refined Drainage Areas shown in Table 4 are based on modeling in MGSFlood using the Puget East 40-inch Mean Annual Precipitation (MAP) climate region unless otherwise noted in the table. See Section 5 for additional discussion of precipitation analysis conducted to determine the relationship between contributing drainage area and MAP. The analysis was needed to develop a more reliable understanding of how much contributing drainage area can be managed to the applicable performance standard as a function not only of Action type, but also climate, which varies considerably across the County. The drainage area versus MAP relationships (Section 5) will be used to support future phases of SUSTAIN modeling.

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*Table 4 – Basis of Unit Action Bottom Footprint Area and Drainage Area Sizing.*

| Action | Phase 1 – Determine Action Bottom Footprint Area | | | | | | Phase 2 – Refine Action Drainage Area | | |
|---|---|---|---|---|---|---|---|---|---|
| | Basis of Sizing Action Bottom Footprint Area | Max Ponding Depth / Max Flow Depth [a] (in) | Native Soil Infiltration Rate (in/hr) | Bottom Footprint Area Sizing Factor [b] | Drainage Area (SF) | Action Bottom Area Footprint (SF) | Basis of Sizing Refined Drainage Area | Refined Drainage Area (SF) [c] | Percent Drainage Area Change from Phase 1 (%) [d] |
| **Green Stormwater Infrastructure (GSI)** | | | | | | | | | |
| Rain Garden Installation – Till Soils | Sizing Factors (Table 5.19, Sloped sides), Water Quality Treatment Standard (COS 2017) | 6 | 0.3 | 4.7% | 532 | 25 | 2016 KCSWDM Basic Water Quality Treatment (MGSFlood) | 806 | 52% |
| Rain Garden Installation – Outwash Soils | Sizing Factors (Table 5.19, Sloped sides), Water Quality Treatment Standard (COS 2017) | 6 | 2.5 | 1.0% | 2,500 | 25 | 2016 KCSWDM Basic Water Quality Treatment (MGSFlood) | 2,844 | 14% |
| Bioretention Planter Installation | Sizing Factors (Table 5.45, Vertical sides), Water Quality Treatment Standard (COS 2017) | 6 | N/A | 1.3% | 1,923 | 25 | 2016 KCSWDM Basic Water Quality Treatment (MGSFlood) | 2,357 | 23% |
| Bioretention Installation -Till Soils | Sizing Factors (Table 5.20, Sloped sides), Water Quality Treatment Standard (COS 2017) | 6 | 0.3 | [0.0097 x Contributing Impervious Area] - 11.3 | 9,928 | 85 | 2016 KCSWDM Basic Water Quality Treatment (MGSFlood) | 12,148 | 22% |
| Bioretention Installation -Outwash Soils | Sizing Factors (Table 5.19, Sloped sides for Outwash), Water Quality Treatment Standard (COS 2017) | 6 | 2.5 | 1.0% | 8,500 | 85 | 2016 KCSWDM Basic Water Quality Treatment (MGSFlood) | 9,570 | 13% |
| Bioswale Installation | 2016 KCSWDM, "Basic Bioswales" (Section 6.3.1) | 4 | N/A | N/A | 43,560 | 200 | 2016 KCSWDM, "Basic Bioswales" (Section 6.3.1) | 27,878 | -36% |
| Media Filter Drains – Till Soils | 2019 SMMWW, Table V-6.5 | 0 | 0.3 | N/A | 2,000 | 200 | 2019 SMMWW, Table V-6.5 | 2,000 | 0% |
| Media Filter Drains – Outwash Soils | 2019 SMMWW, Table V-6.5 | 0 | 2.5 | N/A | 2,000 | 200 | 2019 SMMWW, Table V-6.5 | 2,000 | 0% |

| Action | Phase 1 – Determine Action Bottom Footprint Area | | | | | | Phase 2 – Refine Action Drainage Area | | |
|---|---|---|---|---|---|---|---|---|---|
| | Basis of Sizing Action Bottom Footprint Area | Max Ponding Depth / Max Flow Depth [a] (in) | Native Soil Infiltration Rate (in/hr) | Bottom Footprint Area Sizing Factor [b] | Drainage Area (SF) | Action Bottom Area Footprint (SF) | Basis of Sizing Refined Drainage Area | Refined Drainage Area (SF) [c] | Percent Drainage Area Change from Phase 1 (%) [d] |
| Drywell – Till Soils | Sizing Factors (Table 5.15, 6' Drywell Depth, 0.3 in/hr infiltration [extrapolated], Peak Control Standard) (COS 2017) | N/A | 0.3 | 7.6% | 171 | 13 | Modified Level 1 Flow Control (MGSFlood) | 261 | 53% |
| Drywell – Outwash Soils | Sizing Factors (Table 5.15, 6' Drywell Depth, 2.5 in/hr infiltration, Peak Control Standard) (COS 2017) | N/A | 2.5 | 3.9% | 333 | 13 | Modified Level 1 Flow Control (MGSFlood) | 780 | 134% |
| Deep UIC Well [e] | Barton (AESI 2013) | N/A | N/A | N/A | N/A | 42 | Barton (AESI 2013) | N/A | N/A |
| Permeable Pavement – Till Soils | 2016 KCSWDM, Permeable Pavement (Appendix C, Section C.2.7) | 0 | 0.3 | N/A | 200 | 200 | 2016 KCSWDM, Permeable Pavement (Appendix C, Section C.2.7) | 200 | 0% |
| Permeable Pavement– Outwash Soils | 2016 KCSWDM, Permeable Pavement (Appendix C, Section C.2.7) | 0 | 2.5 | N/A | 200 | 200 | 2016 KCSWDM, Permeable Pavement (Appendix C, Section C.2.7) | 200 | 0% |
| Depaving (Removal of Impervious Surfaces) | N/A | 0 | N/A | N/A | N/A | 100 | N/A | 100 | 0% |

| Action | Phase 1 – Determine Action Bottom Footprint Area | | | | | | Phase 2 – Refine Action Drainage Area | | |
|---|---|---|---|---|---|---|---|---|---|
| | Basis of Sizing Action Bottom Footprint Area | Max Ponding Depth / Max Flow Depth [a] (in) | Native Soil Infiltration Rate (in/hr) | Bottom Footprint Area Sizing Factor [b] | Drainage Area (SF) | Action Bottom Area Footprint (SF) | Basis of Sizing Refined Drainage Area | Refined Drainage Area (SF) [c] | Percent Drainage Area Change from Phase 1 (%) [d] |
| Stormwater Treatment Wetland | 2016 KCSWDM, "Stormwater Wetlands - Basic and Large" (Chapter 6, Section 6.4.3), Sized as Basic facility | 48 | N/A | N/A | 43,560 | 503 | 2016 KCSWDM, "Stormwater Wetlands - Basic and Large" (Chapter 6, Section 6.4.3), Sized as Basic facility | 62,988 | 45% |
| **Stormwater Retention/Detention/Infiltration** | | | | | | | | | |
| Detention Vault | 2016 KCSWDM, Level 2 Flow Control (WWHM) | 72 | N/A | N/A | 43,560 | 2,592 | 2016 KCSWDM, Level 2 Flow Control (MGSFlood) | 28,658 | -34% |
| Detention Pond | 2016 KCSWDM, Level 2 Flow Control (WWHM) | 48 | N/A | N/A | 43,560 | 4,500 | 2016 KCSWDM, Level 2 Flow Control (MGSFlood) | 36,569 | -16% |
| Infiltration Pond – Till Soils | 2016 KCSWDM, Level 2 Flow Control (WWHM) | 48 | 0.3 | N/A | 43,560 | 2,785 | 2016 KCSWDM, Level 2 Flow Control (MGSFlood) | 36,595 | -16% |
| Infiltration Pond – Outwash Soils | 2016 KCSWDM, Level 2 Flow Control (WWHM) | 48 | 2.5 | N/A | 43,560 | 1,479 | 2016 KCSWDM, Level 2 Flow Control (MGSFlood) | 46,396 | 7% |
| Infiltration Vault – Till Soils | 2016 KCSWDM, Level 2 Flow Control (WWHM) | 72 | 0.3 | N/A | 43,560 | 1,836 | 2016 KCSWDM, Level 2 Flow Control (MGSFlood) | 28,719 | -34% |
| Infiltration Vault – Outwash Soils | 2016 KCSWDM, Level 2 Flow Control (WWHM) | 72 | 2.5 | N/A | 43,560 | 1,156 | 2016 KCSWDM, Level 2 Flow Control (MGSFlood) | 39,365 | -10% |

| Action | Phase 1 – Determine Action Bottom Footprint Area | | | | | | Phase 2 – Refine Action Drainage Area | | |
|---|---|---|---|---|---|---|---|---|---|
| | Basis of Sizing Action Bottom Footprint Area | Max Ponding Depth / Max Flow Depth [a] (in) | Native Soil Infiltration Rate (in/hr) | Bottom Footprint Area Sizing Factor [b] | Drainage Area (SF) | Action Bottom Area Footprint (SF) | Basis of Sizing Refined Drainage Area | Refined Drainage Area (SF) [c] | Percent Drainage Area Change from Phase 1 (%) [d] |
| Cistern | 2017 Seattle SW Manual Sizing Factors for SFR cisterns (Table 5.31, COS 2017) | 60 | N/A | 1.4% | 1,300 | 18 | 2017 Seattle SW Manual Sizing Factors for SFR cisterns (Table 5.31, COS 2017) | 1,300 | 0% |
| **Gray Stormwater Treatment** | | | | | | | | | |
| Wetpond | 2016 KCSWDM, "Wetponds - Basic and Large" (Chapter 6, Section 6.4.1), Sized as Basic facility | 48 | N/A | N/A | 43,560 | 553 | 2016 KCSWDM, "Wetponds - Basic and Large" (Chapter 6, Section 6.4.1), Sized as Basic facility | 63,075 | 45% |
| Wetvault | 2016 KCSWDM, "Wetvaults" (Chapter 6, Section 6.4.2) | 48 | N/A | N/A | 43,560 | 1,615 | 2016 KCSWDM, "Wetvaults" (Chapter 6, Section 6.4.2) | 63,010 | 45% |
| High Rate Underground Filter System | Filterra ® - Ecology GULD Approval for Enhanced Water Quality Treatment | 2 | N/A | N/A | 30,492 | 16 | Filterra ® - Ecology GULD Approval for Enhanced Water Quality Treatment | 34,956 | 15% |
| Regional Vegetated Media Filtration Facility | Kitsap County Manchester Stormwater Retrofit Drainage Report (April 2014) | 8.4 | N/A | N/A | 17,249,760 | 5,940 | Kitsap County Manchester Stormwater Retrofit Drainage Report (April 2014) | 17,249,760 | 0% |

**Abbreviations:**

| | |
|---|---|
| H:V | Horizontal:Vertical |
| hr | hour |
| in | inches |
| KCSWDM | 2016 King County Surface Water Design Manual |
| N/A | Not Applicable |
| SF | square feet |
| SFR | Single Family Residential |
| SMMWW | 2019 Stormwater Management Manual of Western Washington |
| SW | Stormwater |

**Notes:**

a. Max Ponding Depth applies to all Actions other than Bioswale, for which Max Flow Depth applies. Bioswales are not designed for ponding.
b. Sizing factors used in Phase 1 were from the 2017 City of Seattle Stormwater Manual (COS 2017).
c. Refined Drainage Areas are based on modeling in MGSFlood using the Puget East 40 inch Mean Annual Precipitation climate region. See additional discussion of precipitation analysis in Section 5.
d. Percent Drainage Area Change for bioswale reports a negative value due to iterations required to provide sizing for 40-inch Mean Annual Precipitation (see Attachment H). Negative values are reported for Actions sized to the Level 2 Flow Control Standard due to 100% impervious area assumption in Phase 2, versus 30% pervious and 70% impervious drainage area assumption in Phase 1 (Section 4.1).
e. Deep UIC wells have a maximum contributing flow rate of 0.111 cubic feet per second.

## 4.1 Long-term Continuous Hydrologic Modeling

Action sizing was primarily conducted through long-term continuous hydrologic modeling in MGSFlood where applicable (Table 4). Although the Western Washington Hydrology Model Version 12 (WWHM) was used in Phase 1 (RKI 2020), MGSFlood was used in Phase 2 because MGSFlood runs much faster and hundreds of model runs were needed in a short time frame for this analysis.

As discussed in Section 4, the modeling methodology entailed adjusting the Action drainage area to maintain consistency with Phase 1 unit Action dimensions and cost estimates.

The following key assumptions and methods were used for long-term continuous hydrologic modeling in MGSFlood:

- **Level 2 Flow Control Actions (Infiltration Ponds, Infiltration Vaults, Detention Ponds and Detention Vaults):** Level 2 Flow Control Actions were sized in Phase 1 based on a 10-acre drainage area consisting of 30% pervious and 70% impervious land use based on King County Department of Natural Resources and Parks *Development of a Stormwater Retrofit Plan for Water Resources Inventory Area 9: SUSTAIN Modeling Report* [WRIA 9; WLRD]). The resulting modeled footprint was scaled down by a factor of 10 to obtain a Unit Action Footprint for a drainage area of one acre.

  In Phase 2, a similar approach was used, but in order to maintain land use consistency between MGSFlood and SUSTAIN models, the 10-acre drainage area was modeled as 100% impervious. This resulted in Level 2 Flow Control facilities having a smaller contributing drainage area when compared with Phase 1 (see Column 10 in Table 4).

  MGSFlood was used to solve for the refined contributing drainage area that can be managed to the applicable standard for the given Phase 1 Action bottom footprint area. Both the Phase 1 Action bottom footprint areas and the Phase 2 refined contributing drainage areas were then scaled down by a factor of 10. See additional discussion of the decision to update to 100% impervious drainage areas for Level 2 Flow Control sizing in the Decision Log (Attachment B).

- **Drywells:** Drywells were designed as cylindrical facilities with infiltration through the bottom and half of the sidewall depth. In order to model the Drywells in MGSFlood, which does not provide for a cylindrical facility geometry, they were represented as rectangular facilities with equivalent total storage volume and wetted infiltration area as the cylindrical design.

- **Actions with Side Slopes (Rain Garden, Bioretention, Infiltration Ponds, and Detention Ponds):** Actions with side slopes modeled in MGSFlood were assumed to have side slopes along the longitudinal sides of the facilities, but vertical sides for the shorter fronts and backs of the facilities. This was done to prevent overestimating excavation and material import costs when such facilities are aggregated, or daisy-chained along their length, when modeled at the subbasin scale in SUSTAIN.

See additional discussion in the Decision Log (Attachment B). See also Attachment E for the modeling assumptions, Attachment F for MGSFlood model output reports for applicable Actions, and Appendix G for additional model outputs needed to support SUSTAIN modeling.

## 4.2 Sizing Factors

Sizing factors from the 2017 Seattle Stormwater Manual (COS 2017) were used for Cisterns only (see Table 4).

## 4.3 King County Surface Water Design Manual Sizing Worksheets

The King County Surface Water Design Manual (KCSWDM) Water Quality Facility Sizing Worksheets provided in Reference 8-C of the KCSWDM were used to size the following four (4) Actions:

1. Bioswale
2. Stormwater Treatment Wetland
3. Wetpond
4. Wetvault

See Section 5 for discussion of the precipitation analysis performed to develop rainfall inputs to the Worksheets. MAP values of 32-inch, 40-inch, and 60-inch were used in the analysis to represent the range of low, medium and high rainfall regions across lowland King County.

In order to size Bioswales, an off-line water quality design flow rate was modeled in MGSFlood for an impervious surface drainage area of 0.64 acres, resulting in a modeled off-line water quality design flow rate of 0.052 cubic feet per second. This off-line water quality design flow rate was used as input in the Worksheet.

Water quality design flow rates were also developed in MGSFlood for Wetponds, Wetvaults, and Stormwater Treatment Wetlands because they are needed as input for future modeling in SUSTAIN. This flow rate is used to determine what surface runoff gets into the facility and what bypasses the facility. The percent removal and irreducible concentration is applied to the runoff that gets into the facility and discharges through the orifice. See Attachment G for additional information.

The off-line water quality design flow rates for Wetponds, Wetvaults, and Stormwater Treatment Wetlands were modeled for an impervious surface drainage area of 1.44 acres, resulting in a modeled off-line water quality design flow rate of 0.118 cubic feet per second. See Attachment H for detailed calculations for these Actions. Off-line water quality design flow rates for SUSTAIN modeling are reported in Attachment G.

## 4.4 Manufacturer Information and Recently Installed Projects

Sizing for Deep UIC Well, High Rate Underground Filter System, and Regional Vegetated Media Filtration Facility was based on manufacturer information and available design information from recently constructed, local projects, as summarized in Table 4 and described below:

- **High Rate Underground Filter System Installation:** Sizing is based on a 4’X4’ Contech Filterra ® Bioscape External Bypass system (see Attachment C), designed to provide enhanced water quality treatment per Ecology’s February 2020 General Use Level Designation (GULD) requirements (see Attachment D) for a 0.7-acre contributing drainage area, with a maximum unit treatment capacity of 0.065 cfs (per the manufacturer, see Attachment H). The current GULD-approved infiltration rate of 175 inches/hour was used for design.
- **Regional Vegetated Media Filtration Facility Installation:** Sizing is based on Kitsap County’s Manchester Stormwater Park, which was based on an earlier (2014) GULD-approved infiltration rate of 24.8 inches/hour for Contech Filterra ® media (Parametrix 2014). For Phase 1 and Phase 2 of this project, the facility footprint size was maintained the same as for the Manchester Stormwater Park design (5,940 square feet), but the 73-acre contributing drainage area for Manchester was scaled up by a factor of 7.06, calculated as the ratio of current to previous GULD-approved infiltration rates (175 in/hr /

24.8 in/hr). A conservative factor of safety of 1.3 was then applied for a unit drainage area of 396 acres (73 x 7.06 / 1.3 = 396). The factor of safety is conservative, assuming relatively high contributions from transportation and commercial areas with heavy sediment loading.

- **Deep UIC Well Installation:** Sizing is based on King County's Barton CSO Control project. A maximum flow rate from the UIC well to the surrounding soil of 50 gallons per minute (0.111 cubic feet per second) was used for this project based on the average flow rate measured by infiltration testing for *Barton*. The design configuration is as follows (AESI 2013):
    - Drilling and casing of 12-inch diameter borehole
    - 20-foot long 8-inch diameter pipe-sized well screen with filter pack
    - 5-foot deep stainless-steel well sump containing energy-dissipation rock, allowing water to drain out of well
    - Sand filter pack around well screen and sump, extending 8 feet above the top of the well screen
    - Maintenance hole over wellhead to convey treated stormwater into the well
    - Maximum well depth of 100 feet to accommodate future removal of sediment by Vactor equipment
    - Underdrain manhole to provide for additional sediment removal

## 4.5 Pre-treatment Sizing

The following Actions are composed of a primary Action (Drywells, Deep UIC Well, Infiltration Pond, Infiltration Vault) and an upstream pre-treatment Action (Bioretention Planter or High Rate Underground Filter System):

1. Drywell with pre-treatment via bioretention planter
2. Deep UIC well with pre-treatment via bioretention planter
3. Deep UIC well with high rate underground filter system as pre-treatment
4. Infiltration pond with high rate underground filter system as pre-treatment
5. Infiltration vault with high rate underground filter system as pre-treatment

The primary Actions are sized according to Table 4, while the upstream pre-treatment Actions are sized according to Table 5. In Phase 1, the upstream pre-treatment Actions were sized based on simplified sizing factors. In Phase 2, the pre-treatment Actions, similar to the primary Actions, were re-sized based on explicit modeling in MGSFlood. Note that primary Action sizing is independent of pre-treatment Action sizing (e.g., the primary Action size is not reduced as a result of the upstream pre-treatment Action sizing).

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*Table 5 – Basis of Sizing for Treatment Trains*

| Action | Pre-treatment Action | Pre-treatment Sizing | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Phase 1 | | | | | Phase 2 | | | |
| | | Pre-treatment Action Size (SF) | Drainage Area (SF) | Basis of Drainage Area | Basis of Pre-treatment Action Size | Notes | Refined Drainage Area (SF) [a] | Basis of Drainage Area | Basis of Pre-treatment Action Size | Percent Drainage Area Change (%) |
| Drywell – Outwash Soils | Bioretention Planter | 4.3 | 333 | Unit Drainage Area for "Drywell – Outwash Soils" from Table 4 | 1.3% Sizing Factor for Water Quality Treatment Standard (2017 Seattle Stormwater Manual, Table 5.45: Non-infiltrating Bioretention with Vertical Sides) | | 396 | Enhanced Water Quality Treatment Standard | Phase 1 Action Size | 19% |
| Deep UIC Well | Bioretention Planter | 579 | 44,550 | Effective impervious area for one residential block based on GSI Program Block Template BL-18 | 11.3% Sizing Factor for Water Quality Treatment Standard (2017 Seattle Stormwater Manual, Table 5.45: Non-infiltrating Bioretention with Vertical Sides) | For costing purposes rounded to 570 SF (i.e. six 5 ft x 19 ft planters). Assumes UIC well can infiltrate all treated flow (design flow rate of approximately 35 gpm). | 54,546 | Enhanced Water Quality Treatment Standard | Phase 1 Action Size | 22% |
| Deep UIC Well | High Rate Underground Filter System | 24 | 44,550 | Effective impervious area for one residential block based on GSI Program Block Template BL-18 | Sized to provide enhanced water quality treatment per Ecology's February 2020 General Use Level Designation (GULD) requirements. | Required size is 23 SF. Rounded up to next standard unit size. Assumes UIC well can infiltrate all treated flow (design flow rate of approximately 44 gpm). | 52,164 | Sized to provide enhanced water quality treatment per Ecology's February 2020 General Use Level Designation (GULD) requirements. | Phase 1 Action Size | 17% |
| Infiltration Pond – Outwash Soils | High Rate Underground Filter System | 24 | 43,560 | Unit Drainage Area for the "Infiltration Pond – Outwash Soils" Action from Table 4 | Sized to provide enhanced water quality treatment per Ecology's February 2020 General Use Level Designation (GULD) requirements. | Required size is 22.4 SF. Rounded up to next standard unit size. | 52,164 | Sized to provide enhanced water quality treatment per Ecology's February 2020 General Use Level Designation (GULD) requirements. | Phase 1 Action Size | 20% |
| Infiltration Vault – Outwash Soils | High Rate Underground Filter System | 24 | 43,560 | Unit Drainage Area for the "Infiltration Vault – Outwash Soils" Action from Table 4 | Sized to provide enhanced water quality treatment per Ecology's February 2020 General Use Level Designation (GULD) requirements. | Required size is 22.4 SF. Rounded up to next standard unit size. | 52,164 | Sized to provide enhanced water quality treatment per Ecology's February 2020 General Use Level Designation (GULD) requirements. | Phase 1 Action Size | 20% |

**Abbreviations:**
gpm gallons per minute
ft feet
MAP Mean Annual Precipitation
SF square feet

**Notes:**
a. Refined drainage areas in Phase 2 are based on modeling in MGSFlood for the Puget East 40-inch MAP climate region (see Section 5).

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# 5 PRECIPITATION ANALYSIS

Phase 2 entailed development of regression equations to relate MAP to contributing drainage area for each Action. These relationships, developed primarily through modeling in MGSFlood, are needed to improve the SUSTAIN model's representation of Action performance across the highly variable climate conditions of the King County lowlands.

To develop these relationships, three (3) MGSFlood climate regions were selected to represent Low, Medium, and High MAP, as follows:

- **Low:** Puget East 32-inch MAP
- **Medium:** Puget East 40-inch MAP
- **High:** Puget East 60-inch MAP

These values were used to develop relationships for KCSWDM Worksheet calculations and MGSFlood modeling as described below.

## 5.1 Scaling in KCSWDM Worksheets

Stormwater Treatment Wetlands, Wetponds, and Wetvaults, sized using KCSWDM worksheets, use a precipitation design value based on the 6-month, 24-hour storm event, estimated as 72% of the 2-year, 24-hour storm event. Storm event input values were calculated by selecting 2-year, 24-hour precipitation values in locations corresponding to the Low, Medium, and High MAP regions, then multiplying those values by 0.72. Figure 1 and Table 6 show the resulting Precipitation Design Values used to scale these Actions.

***Table 6 – Precipitation Design Values for Actions Sized with KCSWDM Worksheets***

| MAP Category | MGSFlood Climate Region | 2-Year, 24-Hour Precipitation | Precipitation Design Value [a] |
|---|---|---|---|
| Low | Puget East 32 in MAP | 1.6 inch | 1.15 inch |
| Medium | Puget East 40 in MAP | 2.0 inch | 1.44 inch |
| High | Puget East 60 in MAP | 3.0 inch | 2.16 inch |

**Note:**
a 72% of the 2-year, 24-hour storm event is used as a precipitation design value for scaling stormwater treatment wetlands, wetponds, and wetvaults (Attachment H).

## 5.2 Scaling in MGSFlood

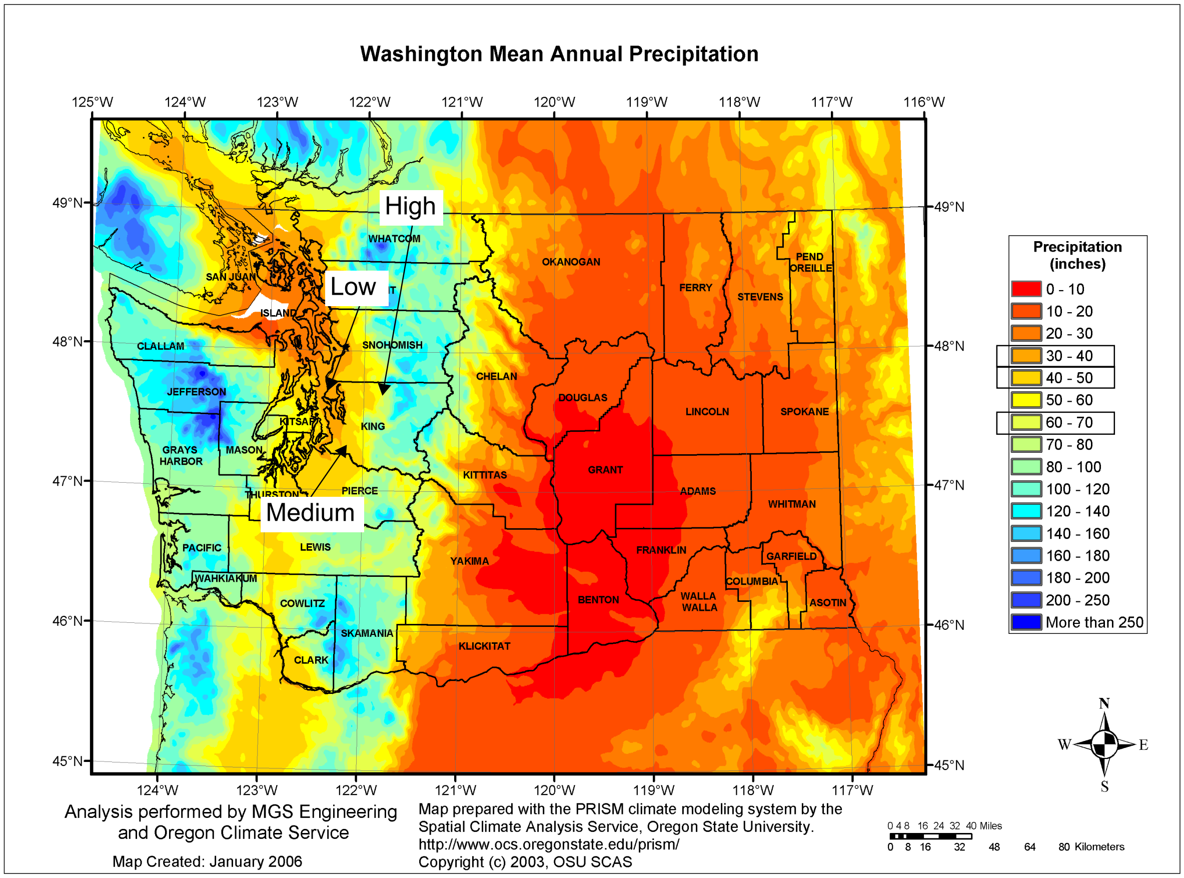
For those Actions that were sized in MGSFlood (Section 4.1), the Actions were first sized for the Medium MAP as described in Section 4 and Attachments A, E, and F. The same process was then repeated to size the Actions for the Low and High MAP in MGSFlood. The resulting three (3) data points for Low, Medium, and High MAP were then used to define polynomial-type expressions (for non-infiltration-based Actions, including Detention Pond and Detention Vault) and power-type expressions (for all other Actions) to illustrate the modeled relationship between MAP and contributing drainage area. These relationships are summarized in Table 7 and shown graphically in Attachment I, with resulting $R^2$ values range between 0.9805 and 1.

As shown in Attachment I, the polynomial-type expressions for Detention Pond and Detention Vault represent concave curves, indicating that increased drainage area can be managed to the applicable standard for increasing MAP between roughly 32 inches per year and 50 inches per year and that decreasing drainage area can be managed to the applicable standard for MAP between roughly 50 inches per year and 60 inches per year. As discussed further in Section 9 (Summary and Recommended Next Steps), these polynomial relationships for Detention Pond and Detention Vault may warrant additional evaluation to verify the type and shape of the resulting expression.

MGSFlood was also used to compute the off-line water quality design flow rates for the Low, Medium, and High MAP as needed for sizing Bioswales, High Rate Underground Filter Systems, and Regional Vegetation Media Filtration Systems.

***Table 7 – Power and Polynomial Expressions Relating Drainage Area to Mean Annual Precipitation.***

| Action | A | B | C | $R^2$ |
|---|---|---|---|---|
| **$y = A*x^B$ (y = Drainage Area in Acres, x = Mean Annual Precipitation in Inches)** | | | | |
| Rain Garden Installation – Till Soils | 0.5723 | -0.932 | N/A | 0.9998 |
| Rain Garden Installation – Outwash Soils | 1.3219 | -0.815 | N/A | 1 |
| Bioretention Planter Installation | 1.0464 | -0.803 | N/A | 1 |
| Bioretention Installation -Till Soils | 5.6493 | -0.816 | N/A | 1 |
| Bioretention Installation – Outwash Soils | 4.4451 | -0.816 | N/A | 1 |
| Bioswale Installation | 15.086 | -0.856 | N/A | 0.9998 |
| Drywell – Till Soils | 0.1222 | -0.817 | N/A | 1 |
| Drywell – Outwash Soils | 0.1268 | -0.529 | N/A | 0.9984 |
| Stormwater Treatment Wetland | 100.87 | -1.149 | N/A | 0.9970 |
| Infiltration Pond – Till Soils | 26.351 | -0.936 | N/A | 0.9994 |
| Infiltration Pond – Outwash Soils | 11.515 | -0.653 | N/A | 0.9863 |
| Infiltration Vault – Till Soils | 21.961 | -0.954 | N/A | 0.9988 |
| Infiltration Vault – Outwash Soils | 9.906 | -0.658 | N/A | 0.9805 |
| Wetpond | 101.23 | -1.149 | N/A | 0.9997 |
| Wetvault | 101.12 | -1.149 | N/A | 0.9997 |
| High Rate Underground Filter System | 18.147 | -0.845 | N/A | 1 |
| Regional Vegetated Media Filtration Facility | 11157 | -0.906 | N/A | 0.9999 |
| Drywell with Pre-treatment via Bioretention Planter | 0.1727 | -0.797 | N/A | 1 |
| Deep UIC Well with Pre-treatment via Bioretention Planter | 23.956 | -0.800 | N/A | 1 |
| Deep UIC Well with Pre-treatment via High Rate Underground Filter System | 27.081 | -0.845 | N/A | 1 |
| Infiltration pond with Pre-treatment via High rate Underground Filter System | 27.081 | -0.845 | N/A | 1 |
| Infiltration Vault with Pre-treatment via High Rate Underground Filter System | 27.081 | -0.845 | N/A | 1 |
| **$y = A*x^2 + B*x + C$ (y = Drainage Area in Acres, x = Mean Annual Precipitation in Inches)** | | | | |
| Detention Vault | -0.0012 | 0.115 | -2.0716 | 1 |
| Detention Pond | -0.0147 | 1.451 | -26.105 | 1 |



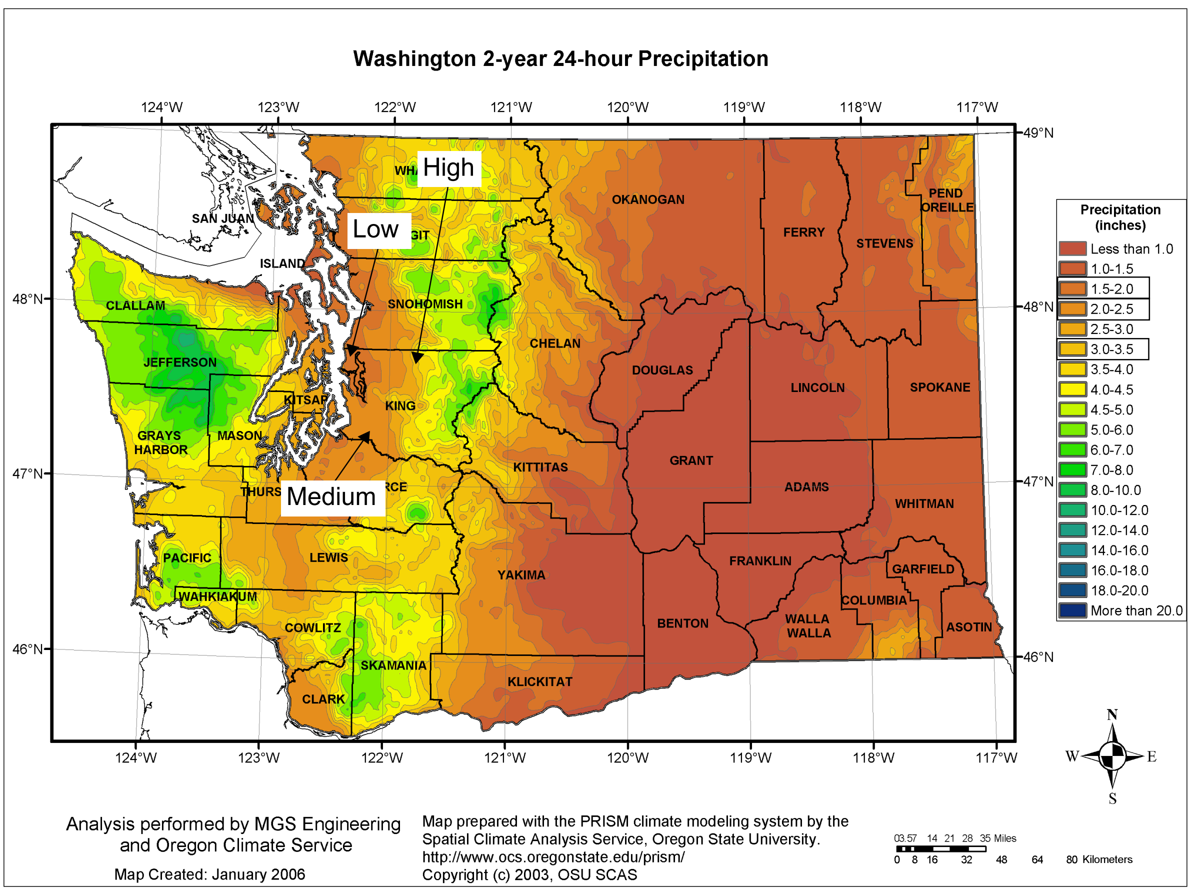




**Figure 1 - Mean Annual Precipitation and 2-Year 24-Hour Precipitation, Washington State**

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# 6 ACTION FACT SHEET DEVELOPMENT

Action Fact Sheets were developed for 19 of the 24 water quality Actions identified in Phase 1 (see Table 1). These Fact Sheets were then refined in Phase 2 (see Attachment A) based on updated parameters and methodologies as discussed in this technical memo. The Fact Sheets provide a consistent template to document the design, SUSTAIN modeling methodology and inputs, performance parameters, unit cost assumptions, and programmatic feasibility and siting considerations.

Each Action Fact Sheet is 2-pages-long and organized as follows:

- Page 1:
  - Action Description
  - Drainage Areas
  - Unit Action Schematic
  - Design Parameters
  - Design Assumptions
- Page 2:
  - SUSTAIN Model Representation
  - Performance Parameters
  - Unit Action Costs
  - Programmatic Feasibility/Siting Considerations

See Attachment J for an annotated Fact Sheet summarizing key components of the Fact Sheets.

# 7 DESIGN CONFIGURATION, PERFORMANCE, AND COST PARAMETERS

See the Fact Sheets in Attachment A and Table 9 for the updated Phase 2 design parameters. Note that the values reported in both the table and attachment represent the Medium MAP (Section 5).

## 7.1 SUSTAIN Model Geometry

SUSTAIN does not account for side slope geometry nor infiltration through the sides of facilities. To overcome this in Phase 1, the SUSTAIN modeling used revised geometry that approximated Actions with side slopes (i.e., “Design Configuration”) as Actions with vertical side slopes (i.e., “Transformed Configuration for SUSTAIN Modeling”). The bottom width of the rectangular section was estimated in Phase 1 as the average of the bottom width and the ponded width. See *Phase I Water Quality Action Development: Water Quality Benefits Evaluation* (RKI 2020) for additional detail.

In Phase 2, the Transformed Configuration for SUSTAIN Modeling was refined to better emulate the performance in MGSFlood. The Basis of Sizing and the basis for the Transformed Configuration are detailed in Table 4. The Transformed Configurations for SUSTAIN Modeling were developed using the following five (5) steps (see a schematic diagram of this SUSTAIN Input Transformation method in Figure 2):

- **Step 1:** Adjust the drainage area for the Design Configuration to meet the applicable performance standard (see Table 4).

- **Step 2:** For infiltration-based Actions, calculate the Design Configuration infiltration wetted perimeter (i.e., in cross-sectional view, the perimeter of the Action where infiltration can occur).
- **Step 3:** Calculate the Design Configuration storage area (i.e., in cross-sectional view, the area below the maximum ponded water depth, including the void area within the bioretention or non-engineered soil layer where water can be stored).
- **Step 4:** Hold the Design Configuration bottom length (and ponding depth for non-infiltrating Actions) and the resulting drainage area constant, while adjusting the following:
    - Adjust the side slopes to vertical;
    - For infiltrating Actions with side slopes, adjust the bottom width to match the infiltration wetted perimeter from Step 2.
    - For non-infiltrating Actions with side slopes, adjust the bottom width to match the storage area from Step 3; and
    - Adjust the ponding depth to match total volume from Phase 1 (for infiltration Actions only).
- **Step 5:** Make final adjustments to the Action's bottom width to meet the applicable performance standard to develop the Transformed Configuration for SUSTAIN Modeling.

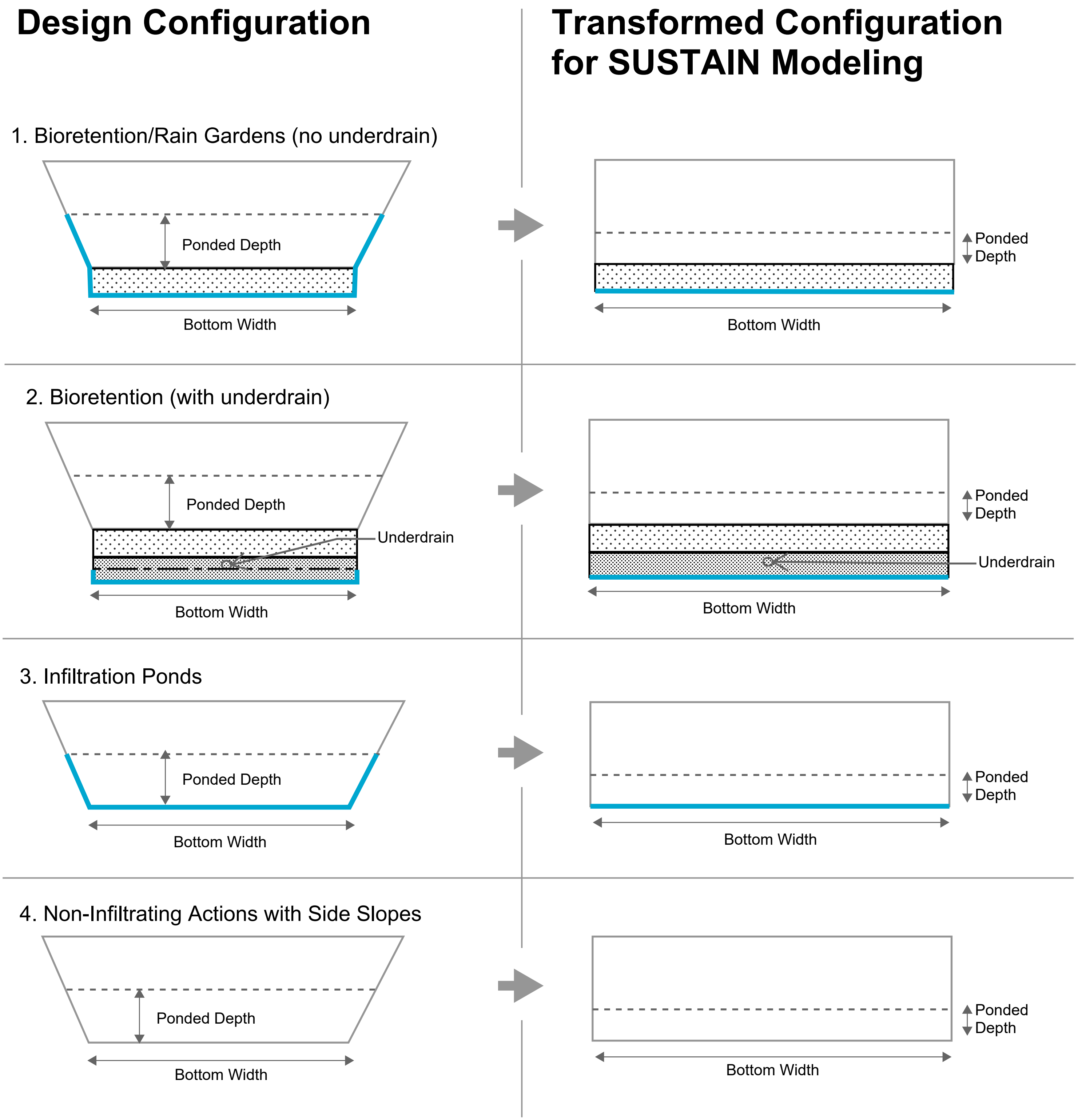
Prior to use on all applicable Actions, the method was first tested for Bioretention on till soils (with an elevated underdrain) and Bioretention on outwash soils (with no underdrain), as summarized in Table 8.

***Table 8 – Preliminary Model Results, SUSTAIN Versus MGSFlood***

| Parameter | MGSFlood Modeling of Transformed Configuration | SUSTAIN Modeling of Transformed Configuration |
|---|---|---|
| Simulation Period | 1936 – 2097 (158 Years) | 2009 – 2019 (20 Years) |
| Mean Annual Precipitation | 40-inch | 40-inch |
| Percent Captured/Percent Treated, Bioretention on Till Soils | 91.05% | 91.39% |
| Percent Captured/Percent Treated, Bioretention on Outwash Soils | 91.01% | 91.79% |

Though SUSTAIN and MGSFlood use different precipitation data (including different periods of record), MGSFlood's 158-year time series is a composite of three different monitoring stations that have been proven to be statistically independent, but with comparable distribution; thus roughly each third of the 158 years are repeating similar climate conditions. Consequently, the longer MGSFlood simulation period is considered comparable to the shorter SUSTAIN model simulation period for purposes of this evaluation.

The preliminary model results in Table 8 show that the facility sized using MGSFlood modeling performed as expected when modeled in SUSTAIN (i.e., the Transformed Configuration modeled in SUSTAIN resulted in 91% treated). Based on these results, all Actions with side slopes were transformed using this same method. See the Decision Log in Attachment B. Dimensions for Transformed Configurations for SUSTAIN modeling are provided in Attachment G.




**Notes:**

1. For Actions with infiltration (1-3), bottom width and ponded depth values were adjusted to maintain equivalent infiltration wetted perimeter and storage area.
2. For non-infiltrating Actions with side slopes (4), bottom width was adjusted to maintain equivalent storage area only.

**Legend:**

- Infiltration Wetted Perimeter
- Max Ponding Elevation
- Underdrain Invert Elevation
- Bioretention Soil Mix
- Underdrain Aggregate Layer

**Figure 2 - SUSTAIN Input Transformation Schematic**

## 7.2 Performance Parameters

The performance parameters on page 2 of each Action Fact Sheet (Attachment A) summarize the median percent removal and median effluent concentrations for several target pollutants that are analyzed in the SUSTAIN model. The target pollutants include:

- Total Copper
- Dissolved Copper
- Total Zinc
- Dissolved Zinc
- Total Phosphorus
- Total Nitrogen
- Total Suspended Solids
- Total PCBs
- Total PBDEs
- Total PAHs
- Bis(2-ethylhexyl)phthalate
- Fecal Coliform

The data sources that were used to identify the performance parameters for each Action and pollutant combination are documented in Appendix C to 431-TM1 (Herrera 2021b).

## 7.3 Cost Parameters

Unit Action Costs (provided on Page 2 of the Action Fact Sheets, Attachment A) are broken down by Total Project cost, including Total Direct Construction, Total Indirect Non-Construction, and Operation and Maintenance costs. Property Acquisition costs, which are a part of Total Indirect Non-Construction costs, are itemized separately in the Action Fact Sheets. These Unit Action Costs are based on the design information provided in Table 9 and in the Action Fact Sheets, as well as the long-term maintenance assumptions provided in Table 10.

The WQBE Phase 2 cost estimate updates refined the cost estimates prepared under Phase 1 to more closely align the costs with similar projects and programs. These refinements included evaluation of indirect cost multipliers such as complexity factors, contingency and cost multipliers. In general, the indirect costs were adjusted to reflect a programmatic delivery approach to implementing the actions. Additionally, property cost values were revised to reflect costs outside of Seattle and in King County in general. Several sources were used to evaluate Unit Action Costs, including internet sources, King County Technical Memoranda and Reports, and the Washington State Department of Transportation (WSDOT) Unit Bid Analysis database. See Appendix D to 431-TM1 (HDR 2021) for detailed documentation of unit Action cost development.

## 7.4 Design and Cost Limitations

The following text provides a summary of key design and cost limitations noted for this Phase of the project.

- **Infiltration for Actions with Side Slopes:** As described in Section 7.1, methodology was developed to transform Actions with side slopes into Actions with vertical slopes for purposes of SUSTAIN modeling, since SUSTAIN only models vertical side slopes. Preliminary modeling in Table 8 showed this method was effective for purposes of this evaluation; however, infiltration is head dependent, and ideally the infiltration rate for Actions with side slopes would vary as a function of Action volume and depth. Since the method described in Section 7.1 is based on a constant infiltration rate, the method developed for this Phase is noted as an approximation.
- **Action Cost and Sizing Optimization:** Action sizing was performed in MGSFlood by modeling the amount of drainage area that can be treated to a given standard under the given set of design and treatment assumptions (Tables 2 and 3). Thus, there was no optimization performed directly in MGSFlood. However, unit costs were optimized, where appropriate, with the goal of providing a representative unit cost for a typical application (HDR 2021) and the programmatic implementation of unit Actions was optimized in SUSTAIN (Herrera 2021a).
- **Climate Change:** Design assumptions are based on King County's current design requirements (2016 KCSWDM). Future climate change conditions have not been evaluated, but may be considered in future phases of study (see Section 8: Summary and Recommended Next Steps).

*Table 9 – Design Parameters.*

| Action | Bottom Area Footprint (SF) | Drainage Area (SF) | Length to Width Ratio (L:W) | Side Slope (H:V) [a] | Max Ponding Depth (in) | Underdrain Diameter (in) | Underdrain Aggregate Porosity (%) | Underdrain Invert Height (in) | Total Underdrain Aggregate Depth (in) | Native Soil Design Infiltration Rate (in/hr) | Treatment Media Depth (in) | Treatment Media Porosity (%) | Treatment Media Design Infiltration Rate (in/hr) | Orifice diameter (in) / height (in) | Off-line Water Quality Design Flow Rate (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Green Stormwater Infrastructure (GSI)** | | | | | | | | | | | | | | | |
| Rain Garden – Till Soils | 25 | 806 | 2:1 | 3 | 6 | N/A | N/A | N/A | N/A | 0.3 | 8 [b] | 25% | N/A | N/A | N/A |
| Rain Garden – Outwash Soils | 25 | 2,844 | 2:1 | 3 | 6 | N/A | N/A | N/A | N/A | 2.5 | 8 [b] | 25% | N/A | N/A | N/A |
| Bioretention Planter | 25 | 2,357 | 3:1 | 0 | 6 | 8 | 40% | 6 | 26 | N/A | 18 | 30% | 6 | N/A | N/A |
| Bioretention – Till Soils | 85 | 12,148 | 3:1 | 3 | 6 | 8 [c] | 40% | 12 | 26 | 0.3 | 18 | 30% | 6 | N/A | N/A |
| Bioretention – Outwash Soils | 85 | 9,570 | 3:1 | 3 | 6 | N/A | N/A | N/A | N/A | 2.5 | 18 | 30% | 6 | N/A | N/A |
| Bioswale | 200 | 27,878 | 50:1 | 3 | 1.4 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 0.052 |
| Media Filter Drains – Till Soils | 200 | 2,000 | 50:1 | 3 | 0 | 8 | 40% | 6 | 20 | 0.3 | 12 | 40% | 10 | N/A | N/A |
| Media Filter Drains – Outwash Soils | 200 | 2,000 | 50:1 | 3 | 0 | N/A | N/A | N/A | N/A | 2.5 | 12 | 40% | 10 | N/A | N/A |
| Drywell – Till Soils | 13 | 261 | N/A | 0 | N/A | N/A | N/A | N/A | N/A | 0.3 | N/A [d] | N/A | N/A | N/A | N/A |
| Drywell – Outwash Soils | 13 | 780 | N/A | 0 | N/A | N/A | N/A | N/A | N/A | 2.5 | N/A [d] | N/A | N/A | N/A | N/A |
| Deep UIC Well | 42 | N/A [e] | N/A | 0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Permeable Pavement – Till Soils | 200 | 200 | 2:1 | N/A | 0 | N/A | N/A | N/A | N/A | 0.3 | 6 [f] | 35% [f] | N/A | N/A | N/A |
| Permeable Pavement – Outwash Soils | 200 | 200 | 2:1 | N/A | 0 | N/A | N/A | N/A | N/A | 2.5 | 6 [f] | 35% [f] | N/A | N/A | N/A |
| Depaving (Removal of Impervious Surfaces) [g] | 100 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Stormwater Treatment Wetland | 503 | 62,988 | 2:1 | 3 | 48 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 0.118 |
| **Stormwater Retention/Detention/Infiltration** | | | | | | | | | | | | | | | |
| Detention Vault | 2,592 | 28,658 | 2:1 / 1.125:1 [h] | 0 | 72 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 1.16 / 0 [i] | N/A |

| Action | Bottom Area Footprint (SF) | Drainage Area (SF) | Length to Width Ratio (L:W) | Side Slope (H:V) [a] | Max Ponding Depth (in) | Underdrain Diameter (in) | Underdrain Aggregate Porosity (%) | Underdrain Invert Height (in) | Total Underdrain Aggregate Depth (in) | Native Soil Design Infiltration Rate (in/hr) | Treatment Media Depth (in) | Treatment Media Porosity (%) | Treatment Media Design Infiltration Rate (in/hr) | Orifice diameter (in) / height (in) | Off-line Water Quality Design Flow Rate (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Detention Pond | 4,500 | 36,569 | 2:1 | 3 | 48 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 1.41 / 0 [i] | N/A |
| Infiltration Pond – Till Soils | 2,785 | 36,595 | 2:1 | 3 | 48 | N/A | N/A | N/A | N/A | 0.3 | N/A | N/A | N/A | N/A | N/A |
| Infiltration Pond – Outwash Soils | 1,479 | 46,396 | 2:1 | 3 | 48 | N/A | N/A | N/A | N/A | 2.5 | N/A | N/A | N/A | N/A | N/A |
| Infiltration Vault – Till Soils | 1,836 | 28,719 | N/A | 0 | 72 | N/A | N/A | N/A | N/A | 0.3 | N/A | N/A | N/A | N/A | N/A |
| Infiltration Vault – Outwash Soils | 1,156 | 39,365 | N/A | 0 | 72 | N/A | N/A | N/A | N/A | 2.5 | N/A | N/A | N/A | N/A | N/A |
| Cistern | 18 | 1,300 | 2:1 | 0 | 60 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 0.25 / 4 | N/A |
| **Gray Stormwater Treatment** | | | | | | | | | | | | | | | |
| Wetpond | 553 | 63,075 | 2:1 | 3 | 48 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 0.118 |
| Wetvault | 1,615 | 63,010 | 3:1 / 4:1 [h] | 0 | 48 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 0.118 |
| High Rate Underground Filter System | 16 | 34,956 | 1:1 | N/A | 2 | 4 | 40% | 0 | 6 | N/A | 21 | 40% | 175 | N/A | 0.081 |
| Regional Vegetated Media Filtration Facility | 5,940 | 17,249,760 | 1.2:1 | N/A | 8.4 | 12 | 40% | 0 | 18 | N/A | 21.6 | 40% | 175 | N/A | N/A |

**Abbreviations:**

| | |
|---|---|
| cfs | cubic feet per second |
| ft | feet |
| hr | hour |
| in | inches |
| L:W | Length to Width ratio |
| N/A | Not Applicable |
| SF | square feet |

**Notes:**

a. Actions with side slopes are sloped only along the long sides, short sides are vertical.
b. Rain gardens are not included in the KCSWDM Basic Water Quality Treatment Menu; however, they were designed to provide basic water quality treatment in accordance with the 2017 Seattle Stormwater Manual (Volume 3, Table 5.19).
c. Bioretention on till soils includes an elevated underdrain with 6" cover, 8" underdrain pipe, and 12" bedding.
d. Drywells do not provide water quality treatment; however, the Action assumes a 72-inch aggregate depth at 40% porosity.
e. Unit Drainage Area based on drainage area of pre-treatment Action (determined during Program development) and assumed maximum flow rate.
f. For permeable pavement, a 3" aggregate layer with 40% porosity is assumed (does not provide treatment). A 6-inch sand layer for treatment is included only for pollution-generating hard surfaces (e.g., low-volume driveways).
g. Depaving will be represented in SUSTAIN as a change in the drainage area from impervious to pervious land use, instead of physically modeling treatment through the soil layers. The difference in runoff loading from the impervious and pervious land use is the assumed benefit from depaving actions.
h. Detention Vaults and Wetvaults were designed with L:W ratio of 2:1 and 3:1, respectively, but costed with L:W ratios of 1.125:1 and 4:1, respectively.
i. In addition to an orifice, detention vaults and ponds also have a notch. Notch and orifice dimensions vary with precipitation factors. The notch on the detention vault Action, using the medium precipitation factor, is 0.368 inches in length, 28.77 inches in height, and has an invert height of 3.6 feet. The notch on the detention pond Action, using the Medium MAP (Section 5), is 0.868 inches in length, 17.31 inches in height, and has an invert height of 2.56 feet.

*Table 10 – Long-term Maintenance Assumptions.*

| Action | Maintenance Activity 1 (Frequency) | Maintenance Activity 2 (Frequency) | Maintenance Activity 3 (Frequency) | Source |
|---|---|---|---|---|
| **Green Stormwater Infrastructure (GSI)** | | | | |
| Rain Garden | Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal (annually and after major storm events) | Inspection and remediation of plant health, i.e. pest, disease, poor vegetation growth, excessive vegetation growth, weed growth (quarterly) | Remediation of erosion of mulch/media layer around inlets, outlets and along slopes (biannually and after major storm events) | 2019 SMMWW, “Bioretention Facilities” (Appendix V-A.21) |
| Bioretention Planter | Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal (annually and after major storm events) | Inspection and remediation of plant health, i.e. pest, disease, poor vegetation growth, excessive vegetation growth, weed growth (quarterly) | Remediation of erosion of mulch/media layer around inlets, outlets and along slopes (biannually and after major storm events) | 2019 SMMWW, “Bioretention Facilities” (Appendix V-A.21) |
| Bioretention | Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal (annually and after major storm events) | Inspection and remediation of plant health, i.e. pest, disease, poor vegetation growth, excessive vegetation growth, weed growth (quarterly) | Remediation of erosion of mulch/media layer around inlets, outlets and along slopes (biannually and after major storm events) | 2019 SMMWW, “Bioretention Facilities” (Appendix V-A.21) |
| Bioswale | Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal (annually and after major storm events) | Inspection and remediation of grass health, i.e. sparse growth or excessive growth (quarterly) | Inspection and remediation of eroded or scoured swale bottom due to flow channelization, or higher flows. Remediation includes filling area with gravel for areas less than 12" wide, and regrading and reseeding for areas larger than 12" (biannually) | 2019 SMMWW, “Bioretention Facilities” (Appendix V-A.21) |
| Media Filter Drains | Removal of trash, sediment and debris, and releveling media filter drain areas damaged or destroyed by trash, sediment and debris removal. (biannually) | Inspection and remediation of grass health, i.e. sparse growth or excessive growth (quarterly) | Inspection and remediation of eroded or scoured swale bottom due to flow channelization, or higher flows. Remediation includes filling area with gravel for areas less than 12" wide, and regrading and reseeding for areas larger than 12" (biannually) | 2019 SMMWW, “Media Filter Drain (MFD)” (Appendix V-A.19) |
| Drywell | Removal of trash, debris or obstructions limiting flow into drywell (annually and after major storm events) | Inspection of vegetation and removal of roots that reduce free movement of water through pipes (biannually) | Inspection and remediation of holes or breaks that allow water to leave the basin at locations other than per design (biannually) | KCSWDM, “Drywell BMP” (Appendix A, No.25) |
| Deep UIC Well | General inspection of UIC well and associated maintenance hole structures, including measuring water level and well depth, not including confined space entry (annually) | Sediment removal from well and associated maintenance hole structures, by use of vactor truck (annually) | UIC flow testing, performed under the direction of a licensed hydrogeologist or professional engineer experienced with aquifer testing methods. Testing procedures require total of 8 hours, and access to constant water source such as a fire hydrant (once every five years) | Barton CSO Control Project with GSI, O &M Manual (2015) |
| Permeable Pavement | Removal of soil, mulch or sediment on paving biannually with a crew of two using a regenerative air sweeper (quarterly) | Remediation of small cracks, trip hazards, or small areas of concrete spalling and raveling by filling with patching mixes (annually) | Remediation of major cracks, trip hazards, or large areas of concrete spalling and raveling by cutting and replacing (annually) | 2019 SMMWW, “Permeable Pavement” (Appendix V-A.22) |
| Depaving (Removal of Impervious Surfaces) | Tilling and overseeding (biannually) | N/A | N/A | Professional Judgement |

| Action | Maintenance Activity 1 (Frequency) | Maintenance Activity 2 (Frequency) | Maintenance Activity 3 (Frequency) | Source |
|---|---|---|---|---|
| Stormwater Treatment Wetland | Removal of sediment from forebay and inlet/outlet pipe (annually) | Removal of trash and debris from facility (annually or after each major storm event) | Remediation of eroded areas over 2" deep of side slopes, berms or embankments (biannually or after major storm event) | 2016 KCSWDM, "Stormwater Wetland" (Appendix A: No. 18) |
| **Stormwater Retention/Detention/Infiltration** | | | | |
| Detention Vault | Removal of all sediment and debris from storage area (annually) | Inspection and repair of joints, vault walls, cracks wider than 1/2 inch (annually) | N/A | 2019 SMMWW, "Closed Detention Systems (Tanks/Vaults)" (Appendix V-A.3) |
| Detention Pond | Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal (annually) | Removal of dead, diseased or dying trees (annually) | Stabilization of eroded berms, slopes, embankments, and animal borrows (annually) | 2019 SMMWW, "Detention Ponds" (Appendix V-A.1) |
| Infiltration Pond | Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal (annually) | Removal of dead, diseased or dying trees (annually) | Stabilization of eroded berms, slopes, embankments, and animal borrows (annually) | 2019 SMMWW, "Detention Ponds" (Appendix V-A.1) |
| Infiltration Vault | Removal of all sediment and debris from storage area (annually) | Inspection and repair of joints, vault walls, cracks wider than 1/2 inch (annually) | N/A | 2019 SMMWW, "Closed Detention Systems (Tanks/Vaults)" (Appendix V-A.3) |
| Cistern | Removal of all sediment and debris from storage area (annually) | Inspection and repair of joints, vault walls, cracks wider than 1/2 inch (annually) | N/A | 2019 SMMWW, "Closed Detention Systems (Tanks/Vaults)" (Appendix V-A.3);<br><br>2016 KCSWDM "Rainwater Harvesting BMP" (Appendix A No. 32) |
| **Gray Stormwater Treatment** | | | | |
| Wetpond | Removal of trash, debris and sediment (annually) | Removal of visible oil sheen by using oil-absorbent pads or vactor truck (annually) | Inspection and remediation of erosion of the pond's side slopes and/or scouring of the pond bottom, that exceeds 6-inches, or where continued erosion is prevalent (3 times per year) | 2019 SMMWW, "Wetponds" (Appendix V-A.11) |
| Wetvault | Removal of all sediment and debris from storage area (annually) | Inspection and repair of joints, vault walls, cracks wider than 1/2 inch (annually) | N/A | 2019 SMMWW, "Wetvaults" (Appendix V-A.12) |
| High Rate Underground Filter System | Removal of trash, debris and sediment from facility (biannually or after major storm event) | Removal and replacement of 3" mulch layer (biannually) | Evaluation of plant health and replacement and/or pruning (bi-annually) | Kitsap County Operations and Maintenance Manual: Manchester Stormwater Park (December 2015) |
| Regional Vegetated Media Filtration Facility | Removal of trash, debris and sediment from facility (biannually or after major storm event) | Removal and replacement of 3" mulch layer (biannually) | Evaluation of plant health and replacement and/or pruning (bi-annually) | Kitsap County Operations and Maintenance Manual: Manchester Stormwater Park (December 2015) |

**Abbreviations:**

KCSWDM 2016 King County Surface Water Design Manual
SMMWW 2019 Stormwater Management Manual of Western Washington

# 8 SUMMARY AND RECOMMENDED NEXT STEPS

King County is developing the WQBE Toolkit to inform County decision-making processes regarding selection of cost-effective water quality improvement investments, reducing pollutant load and improving ecological and human health outcomes. The WQBE Toolkit will provide transparent, standardized methods for evaluating benefits of water quality Actions and Programs in terms of estimated pollutant load reductions and improved outcomes for a suite of ecological/human health endpoints.

A SUSTAIN model will be used to identify cost-effective combinations of potential water quality Actions for reduction of pollutant loads or stormwater volumes. Qualitative causal models will be used to define relationships between potential water quality projects and programs and ecological/human health endpoints (such as southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches).

The WQBE toolkit is being developed in two phases over a period extending from 2020 through 2022. During Phase 1 (2020), a preliminary set of models was developed. In Phase 2 (2021-2022), these models are being further calibrated and refined to support County planning efforts (e.g., Clean Water Plan and CSO Long-Term Control Plan [LTCP]). Significant refinements were also made with respect to scaling the contributing drainage area that can be managed to the applicable standard for each Action (Table 4) as a function of Mean Annual Precipitation, which varies widely across the lowlands of King County. Finally, this memorandum also documents significant refinements made to the way in which Actions with side slopes are represented in SUSTAIN. Collectively, these refinements are expected to significantly improve the accuracy and reliability of SUSTAIN modeling and the scaling of Action cost-benefits based on Action type, location, and climate.

Recommended next steps include the following:

- Further evaluate and refine, if needed, the polynomial expressions developed to illustrate the relationship between Mean Annual Precipitation and drainage area for the non-infiltration-based, flow control Actions (Detention Pond and Detention Vault). These relationships are more complex for non-infiltration-based, flow control Actions than those for infiltration-based Actions, and the relationships may warrant additional validation depending on how they will be used in future SUSTAIN modeling.
- Coordinate with the County to leverage ongoing climate change research to evaluate future changes to design storm intensities, durations, and frequencies.
- Evaluate advanced active treatment system Actions such as on polymer-enhanced filtration, electrocoagulation, activated carbon filtration, and ion exchange.
- Evaluate additional cost-effective Actions, such as vegetated filter strips, which can disperse runoff from surface types including roads.
- Consider incorporating permeable pavement without a sand layer for flow control (in addition to permeable pavement with a sand layer for water quality treatment) in future phases of study.
- Conduct further coordination between the Action Design and SUSTAIN Modeling Teams so that future SUSTAIN modeling methodologies incorporate the results documented in this memorandum, as well as any future revisions. For example, the SUSTAIN modeling method for flow control Actions, such as Detention Pond and Detention Vault, need to be developed and reviewed internally to ensure that the Performance Parameters (Attachment A) are paired with the correct flow rates to reliably predict pollutant load reductions that correspond with the sizing and cost estimates for those Actions.
- Update the Action Fact Sheets (Attachment A) as needed based on the above further coordination.

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# ATTACHMENT A

Action Fact Sheets

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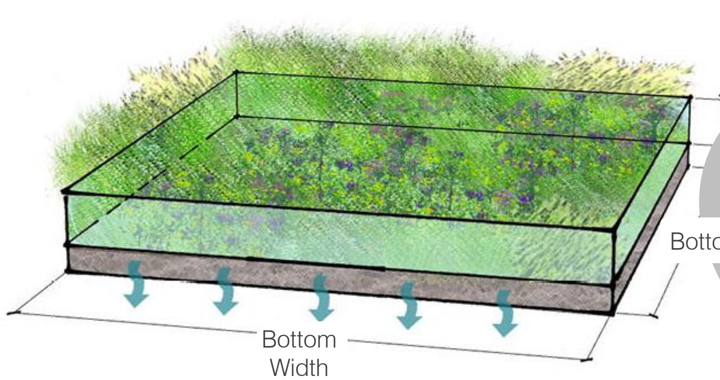
# RAIN GARDEN
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022

City of Bellevue 145th Place SE Project
Photo courtesy of RKI

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

A shallow, landscaped depression with adapted plants, visually similar to bioretention but with compost-amended native soils and no underdrain. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas and to allow stormwater to pass through the amended soil profile. Provides volume and peak flow reduction and water quality treatment.

## DESIGN PARAMETERS

| Parameter | Soil Type | |
|---|---|---|
| | Till | Outwash |
| Unit Footprint Area | 25 SF | 25 SF |
| Unit Drainage Area | 806 SF | 2,844 SF |
| Ponding Depth | 6 in | 6 in |
| Bottom Length | 7.08 ft | 7.08 ft |
| Bottom Width | 3.54 ft | 3.54 ft |
| Side Slope | 3H : 1V | 3H : 1V |
| Treatment Media Depth [a] | 8 in | 8 in |
| Treatment Media Porosity [a] | 25% | 25% |
| Native Soil Design Infiltration Rate | 0.3 in/hr | 2.5 in/hr |

N/A: Not Applicable

a. The Treatment Media is non-engineered and does not provide Basic Water Quality treatment. Infiltration through the Treatment Media is assumed to occur at the Native Soil Design Infiltration Rate



## TREATMENT AREAS

**Land Uses:**
- Residential
- Commercial

**Property Types:**
- Private Parcel
- Public Parcel

**Surface Types:**
- Roofs
- Lawns
- Driveways
- Sidewalks
- Parking Lots

## DESIGN ASSUMPTIONS

- Design is based on the *Seattle Stormwater Manual*, "*Rain Garden*" (Volume 3 Section 5.4.5).
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Although not listed in the Basic or Enhanced Water Quality Treatment Menu in the *2016 King County Surface Water Design Manual*, this project assumes the Unit Action provides Basic Water Quality Treatment.
- Non-engineered treatment media consists of 3" compost tilled in to an 8-inch finished depth.
- No underdrain included.



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# RAIN GARDEN
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022

## SUSTAIN MODEL REPRESENTATION

Hydrologic:
- Model explicitly represents ponding, infiltration, and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:
- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | Median Effluent Concentration |
|---|---|---|
| Total Copper | N/A | N/A |
| Dissolved Copper | N/A | N/A |
| Total Zinc | N/A | N/A |
| Dissolved Zinc | N/A | N/A |
| Total Phosphorus | N/A | N/A |
| Total Nitrogen | N/A | N/A |
| Total Suspended Solids | N/A | N/A |
| Total PCBs | N/A | N/A |
| Total PBDEs | N/A | N/A |
| Total PAHs | N/A | N/A |
| Bis(2-ethylhexyl)phthalate | N/A | N/A |
| Fecal Coliform | N/A | N/A |

N/A: Not applicable. See model representation treatment section.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property without Acquisition |
|---|---|
| Total Project | $24,000 |
| Total Direct Construction | $17,000 |
| Total Indirect Non-Construction | $7,000 |
| Operation and Maintenance | $2,800/year |
| Property Acquisition [c] | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.



## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Maximum drainage areas of 10,000 square feet of impervious surface to an individual facility.
- Meet local jurisdiction utility separation requirements.
- Locate away from traveled areas on individual lots to prevent soil compaction and damage to vegetation.
- No discharge towards existing basements, erosion hazard areas, or landslide hazard areas.
- Meet infiltration siting restrictions, including setbacks:
  - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
  - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
  - 100 feet away from proposed or existing septic system drainfields
- See comprehensive list of infeasibility criteria in Section C.2.6 of the *2016 King County Surface Water Design Manual.*



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# BIORETENTION PLANTER
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022

Photo courtesy of Paradigm

## ACTION DESCRIPTION

Similar to bioretention, this Action includes a designed high-performance bioretention soil media (HPBSM) and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants. This Action varies from bioretention in that the sides are vertically contained by walls constructed from formed concrete. These designs are often used in highly-urbanized settings. Provides water quality treatment and peak flow reduction. For this analysis, the Action is assumed to have an underdrain and closed bottom.

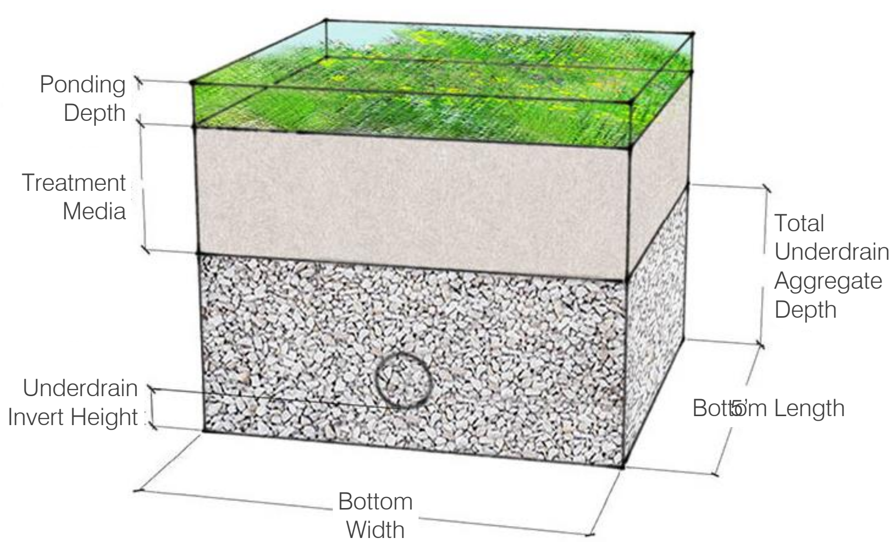
## TREATMENT AREAS

**Land Uses:**
- Residential
- Commercial
- Industrial

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Driveways
- Parking Lots
- Sidewalks
- Plazas
- Local Roads
- Arterial Roads

## UNIT ACTION SCHEMATIC




## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 25 SF |
| Unit Drainage Area | 2,357 SF |
| Ponding Depth | 6 in |
| Bottom Length | 8.7 ft |
| Bottom Width | 2.9 ft |
| Side Slope | Vertical |
| Treatment Media Depth | 18 in |
| Treatment Media Porosity | 30% |
| Treatment Media Design Infiltration Rate | 6 in/hr |
| Total Underdrain Aggregate Depth | 26 in |
| Underdrain Invert Height | 6 in |
| Underdrain Diameter | 8 in |
| Underdrain Aggregate Porosity | 40% |
| Native Soil Design Infiltration Rate [a] | N/A |

N/A: Not Applicable

a. Any incidental infiltration to native soils ignored.

## DESIGN ASSUMPTIONS

- Design is based on the *Seattle Stormwater Manual*, "Non-infiltrating Bioretention" (Volume 3 Section 5.8.2).
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Although not listed in the Basic or Enhanced Water Quality Treatment Menu in the KCSWDM, this project assumes the Action, including the HPBSM, provides Enhanced Water Quality Treatment.
- The HPBSM is a low phosphorus media composed of 70% sand, 20% coir and 10% high carbon wood ash (biochar). No polishing layer is included.
- Underdrain layer includes 12" cover, 8" underdrain pipe, and 6" bedding.
- Vertical sides.



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# BIORETENTION PLANTER

## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

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## SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, infiltration, underdrain flow, and overflow.

Treatment:

- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal [a] | Median Effluent Concentration [a] |
|---|---|---|
| Total Copper | 62.3% | 10.5 µg/L |
| Dissolved Copper | 57.6% | 6.4 µg/L |
| Total Zinc | 91.0% | 10.0 µg/L |
| Dissolved Zinc | 86.2% | <4.0 µg/L [b] |
| Total Phosphorus | 54.9% | 0.113 mg-P/L |
| Total Nitrogen | 51.3% | 1.33 mg/L |
| Total Suspended Solids | 78.0% | 21.5 mg/L |
| Total PCBs | 78.0%[c] | 572 pg/L[c] |
| Total PBDEs | 67.1%[c] | 0.054 ng/L[c] |
| Total PAHs | 95.0% | <0.01 µg/L [b] |
| Bis(2-ethylhexyl)phthalate | 63.2%[c] | 0.070 µg/L[c] |
| Fecal Coliform | 61.5 % | 240 CFU |

a. Performance based on the low phosphorus alternative bioretention soil media with 70% sand/20% coconut coir/10% high carbon wood ash
b. Method detection limit.
c. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property with Acquisition | On Property without Acquisition | In Right of Way |
|---|---|---|---|
| Total Project | $44,000 | $42,000 | $56,000 |
| Total Direct Construction | $29,000 | $29,000 | $39,000 |
| Total Indirect Non-Construction | $15,000 | $13,000 | $17,000 |
| Operation and Maintenance | $2,800 | $2,800 | $2,800 |
| Property Acquisition [c] | $1,400 | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Because non-infiltrating bioretention facilities do not infiltrate water to surrounding soils (water discharges via an underdrain and surface overflow), these Actions are not subject to infiltration facility requirements.
- Non-infiltrating bioretention is not permitted if the under-drained water would be routed to a nutrient-critical receiving water.
- Public Right-of-Way installation for urban areas only.



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# BIORETENTION
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

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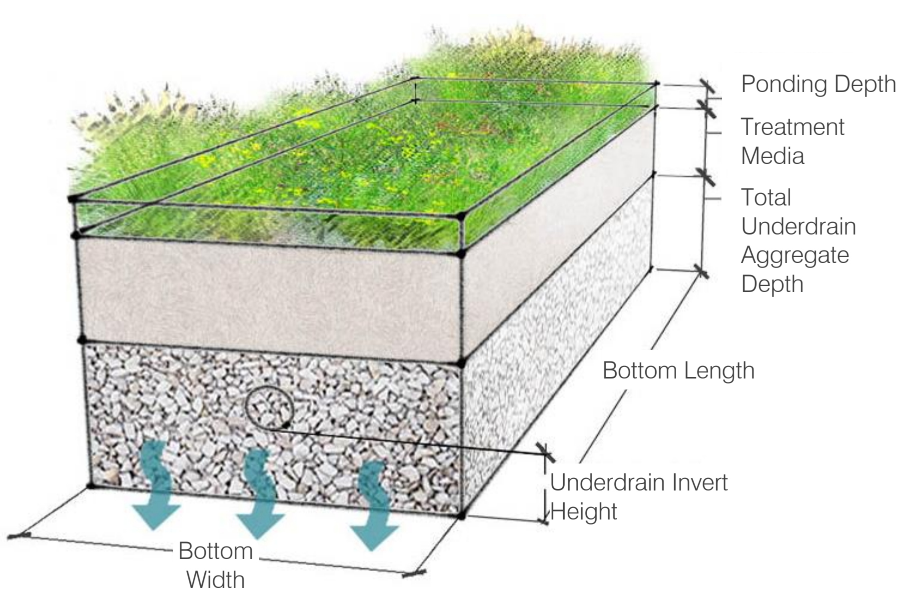
City of Redmond Overlake Village LID Retrofit Project
Photo courtesy of RKI

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

Shallow earthen depressions with a designed high-performance bioretention soil media (HPBSM) and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system. Provides volume and peak flow reduction and water quality treatment.

## DESIGN PARAMETERS

| Parameter | Soil Type: Till | Soil Type: Outwash |
|---|---|---|
| Unit Footprint Area | 85 SF | 85 SF |
| Unit Drainage Area | 12,148 SF | 9,570 SF |
| Ponding Depth | 6 in | 6 in |
| Bottom Length | 16 ft | 16 ft |
| Bottom Width | 5.33 ft | 5.33 ft |
| Side Slope | 3H : 1V | 3H : 1V |
| Treatment Media Depth | 18 in | 18 in |
| Treatment Media Porosity | 30% | 30% |
| Treatment Media Infiltration Rate | 6 in/hr | 6 in/hr |
| Total Underdrain Aggregate Depth | 26 in | N/A |
| Underdrain Invert Height | 12 in | N/A |
| Underdrain Diameter | 8 in | N/A |
| Underdrain Aggregate Porosity | 40% | N/A |
| Native Soil Design Infiltration Rate | 0.3 in/hr | 2.5 in/hr |

N/A: Not Applicable

## TREATMENT AREAS

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Driveways
- Parking Lots
- Sidewalk
- Plazas
- Local Roads
- Arterial Roads
- Highways

## DESIGN ASSUMPTIONS

- Design is based on *2016 King County Surface Water Design Manual (KCSWDM)* Section C.2.6.1.
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Although not listed in the Basic or Enhanced Water Quality Treatment Menu in the KCSWDM, this project assumes the Action, including the HPBSM, provides Enhanced Water Quality Treatment.
- The HPBSM is a low phosphorus media composed of 70% sand, 20% coir and 10% high carbon wood ash (biochar). No polishing layer is included.
- For bioretention installed in till soils, an elevated underdrain promotes infiltration. Design includes 6” cover, 8” underdrain pipe, and 12” bedding.
- For bioretention installed on outwash soils, no underdrain is included.



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## SUSTAIN MODEL REPRESENTATION

Hydrologic:
- Model explicitly represents ponding, infiltration, underdrain flow, and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:
- Water that infiltrates is lost to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal [a] | Median Effluent Concentration [a] |
|---|---|---|
| Total Copper | 62.3% | 10.5 µg/L |
| Dissolved Copper | 57.6% | 6.4 µg/L |
| Total Zinc | 91.0% | 10.0 µg/L |
| Dissolved Zinc | 86.2% | <4.0 µg/L [b] |
| Total Phosphorus | 54.9% | 0.113 mg-P/L |
| Total Nitrogen | 51.3% | 1.33 mg/L |
| Total Suspended Solids | 78.0% | 21.5 mg/L |
| Total PCBs | 78.0%[c] | 572 pg/L[c] |
| Total PBDEs | 67.1%[c] | 0.054 ng/L[c] |
| Total PAHs | 95.0% | <0.01 µg/L [b] |
| Bis(2-ethylhexyl)phthalate | 63.2%[c] | 0.070 µg/L[c] |
| Fecal Coliform | 61.5 % | 240 CFU |

a. Performance based on the low phosphorus alternative bioretention soil media with 70% sand/20% coconut coir/10% high carbon wood ash
b. Method detection limit
c. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | With Underdrain | | | No Underdrain | | |
|---|---|---|---|---|---|---|
| | On Property with Acquisition | On Property without Acquisition | In Right of Way/ Highway | On Property with Acquisition | On Property without Acquisition | In Right of Way/ Highway |
| Total Project | $100,000 | $85,000 | $139,000 | $98,000 | $83,000 | $135,000 |
| Total Direct Construction | $59,000 | $59,000 | $97,000 | $57,000 | $57,000 | $94,000 |
| Total Indirect Non-Construction | $42,000 | $26,000 | $42,000 | $41,000 | $25,000 | $41,000 |
| Operation and Maintenance | $2,800/year | $2,800/year | $2,800/year | $2,800/year | $2,800/year | $2,800/year |
| Property Acquisition [c] | $14,000 | $0 | $0 | $14,000 | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.



## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Site must have sufficient space (e.g., right-of-way applications typically require minimum planter width of 12 feet)
- Locate away from traveled areas on individual lots to prevent soil compaction and damage to vegetation
- No discharge towards existing basements, erosion hazard areas, or landslide hazard areas
- Meet infiltration siting restrictions, including setbacks:
  - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
  - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
  - 100 feet away from proposed or existing septic system drainfields
- See comprehensive list of infeasibility criteria in Section C.2.6 of *the 2016 King County Surface Water Design Manual*



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# BIOSWALE
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022



## ACTION DESCRIPTION

An open, gently sloped, vegetated channel designed for treatment of stormwater. Grass is most common vegetation, but wetland vegetation can be used if soil is saturated. Provides water quality treatment, peak flow reduction, and conveyance. These are designed to "filter" water as it is conveyed through a vegetated swale. While this Action may provide incidental infiltration, that is not the primary treatment mechanism.

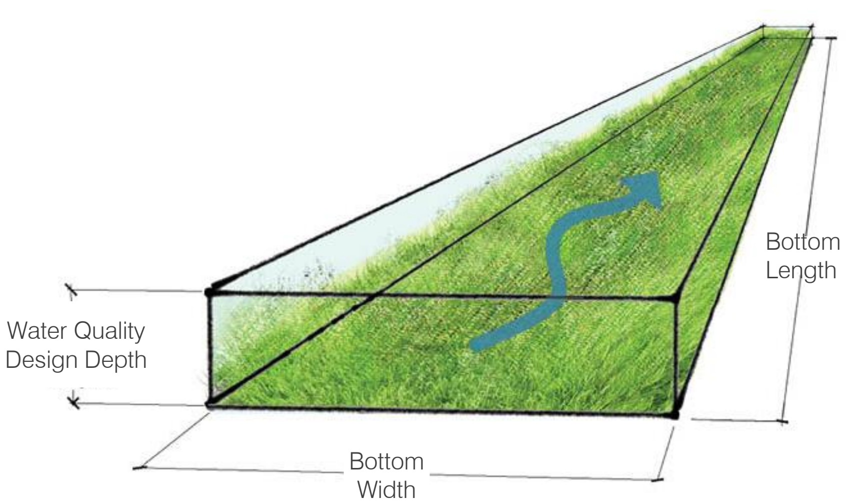
## TREATMENT AREAS

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Parking Lots
- Arterial Roads
- Local Roads
- Highways

## UNIT ACTION SCHEMATIC




## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 200 SF |
| Unit Drainage Area | 27,878 SF |
| Bottom Length | 100 ft |
| Bottom Width | 2 ft |
| Side Slope | 3H : 1V |
| Water Quality Design Depth | 1.4 in |
| Native Soil Design Infiltration Rate [a] | N/A |
| Water Quality Design Flow Rate (Off-line) | 0.052 cfs |

N/A: Not Applicable

a. Any incidental infiltration to native soils ignored.

## DESIGN ASSUMPTIONS

- Design is based on the *2016 King County Surface Water Design Manual, "Basic Bioswales"*, Section 6.3.1.
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Off-line design assumes flow splitter will be used to divert flows up to the Water Quality Design Flow Rate to the Action.
- Non-engineered soil media consists of 2" compost tilled into 6" native soil.
- Water flows relatively evenly across the entire width of a densely-vegetated area.
- No infiltration to underlying native soils assumed.



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## SUSTAIN MODEL REPRESENTATION

Hydrologic:
- Model explicitly represents overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:
- Water that flows through the bioswale (up to the water quality design flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (see Performance Parameters table below).

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | Median Effluent Concentration |
|---|---|---|
| Total Copper | 33.9% | 9.20 µg/L |
| Dissolved Copper | 8.99% | 5.6 µg/L |
| Total Zinc | 33.3% | 35.0 µg/L |
| Dissolved Zinc | 29.0% | 20.9 µg/L |
| Total Phosphorus | -37.2% | 0.188 mg-P/L |
| Total Nitrogen | -7.63% | 0.860 mg/L |
| Total Suspended Solids | 27.9% | 22.3 mg/L |
| Total PCBs | 27.9%[a] | 592 pg/L[a] |
| Total PBDEs | 24.0%[a] | 0.056 ng/L[a] |
| Total PAHs | 27.9%[a] | 0.0028 µg/L[a] |
| Bis(2-ethylhexyl)phthalate | 23.0%[a] | 0.073 µg/L[a] |
| Fecal Coliform | 6.25% | 4900 CFU |

a. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

## UNIT ACTION COSTS

| Costs/Unit Action[a, b] | On Property with Acquisition | On Property without Acquisition | In Right of Way/ Highway |
|---|---|---|---|
| Total Project | $66,000 | $20,000 | $41,000 |
| Total Direct Construction | $14,000 | $14,000 | $29,000 |
| Total Indirect Non-Construction | $52,000 | $6,000 | $12,000 |
| Operation and Maintenance | $2,600/year | $2,600/year | $2,600/year |
| Property Acquisition[c] | $40,000 | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Generally appropriate when there is less than 5 acres of contributing impervious surface.
- Site in areas with a minimum of 6 hours of sunlight daily throughout the year.
- Do not site in high-use areas without oil control, as required in Section 6.6 in the *King County Surface Water Design Manual.*





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# MEDIA FILTER DRAIN (MFD)
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022



Photo accessed on 7/2/2020 from https://www.wsdot.wa.gov/design/roadside/stormwater-management

## ACTION DESCRIPTION

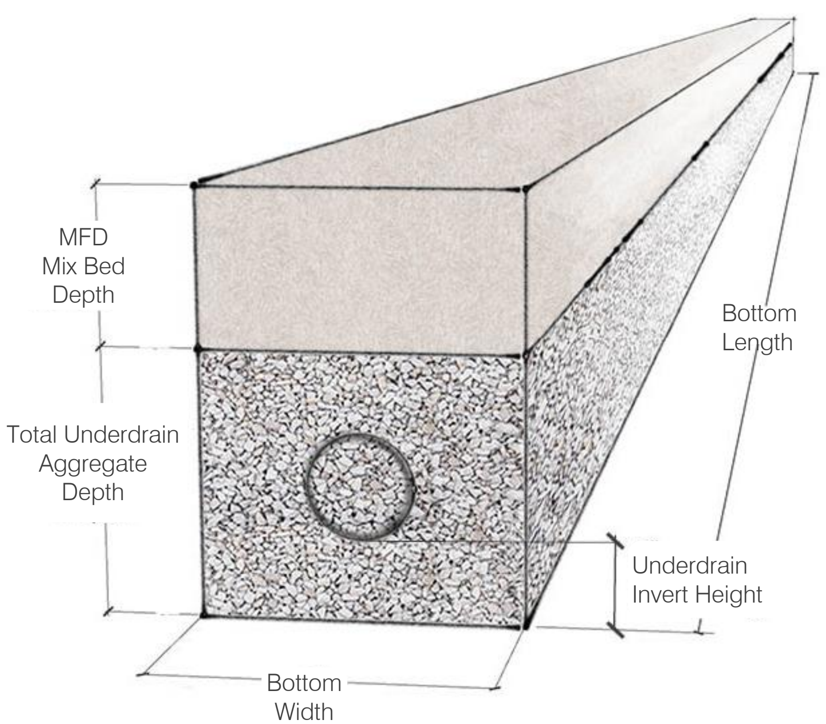
A linear flow-through stormwater treatment device that can be sited along roadway side slopes (conventional design) and medians, borrow ditches, or other linear depressions. Cut-slope applications may also be considered. MFDs have four basic components: a gravel no-vegetation zone, a vegetated filter strip, the MFD mix bed, and an optional gravel-filled underdrain trench or layer of crushed surfacing base course. Treated water is either infiltrated into the underlying soil or collected by an underdrain and discharged to the drainage system.

## DESIGN PARAMETERS

| Parameter | Soil Type | |
|---|---|---|
| | Till | Outwash |
| Unit Footprint Area | 200 SF | 200 SF |
| Unit Drainage Area | 2,000 SF | 2,000 SF |
| Lateral Slope | 3H : 1V | 3H : 1V |
| Ponding Depth | 0 in | 0 in |
| Bottom Length | 100 ft | 100 ft |
| Bottom Width | 2 ft | 2 ft |
| MFD Mix Bed Depth | 12 in | 12 in |
| MFD Mix Porosity | 40% | 40% |
| MFD Mix Media Infiltration Rate | 10 in/hr | 10 In/hr |
| Total Underdrain Aggregate Depth | 20 in | N/A |
| Underdrain Invert Height | 6 in | N/A |
| Underdrain Diameter | 8 in | N/A |
| Underdrain Aggregate Porosity | 40% | N/A |
| Native Soil Design Infiltration Rate | 0.3 in/hr | 2.5 in/hr |

N/A: Not Applicable

## UNIT ACTION SCHEMATIC




## TREATMENT AREAS

**Land Uses:**
- Highway
- Agricultural

**Property Types:**
- Public Right-of-Way

**Surface Types:**
- Arterial Roads
- Local Roads
- Highway

## DESIGN ASSUMPTIONS

- Design is based on the *2019 Washington State Department of Ecology Stormwater Management Manual for Western WA (SWMMWW)*, Best Management Practice (BMP) T8.40.
- Sizing is based on the *SWMMWW* Table V-6.5.
- The MFD mix consists crushed rock, dolomite, gypsum, and perlite.
- No underdrain included for MFDs installed on outwash soils.
- Treatment steps include:
    - Stormwater runoff enters the media filter drain and is conveyed via sheet flow over a vegetation-free gravel zone for sheet dispersion and to provide some pollutant trapping
    - A grass strip is incorporated into the top of the fill slope to provide pretreatment, further enhancing filtration and extending the life of the system
    - Runoff is then filtered through the treatment media bed and treated water is drained to an approved discharge location



Visit kingcounty.gov/WQBE for more information.

# MEDIA FILTER DRAIN (MFD)
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022

## SUSTAIN MODEL REPRESENTATION

Hydrologic:
- Model explicitly represents ponding, filtration, underdrain flow, and overflow.

Treatment:
- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | Median Effluent Concentration |
|---|---|---|
| Total Copper | 68.7% | 12.3 µg/L |
| Dissolved Copper | 25.6% | 9.0 µg/L |
| Total Zinc | 68.5% | 37.7 µg/L |
| Dissolved Zinc | 51.0% | 29.0 µg/L |
| Total Phosphorus | 44.6% | 0.067 mg-P/L |
| Total Nitrogen | NF | NF |
| Total Suspended Solids | 86.1% | 5.3 mg/L |
| Total PCBs | 86.1%[a] | 141 pg/L[a] |
| Total PBDEs | 74.1%[a] | 0.013 ng/L[a] |
| Total PAHs | 86.1%[a] | 0.00066 µg/L[a] |
| Bis(2-ethylhexyl)phthalate | 70.0%[a] | 0.017 µg/L[a] |
| Fecal Coliform | NF | NF |

NF: No data found.
a. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | Rural Roadway/Highway | |
|---|---|---|
| | With Underdrain | No Underdrain |
| Total Project | $34,000 | $30,000 |
| Total Direct Construction | $24,000 | $21,000 |
| Total Indirect Non-Construction | $10,000 | $9,000 |
| Operation and Maintenance | $2,300/year | $2,300/year |
| Property Acquisition [c] | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.



## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Avoid construction on longitudinal slopes steeper than 5%.
- For narrow roadway shoulders, ensure sufficient space available for parking.
- Do not construct in wetlands and wetland buffers.
- Install above the site mean high water table levels to ensure the media filter drain mix bed and the underdrain (if needed) will not become saturated by shallow ground water.
- Do not site in areas of seasonal ground water inundation or basement flooding.
- Meet infiltration siting restrictions, including setbacks:
  - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
  - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
  - 100 feet away from proposed or existing septic system drainfields





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# DRYWELL
## Water Quality Benefits Evaluation Action Fact Sheet

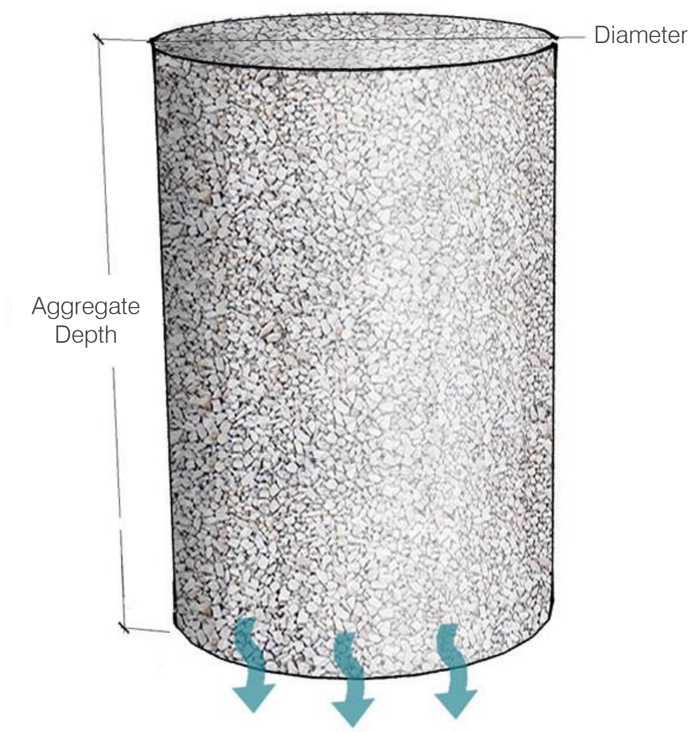
Phase 2

01/14/2022



Photo accessed on 7/2/2020 from https://www.thisoldhouse.com/

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

A gravel filled hole that conveys stormwater runoff into the soil matrix. Provides volume and peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Soil Type: Till | Soil Type: Outwash |
|---|---|---|
| Unit Footprint Area | 13 SF | 13 SF |
| Unit Drainage Area | 261 SF | 780 SF |
| Ponding Depth | N/A | N/A |
| Diameter | 4 ft | 4 ft |
| Aggregate Depth | 6 ft | 6 ft |
| Aggregate Porosity | 40% | 40% |
| Native Soil Design Infiltration Rate [a] | 0.3 in/hr | 2.5 in/hr |

a. Lateral infiltration assumed to occur through half of the sidewall depth.

## TREATMENT AREAS

**Land Uses:**
- Residential
- Commercial
- Industrial
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel

**Surface Types:**
- Roofs
- Sidewalks
- Driveways
- Parking Lots
- Lawns

## DESIGN ASSUMPTIONS

- Design is based on the *2017 Seattle Stormwater Manual*, “Drywells" (Volume 3 Section 5.4.3).
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step. The unit Action was sized to meet a Modified Level 1 Flow Control Standard, in which peak discharge rates were matched to the pre-developed (forested) peak discharge rates for the 2- and 10-year return intervals.
- Pre-treatment via upstream treatment Action will be provided.
- Infiltration to native soil assumes infiltration through the bottom surface and half of the sidewall surface area.
- The installed Action must be registered with Ecology as an Underground Injection Control (UIC).



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# DRYWELL
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Model explicitly represents storage, infiltration and overflow.

**Treatment:**
- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | Median Effluent Concentration |
|---|---|---|
| Total Copper | N/A | N/A |
| Dissolved Copper | N/A | N/A |
| Total Zinc | N/A | N/A |
| Dissolved Zinc | N/A | N/A |
| Total Phosphorus | N/A | N/A |
| Total Nitrogen | N/A | N/A |
| Total Suspended Solids | N/A | N/A |
| Total PCBs | N/A | N/A |
| Total PBDEs | N/A | N/A |
| Total PAHs | N/A | N/A |
| Bis(2-ethylhexyl)phthalate | N/A | N/A |
| Fecal Coliform | N/A | N/A |

N/A: Not applicable. See model representation treatment section.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property without Acquisition |
|---|---|
| Total Project | $16,000 |
| Total Direct Construction | $11,000 |
| Total Indirect Non-Construction | $5,000 |
| Operation and Maintenance | $1,800/year |
| Property Acquisition [c] | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.



## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Minimum spacing between drywells is 10 feet.
- Setback is at least 15 feet from buildings with crawl space or basement elevations that are below the overflow point of the drywell.
- Can be placed under a pervious or impervious surface cover to conserve space.
- A minimum 5' setback shall be maintained between any part of the action and any structure or property line.
- Locate downgradient of the primary and secondary reserve drainfield areas.
- Locate away from sensitive area buffers.
- Do not direct overflows toward a slope steeper than 15%.
- Meet infiltration siting restrictions, including setbacks:
  - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
  - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
  - 100 feet away from proposed or existing septic system drainfields



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# DEEP UNDERGROUND INJECTION CONTROL (UIC) WELL
## Water Quality Benefits Evaluation Action Fact Sheet

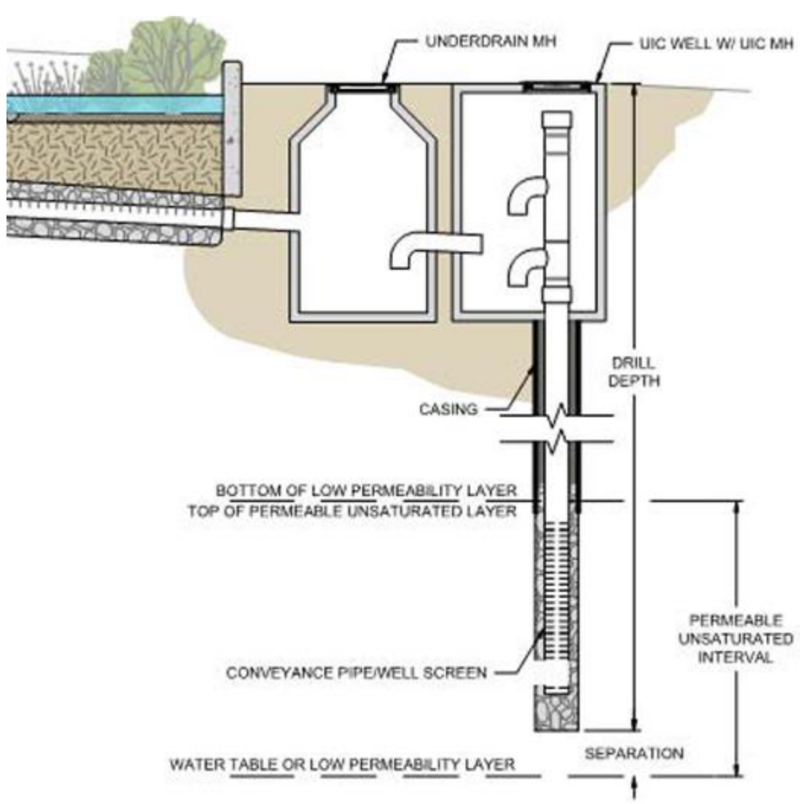
Phase 2

01/14/2022



Seattle Public Utilities Delridge Natural Drainage System
Photo courtesy of RKI

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

A well that extends below an upper confining layer and discharges into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below. This analysis assumes a water-well style UIC downstream of a pre-treatment Action. Provides volume and peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Assumed Maximum Flow Rate | 0.111 cfs |
| Unit Footprint Area | 42 SF |
| Unit Drainage Area [a] | N/A |

N/A: Not Applicable
a. Unit Drainage Area based on drainage area of pre-treatment Action.

## TREATMENT AREAS

**Land Uses:**
- Residential
- Commercial

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Sidewalks
- Lawns
- Local Roads
- Arterial Roads

## DESIGN ASSUMPTIONS

- Design and sizing based on *King County Wastewater Treatment Division's Barton Basin Combined Sewer Overflow Control Project with Green Stormwater Infrastructure* (Barton).
- Maximum flow rate assumed to be 50 gallons per minute (0.111 cubic feet per second) based on average results presented in the Barton Drainage Report, Section 6.4.
- Well includes the following configuration:
  - Drilling and casing of 12-inch diameter borehole
  - 20-foot long 8-inch diameter pipe-sized well screen with filter pack
  - 5-foot deep stainless-steel well sump containing energy-dissipation rock, allowing water to drain out of well
  - Sand filter pack around well screen and sump, extending 8 feet above the top of the well screen
  - Maintenance hole over wellhead to convey treated stormwater into the well
  - Maximum well depth of 100 feet to accommodate future removal of sediment by vactor equipment
  - Underdrain manhole to provide for additional sediment removal
- Pre-treatment via upstream treatment Action will be provided.
- Includes a surface seal in the final completion of a deep UIC.



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# DEEP UNDERGROUND INJECTION CONTROL (UIC) WELL
Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022



## SUSTAIN MODEL REPRESENTATION

Hydrologic:
- Model explicitly represents infiltration and overflow

Treatment:
- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | Median Effluent Concentration |
|---|---|---|
| Total Copper | N/A | N/A |
| Dissolved Copper | N/A | N/A |
| Total Zinc | N/A | N/A |
| Dissolved Zinc | N/A | N/A |
| Total Phosphorus | N/A | N/A |
| Total Nitrogen | N/A | N/A |
| Total Suspended Solids | N/A | N/A |
| Total PCBs | N/A | N/A |
| Total PBDEs | N/A | N/A |
| Total PAHs | N/A | N/A |
| Bis(2-ethylhexyl)phthalate | N/A | N/A |
| Fecal Coliform | N/A | N/A |

N/A: Not applicable. See model representation treatment section.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property with Acquisition | On Property without Acquisition | In Right of Way |
|---|---|---|---|
| Total Project | $48,000 | $46,000 | $66,000 |
| Total Direct Construction | $32,000 | $32,000 | $46,000 |
| Total Indirect Non-Construction | $16,000 | $14,000 | $20,000 |
| Operation and Maintenance | $2,000/year | $2,000/year | $2,000/year |
| Property Acquisition [c] | $1,400 | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Locate away from wellhead protection area, Critical Aquifer Recharge Area, or a Sole Source Aquifer.
- Submittal of a State Waste Discharge Permit application required and will be determined on a site-by-site basis following the evaluation of the UIC permit application.



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# PERMEABLE PAVEMENT
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

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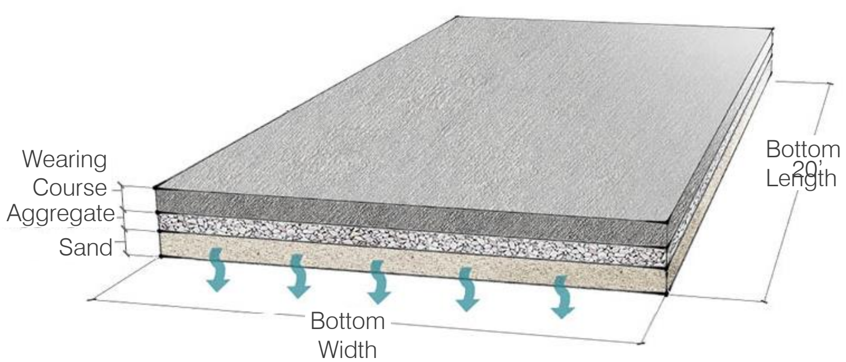
City of Puyallup 9th St NW Porous Asphalt Roadway and Driveway Aprons
Photo courtesy of RKI

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

Includes pervious concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material. Intended to allow passage of water through pavement. Provides volume and peak flow reduction. Provides water quality treatment when sand treatment layer is provided.

## DESIGN PARAMETERS

| Parameter | Soil Type: Till | Soil Type: Outwash |
|---|---|---|
| Unit Footprint Area | 200 SF | 200 SF |
| Unit Drainage Area | 200 SF | 200 SF |
| Ponding Depth | 0 in | 0 in |
| Bottom Length | 20 ft | 20 ft |
| Bottom Width | 10 ft | 10 ft |
| Treatment Media Depth [a] | 6 in | 6 in |
| Treatment Media Porosity | 35% | 35% |
| Aggregate Depth | 3 in | 3 in |
| Aggregate Porosity | 40% | 40% |
| Native Soil Design Infiltration Rate | 0.3 in/hr | 2.5 in/hr |

a. Sand treatment layer provided for pollution-generating hard surfaces (i.e., low volume residential driveways) only.

## TREATMENT AREAS

Land Uses:
- Residential
- Commercial

Property Types:
- Private Parcel
- Public Parcel

Surface Types:
- Low Volume Residential Driveways
- Sidewalks
- Plazas
- Trails
- Pedestrian and bike paths
- Parking Lots

## DESIGN ASSUMPTIONS

- Design and sizing based on the *2016 King County Surface Water Design Manual, "Permeable Pavement"*, Appendix C, Section C.2.7.
- Section consists of 5" wearing course (pervious concrete or porous asphalt) over 3" aggregate. For low volume residential driveways, the section is underlain by 6" sand treatment layer
- Subsurface ponding assumed to include:
  - Ponding in aggregate layer: 3" x 40% porosity = 1.2"
  - Ponding in sand layer: 6" x 35% porosity = 2.1"
  - Storage in wearing course neglected
- The aggregate base contains less than 5% fines (material passing the #200 sieve) based on the fraction passing the #4 sieve.
- No run-on from other areas. The permeable pavement surface manages stormwater runoff from its own footprint only.
- Installation is on flat grades (e.g., <5% slope). No subsurface check dams required.

Outdated



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# PERMEABLE PAVEMENT
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022

## SUSTAIN MODEL REPRESENTATION

Hydrologic:
- Model explicitly represents subsurface ponding, infiltration, and overflow.

Treatment:
- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | Median Effluent Concentration |
|---|---|---|
| Total Copper | N/A | N/A |
| Dissolved Copper | N/A | N/A |
| Total Zinc | N/A | N/A |
| Dissolved Zinc | N/A | N/A |
| Total Phosphorus | N/A | N/A |
| Total Nitrogen | N/A | N/A |
| Total Suspended Solids | N/A | N/A |
| Total PCBs | N/A | N/A |
| Total PBDEs | N/A | N/A |
| Total PAHs | N/A | N/A |
| Bis(2-ethylhexyl)phthalate | N/A | N/A |
| Fecal Coliform | N/A | N/A |

N/A: Not applicable. See model representation treatment section.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | Permeable Paver Plaza (no sand layer) | Pervious Concrete Sidewalk (no sand layer) | Permeable Paver Driveway (with sand layer) | Porous Asphalt Driveway (with sand layer) |
|---|---|---|---|---|
| Total Project | $4,000 | $12,000 | $4,000 | $6,000 |
| Total Direct Construction | $3,000 | $8,000 | $3,000 | $4,000 |
| Total Indirect Non-Construction | $1,000 | $4,000 | $1,000 | $2,000 |
| Operation and Maintenance | $2,100/year | $2,100/year | $2,100/year | $2,200/year |
| Property Acquisition [c] | $0 | $0 | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Limit to sites with 5% or less grade.
- Do not locate in high traffic or heavy load applications such as arterial roads, highways, and industrial/commercial loading areas.
- Do not locate in areas where King County's Permeable Pavement Infeasibility Criteria (see Section C.2.7 in the *2016 King County Surface Water Design Manual*) apply, such as (but not limited to) the following areas:
  - Where ground water drains into an erosion hazard or landslide hazard area
  - Where nearby basements that may be impacted
  - Where seasonal high groundwater or an underlying impermeable/low permeable layer lies within 1 foot of the bottom of the installation
  - Downslope of steep, erosion prone areas that are likely to deliver sediment
  - Within 50 feet from the top of slopes greater than 20%
  - Within 100 feet of a closed or active landfill
  - Within 100 feet of a drinking water well, or a spring used for drinking water supply, for pollution-generating surfaces (e.g., driveways)





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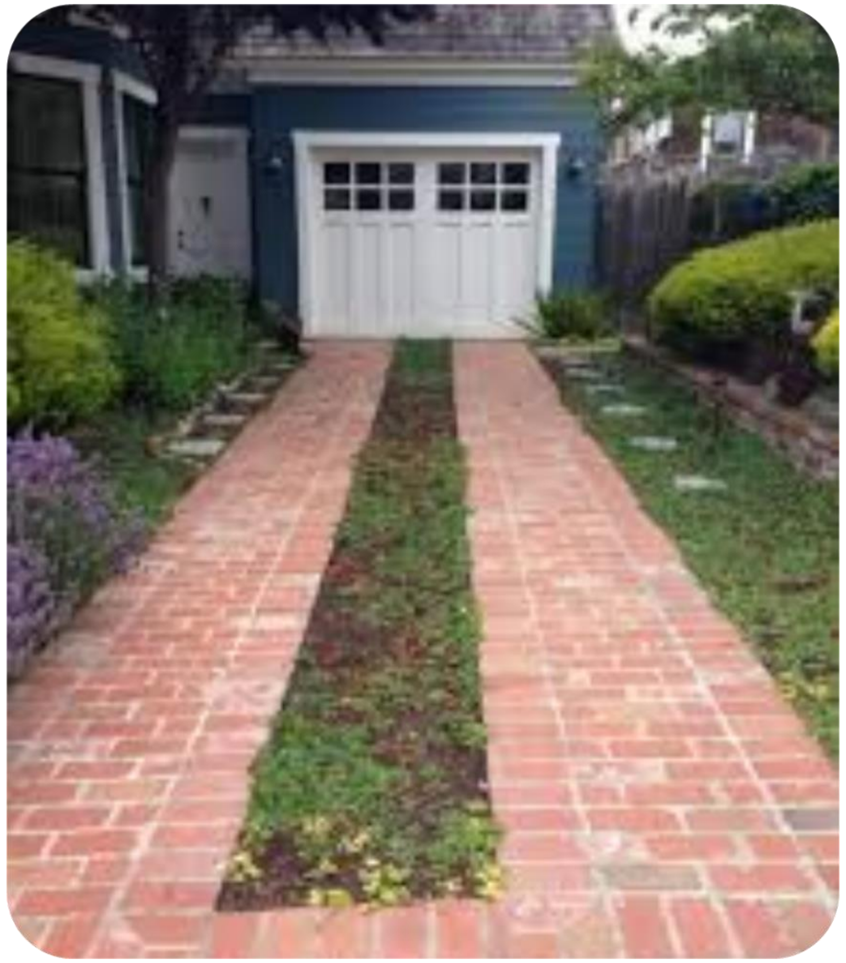
# DEPAVING (REMOVAL OF IMPERVIOUS SURFACES)
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022



Wheel strips replacing fully impervious driveway
Photo accessed on 7/2/2020 from
https://www.cityofpacificgrove.org/

## ACTION DESCRIPTION

Depaving, or removal of impervious surfaces down to bare soil. The area is amended with soil and planted with low lying ground cover. To allow continued site use, the area is retrofit with an alternative treatment (e.g., wheel strip driveways) per King County Surface Water Design Manual, "Reduced Impervious Surface Credit". Provides volume and peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 100 SF |
| Unit Drainage Area [a] | N/A |
| Ponding Depth | 0 in |

N/A: Not Applicable

a. This Action will be modeled in SUSTAIN as a land swap (from an impervious to pervious surface) and not as a Best Management Practice. Therefore, no impervious surface will be directed to the Action area.

## TREATMENT AREAS

Land Uses:
- Residential
- Commercial
- Industrial

Property Types:
- Private Parcel
- Public Parcel

Surface Types:
- Driveways
- Sidewalks
- Parking Lots

## DESIGN ASSUMPTIONS

- Designs based on the *2016 King County Surface Water Design Manual*, "Reduced Impervious Surface Credit" (Appendix C, Section C.2.9).
- For wheel strip driveways, assume 10-foot-wide by 10-foot-long driveway converted to two (2) concrete pavement strips, each 2-feet-wide by 10-feet-long, for a total of 40 square feet impervious area (60% impervious area reduction).
- Restored pervious areas amended with 4 inches of well-rotted compost tilled into the upper 8 inches of the soil.





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# DEPAVING (REMOVAL OF IMPERVIOUS SURFACES)
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022



## SUSTAIN MODEL REPRESENTATION

Hydrologic:
- Change the land cover from existing pollution generating impervious land cover to a land cover representing amended native soil.

Treatment:
- Load reduction would be the result of the differences in pollution generating in surface runoff from the different land surfaces.

## PERFORMANCE PARAMETERS*

| Target Pollutants | Median Percent Removal | Median Effluent Concentration |
|---|---|---|
| Total Copper | -- | -- |
| Dissolved Copper | -- | -- |
| Total Zinc | -- | -- |
| Dissolved Zinc | -- | -- |
| Total Phosphorus | -- | -- |
| Total Nitrogen | -- | -- |
| Total Suspended Solids | -- | -- |
| Total PCBs | -- | -- |
| Total PBDEs | -- | -- |
| Total PAHs | -- | -- |
| Bis(2-ethylhexyl)phthalate | -- | -- |
| Fecal Coliform | -- | -- |

* Performance will be assessed based on conversion of pollutant generating surface to non-pollutant generating surface

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | Driveway Depaving with Wheel Strips | Driveway Depaving without Alternative Surface |
|---|---|---|
| Total Project | $2,000 | $2,000 |
| Total Direct Construction | $1,000 | $1,000 |
| Total Indirect Non-Construction | $1,000 | $1,000 |
| Operation and Maintenance | $600/year | $600/year |
| Property Acquisition [c] | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- The area credited as mitigated must be no more than 10,000 square feet on any one site/lot unless the surface is served by a flow control facility designed by a civil engineer in accordance with Section 1.2.3 of the *2016 King County Surface Water Design Manual.*
- Any runoff from the area credited as mitigated must be directed to vegetated pervious areas on the site/lot or discharged through a perforated pipe connection per Section C.2.11 of the *2016 King County Surface Water Design Manual.*
- Any portion of the area credited as mitigated that is pollution-generating impervious surface must be less than 5,000 square feet on any one site/lot unless the surface is served by a water quality treatment facility designed by a civil engineer in accordance with Section 1.2.8 of the *2016 King County Surface Water Design Manual.*



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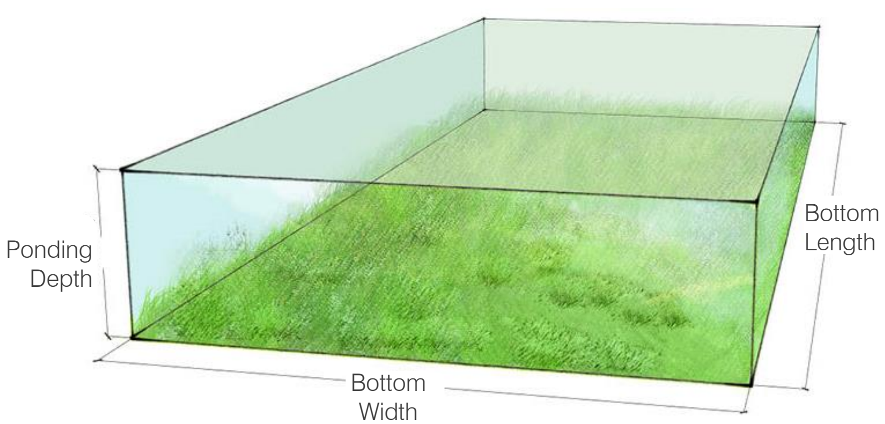
# STORMWATER TREATMENT WETLAND
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022

Photo accessed on 7/2/2020 from
https://www.portseattle.org/projects/wetlands-and-habitat-restoration

### UNIT ACTION SCHEMATIC




### ACTION DESCRIPTION

Similar to a wet pond but also provides a shallow marsh area to allow the establishment of emergent wetland aquatic plants, which improves pollutant removal. Provides water quality treatment and peak flow reduction.

### DESIGN PARAMETERS

| Parameter | Value |
| --- | --- |
| Unit Footprint Area | 503 SF |
| Unit Drainage Area | 62,988 SF |
| Ponding Depth | 48 in |
| Bottom Length | 31.5 ft |
| Bottom Width | 16 ft |
| Side Slope | 3H : 1V |
| Water Quality Design Flow Rate (Off-line) | 0.118 cfs |
| Native Soil Design Infiltration Rate [a] | N/A |

a. Not Applicable, any incidental infiltration to native soils ignored.

### TREATMENT AREAS

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Sidewalks
- Driveway
- Parking Lots
- Local Roads
- Arterial Roads
- Highways

### DESIGN ASSUMPTIONS

- Design and sizing are based on *2016 King County Surface Water Design Manual* Section 6.4.3 “Stormwater Wetlands”.
- Off-line Water Quality Design Flow Rate is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Sized and designed as a Basic facility.
- Two-cell facility includes:
  - Pre-settling cell with volume equal to one-third the volume of the entire facility and minimum sediment storage depth of 1 foot
  - 1-foot freeboard over entire surface area
  - Dividing berm submerged 1 foot below the WQ design water surface
- No infiltration to native soils.
- 12-inch-diameter outlet pipe back-sloped and extended 1 foot below the WQ design water surface.





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# STORMWATER TREATMENT WETLAND
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022

## SUSTAIN MODEL REPRESENTATION

Hydrologic:
- Model explicitly represents ponding and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:
- Water that flows through the Action (up to the water quality design flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (see Performance Parameters table below).

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | Median Effluent Concentration |
|---|---|---|
| Total Copper | 25.0% | 4.7 µg/L |
| Dissolved Copper | 0.0% | 7.8 µg/L |
| Total Zinc | 45.9% | 22.5 µg/L |
| Dissolved Zinc | 0.0% | 17.9 µg/L |
| Total Phosphorus | 24.2% | 0.139 mg-P/L |
| Total Nitrogen | 5.81% | 1.371 mg/L |
| Total Suspended Solids | 52.4% | 17.0 mg/L |
| Total PCBs | 78.1% | 406 pg/L |
| Total PBDEs | 45.1%[a] | 0.043 ng/L[a] |
| Total PAHs | 85.6% | 0.030 µg/L |
| Bis(2-ethylhexyl)phthalate | 42.4%[a] | 0.056 µg/L[a] |
| Fecal Coliform | 19.1% | 1450 CFU |

a. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

## UNIT ACTION COSTS

| Costs/Unit Action[a, b] | On Property with Acquisition | On Property/Highway without Acquisition |
|---|---|---|
| Total Project | $1,489,000 | $642,000 |
| Total Direct Construction | $360,000 | $360,000 |
| Total Indirect Non-Construction | $1,130,000 | $282,000 |
| Operation and Maintenance | $2,300/year | $2,300/year |
| Property Acquisition[c] | $678,000 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.



## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Areas with high winter groundwater levels are ideal for wetland siting.
- Potential site evapotranspiration must be considered as sufficient water must be retained in facility to supply adequate water for aquatic vegetation.
- The pre-settling cell must retain a permanent pool of water throughout the wet season, and the second cell must retain water for at least 10 months of the year.
- Setback required from tract line is 5-feet from emergency overflow water surface.
- Access and maintenance roads are required and must extend to both the wetland inlet and outlet structures.
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 6.2.3 and Section 6.4.2.



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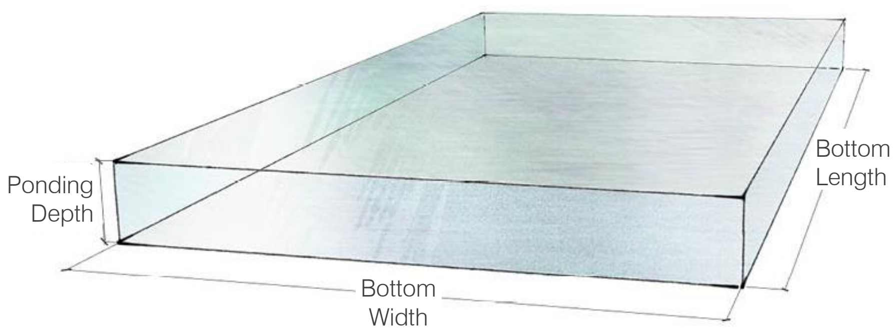
# DETENTION VAULT
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022

Photo accessed on 7/2/2020 from https://csengineermag.com/

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

A box-shaped underground facility that provides temporary storage of stormwater runoff. The stored stormwater runoff is then released through a control structure at an attenuated rate. Provides peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 2,592 SF |
| Unit Drainage Area | 28,658 SF |
| Ponding Depth | 72 in |
| Bottom Length | 54 ft |
| Bottom Width | 48 ft |
| Side Slope | Vertical |
| Orifice Diameter | 1.16 in |
| Orifice Height | 0 ft |
| Notch Width | 0.37 in |
| Notch Height | 2.40 ft |

## TREATMENT AREAS

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads
- Highways

## DESIGN ASSUMPTIONS

- Design is based on *2016 King County Surface Water Design Manual*, "Detention Vaults" (Chapter 5, Section 5.1.3).
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step. The unit Action was sized to meet the Level 2 Flow Control standard with pre-developed forest condition.
- The invert elevation of the outlet is elevated above the bottom of the vault to provide an average 6 inches of sediment storage over the entire bottom.
- The outlet is also elevated a minimum of 2 feet above the orifice to retain oil within the vault.
- Access is provided by a 5-foot by 10-foot removable, locking panel.
- Internal height of 7 feet.





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# DETENTION VAULT

## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

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## SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding and overflow.
- Orifice flow will be represented as a constant outflow rate equal to the water quality design flow rate.

Treatment:

- Water that flows through the orifice will be assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. While not designed for treatment, there will be some pollutant removal via sedimentation (see Performance Parameters table below).

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | Median Effluent Concentration |
| --- | --- | --- |
| Total Copper | 26.2%[b] | 9.5 µg/L[b] |
| Dissolved Copper | 3.23%[b] | 5.3 µg/L[b] |
| Total Zinc | 44.0%[b] | 4[illegible].2 µg/L[b] |
| Dissolved Zinc | 13.6%[b] | 29.5 µg/L[b] |
| Total Phosphorus | 17.7%[b] | 0.[illegible]8 mg-P/L[b] |
| Total Nitrogen | 7.80%[b] | 1.04 mg/L[b] |
| Total Suspended Solids | 57.6%[b] | 25.8 mg/L[b] |
| Total PCBs | 57.6%[a] | 685 pg/L[a] |
| Total PBDEs | 56.9% | 93.5 ng/L |
| Total PAHs | 52.1% | 0.309 µg/L |
| Bis(2-ethylhexyl)phthalate | 46.7%[a] | 0.084 µg/L[a] |
| Fecal Coliform | 31.4%[b] | 2,600 CFU[b] |

a. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.
b. Performance based on detention pond performance which provide similar unit processes for pollutant removal.

## UNIT ACTION COSTS

| Costs/Unit Action[a, b] | On Property with Acquisition | On Property without Acquisition | In Right of Way/ Highway |
| --- | --- | --- | --- |
| Total Project | $6,965,000 | $6,229,000 | $7,603,000 |
| Total Direct Construction | $3,519,000 | $3,519,000 | $4,473,000 |
| Total Indirect Non-Construction | $3,446,000 | $2,710,000 | $3,130,500 |
| Operation and Maintenance | $4,900/year | $4,900/year | $4,900/year |
| Property Acquisition[c] | $589,000 | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.



## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Setbacks to tract/easement lines for vaults shall be 5 feet; adjacent building setback lines shall be 10 feet.
- For privately owned and maintained vaults, building foundations may serve as one or more of the vault walls.



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# DETENTION POND
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

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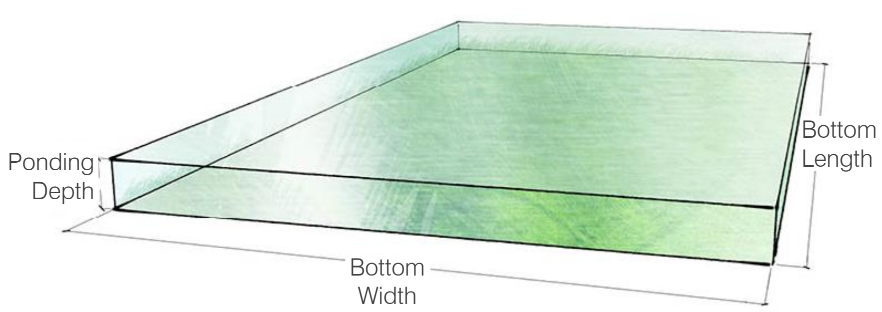
Photo courtesy of Paradigm

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

A surface basin that provides temporary storage of stormwater runoff. The stored stormwater runoff is then released through a control structure at an attenuated rate, allowing the basin to dry out between storm events. Provides peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 4,500 SF |
| Unit Drainage Area | 36,569 SF |
| Ponding Depth | 48 in |
| Bottom Length | 95 ft |
| Bottom Width | 47.4 ft |
| Side Slope | 3H : 1V |
| Orifice Diameter | 1.41 in |
| Orifice Elevation | 0 ft |
| Notch Width | 0.87 in |
| Notch Height | 1.44 ft |

## TREATMENT AREAS

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Local Roads
- Arterial Roads
- Highways

## DESIGN ASSUMPTIONS

- Design is based on *2016 King County Surface Water Design Manual,* Chapter 5, Section 5.1.1 "Detention Ponds".
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region precipitation time series with a 15-minute model time step. The Unit Action was sized to meet the Level 2 Flow Control standard with a pre-developed forest condition.





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# DETENTION POND
## Water Quality Benefits Evaluation Action Fact Sheet

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## SUSTAIN MODEL REPRESENTATION

Hydrologic:
- Model explicitly represents ponding and overflow.
- Orifice flow will be represented as a constant outflow rate equal to the water quality design flow rate.
- Design Parameters were modified to accurately represent the Unit Action's performance in SUSTAIN.

Treatment:
- Water that flows through the orifice will be assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. While not designed for treatment, there will be some pollutant removal via sedimentation (see Performance Parameters table below).

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | Median Effluent Concentration |
|---|---|---|
| Total Copper | 26.2% | 9.5 µg/L |
| Dissolved Copper | 3.23% | 5.3 µg/L |
| Total Zinc | 44.0% | 43.2 µg/L |
| Dissolved Zinc | 13.6% | 29.5 µg/L |
| Total Phosphorus | 17.7% | 0.198 mg-P/L |
| Total Nitrogen | 7.80% | 1.04 mg/L |
| Total Suspended Solids | 57.6% | 25.8 mg/L |
| Total PCBs | 57.6%[a] | 685 pg/L[a] |
| Total PBDEs | 56.9%[b] | 93.5 ng/L[b] |
| Total PAHs | 52.1%[b] | 0.309 µg/L[b] |
| Bis(2-ethylhexyl)phthalate | 46.7%[a] | 0.084 µg/L[a] |
| Fecal Coliform | 31.4% | 2600 CFU |

a. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.
b. Performance based on detention vault performance which provide similar unit processes for pollutant removal.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property with Acquisition | On Property/Highway without Acquisition |
|---|---|---|
| Total Project | $2,443,000 | $1,102,000 |
| Total Direct Construction | $617,000 | $617,000 |
| Total Indirect Non-Construction | $1,826,000 | $484,000 |
| Operation and Maintenance | $9,400/year | $9,400/year |
| Property Acquisition [c] | $1,073,000 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Do not locate in dedicated public road right-of-way.
- Must meet the following setbacks:
  - Tract or property line must be setback 5 feet from the emergency overflow water surface
  - The water surface at the pond outlet invert elevation must be setback 100 feet from proposed or existing septic system drainfields
  - Design water surface must be a minimum of 200 feet from any steep slope hazard area or landslide hazard area
  - Design water surface must be setback a minimum distance from top of slope equal to the total vertical height of a slope area that is steeper than 15%
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 5.1.1.



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# INFILTRATION POND
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

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Photo accessed on 7/2/2020 from https://www.stormwater.pca.state.mn.us

## ACTION DESCRIPTION

A surface basin that temporarily stores stormwater runoff similar to a detention pond, but also provides infiltration. Provides volume and peak flow reduction.

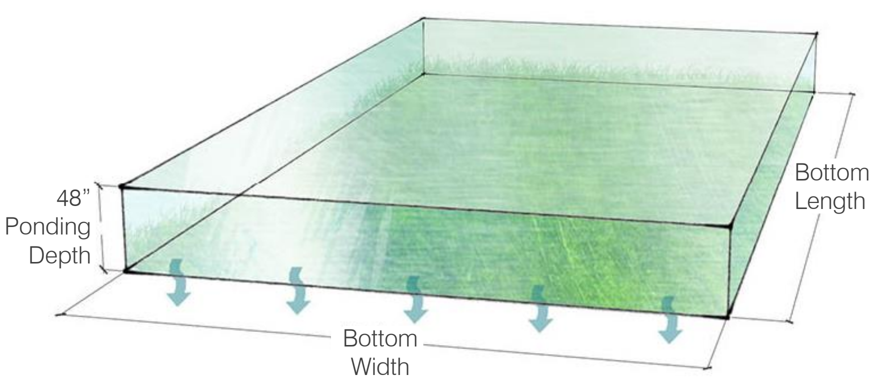
## TREATMENT AREAS

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Local Roads
- Arterial Roads
- Highways

## UNIT ACTION SCHEMATIC




## DESIGN PARAMETERS

| Parameter | Soil Type: Till | Soil Type: Outwash |
|---|---|---|
| Unit Footprint Area | 2,785 SF | 1,479 SF |
| Unit Drainage Area | 36,595 SF | 46,396 SF |
| Ponding Depth | 48 in | 48 in |
| Bottom Length | 74.6 ft | 54.4 ft |
| Bottom Width | 37.3 ft | 27.2 ft |
| Side Slope | 3H : 1V | 3H : 1V |
| Native Soil Design Infiltration Rate | 0.3 in/hr | 2.5 in/hr |

## DESIGN ASSUMPTIONS

- Design based on *2016 King County Surface Water Design Manual* Chapter 5, Section 5.2.2 “Infiltration Ponds”
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region precipitation time series with a 15-minute model time step. The Unit Action was sized to meet the Level 2 Flow Control standard with a pre-developed forest condition.
- Length-to-width ratio assumed to be 2:1
- Pre-treatment via upstream treatment Action will be provided
- Maintenance access roads must be provided to the control structure and other drainage structures associated with the pond
- An overflow structure and emergency spillway shall be provided



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# INFILTRATION POND
## Water Quality Benefits Evaluation Action Fact Sheet

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## SUSTAIN MODEL REPRESENTATION

Hydrologic:
- Model explicitly represents ponding, infiltration, and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:
- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | Median Effluent Concentration |
|---|---|---|
| Total Copper | N/A | N/A |
| Dissolved Copper | N/A | N/A |
| Total Zinc | N/A | N/A |
| Dissolved Zinc | N/A | N/A |
| Total Phosphorus | N/A | N/A |
| Total Nitrogen | N/A | N/A |
| Total Suspended Solids | N/A | N/A |
| Total PCBs | N/A | N/A |
| Total PBDEs | N/A | N/A |
| Total PAHs | N/A | N/A |
| Bis(2-ethylhexyl)phthalate | N/A | N/A |
| Fecal Coliform | N/A | N/A |

N/A: Not applicable. See model representation treatment section.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property with Acquisition | | On Property/Highway without Acquisition | |
|---|---|---|---|---|
| | In Till Soil | In Outwash Soil | In Till Soil | In Outwash Soil |
| Total Project | $1,834,000 | $1,758,000 | $705,000 | $629,000 |
| Total Direct Construction | $395,000 | $352,000 | $395,000 | $352,000 |
| Total Indirect Non-Construction | $1,439,000 | $1,405,000 | $310,000 | $276,000 |
| Operation and Maintenance | $5,500/year | $3,500/year | $5,500/year | $3,500/year |
| Property Acquisition [c] | $903,000 | $903,000 | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Not allowed on slopes greater than 25% (4H:1V).
- Must meet infiltration siting restrictions, including setbacks:
  - The tract, easement or property line must be set back 5 feet from the emergency overflow water surface
  - Design water surface must be set back 100 feet from proposed or existing septic system drainfields
  - Design water surface must be minimum 200 feet from any steep slope hazard area or landslide hazard area
  - Design water surface must be set back 20 feet from external tract, easement or property lines
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 5.2.2.





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# INFILTRATION VAULT
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

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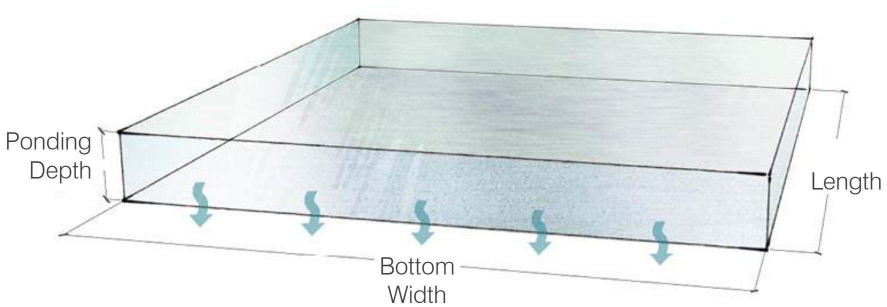
City of Redmond Overlake Village Infiltration Vault
Photo accessed on 7/2/2020 from
https://content.govdelivery.com/accounts/WAREDMOND/bulletins/1e5d116

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

An open bottomed, box-shaped underground facility that stores stormwater runoff similar to detention vaults, but also provides infiltration via an open bottom. Provides volume reduction and peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Soil Type: Till | Soil Type: Outwash |
|---|---|---|
| Unit Footprint Area | 1,836 SF | 1,156 SF |
| Unit Drainage Area | 28,719 SF | 39,365 SF |
| Ponding Depth | 72 in | 72 in |
| Bottom Length | 51 ft | 34 ft |
| Bottom Width | 36 ft | 34 ft |
| Side Slope | Vertical | Vertical |
| Native Soil Design Infiltration Rate | 0.3 in/hr | 2.5 in/hr |

## TREATMENT AREAS

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads
- Highways

## DESIGN ASSUMPTIONS

- Design based on *2016 King County Surface Water Design Manual* Chapter 5, Section 5.2.4 "Infiltration Vaults".
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region precipitation time series with a 15-minute model time step. The Unit Action was sized to meet the Level 2 Flow Control standard with a pre-developed forest condition.
- Pre-treatment via upstream treatment Action will be provided.
- Designs include a solid bottom riser (with clean-out gate) and outflow system for safely discharging overflows to the downstream conveyance system or acceptable discharge point.
- Energy dissipation at the inlet is required to prevent scour and will be accomplished by using the detail for the sand filter vault (see Figure 6.5.3.A in the 2016 King County Surface Water Design Manual).
- Access roads are required to the vault access panel.





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# INFILTRATION VAULT
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## SUSTAIN MODEL REPRESENTATION

Hydrologic:
- Model explicitly represents ponding, infiltration, and overflow.

Treatment:
- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | Median Effluent Concentration |
|---|---|---|
| Total Copper | N/A | N/A |
| Dissolved Copper | N/A | N/A |
| Total Zinc | N/A | N/A |
| Dissolved Zinc | N/A | N/A |
| Total Phosphorus | N/A | N/A |
| Total Nitrogen | N/A | N/A |
| Total Suspended Solids | N/A | N/A |
| Total PCBs | N/A | N/A |
| Total PBDEs | N/A | N/A |
| Total PAHs | N/A | N/A |
| Bis(2-ethylhexyl)phthalate | N/A | N/A |
| Fecal Coliform | N/A | N/A |

N/A: Not applicable. See model representation treatment section.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property with Acquisition | | On Property without Acquisition | | In Right of Way/ Highway | |
|---|---|---|---|---|---|---|
| | In Till Soil | In Outwash Soil | In Till Soil | In Outwash Soil | In Till Soil | In Outwash Soil |
| Total Project | $5,256,000 | $4,238,000 | $4,589,000 | $3,572,000 | $5,253,000 | $4,120,000 |
| Total Direct Construction | $2,577,000 | $2,009,000 | $2,577,000 | $2,009,000 | $3,008,000 | $2,351,000 |
| Total Indirect Non-Construction | $2,679,000 | $2,229,000 | $2,012,000 | $1,562,000 | $2,245,000 | $1,769,000 |
| Operation and Maintenance | $4,900/year | $4,900/year | $4,900/year | $4,900/year | $4,900/year | $4,900/year |
| Property Acquisition [c] | $533,000 | $533,000 | $0 | $0 | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- The proposed vault bottom shall be at least 3 feet above the seasonal high groundwater level and have at least 3 feet of permeable soil beneath the bottom.
- Not allowed on slopes greater than 25% (4H:1V).
- Must meet infiltration siting restrictions, including setbacks:
  - The tract, easement or property line must be set back 5 feet from the emergency overflow water surface
  - Design water surface must be set back 100 feet from proposed or existing septic system drainfields
  - Design water surface must be minimum 200 feet from any steep slope hazard area or landslide hazard area
  - Design water surface must be set back 20 feet from external tract, easement or property lines
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 5.2.4.



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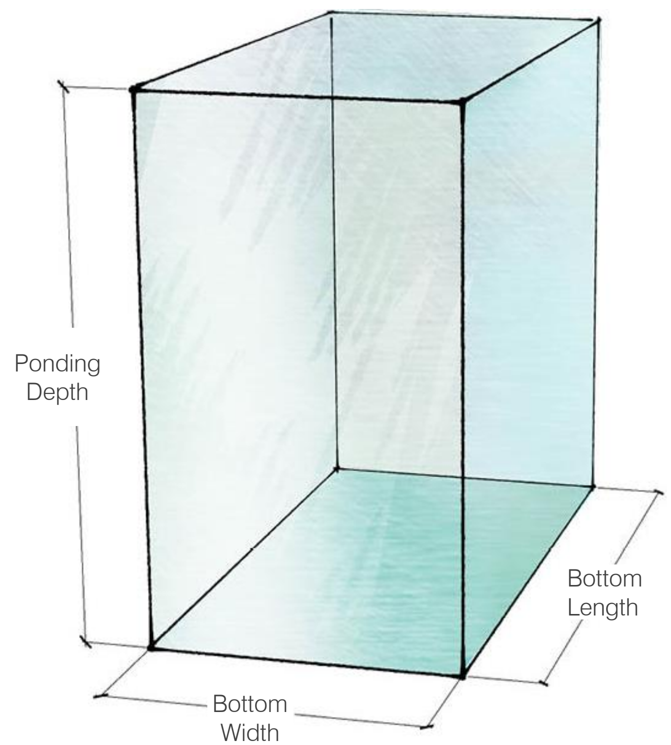
Freeland RainCatchers
Photo courtesy of RKI

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

A tank designed to provide temporary storage and slow release of rooftop stormwater runoff. Provides peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 18 SF |
| Unit Drainage Area | 1,300 SF |
| Ponding Depth | 60 in |
| Bottom Length | 6 ft |
| Bottom Width | 3 ft |
| Orifice Diameter | 0.25 in |
| Orifice Elevation | 4 in |

## TREATMENT AREAS

**Land Uses:**
- Residential
- Commercial
- Industrial

**Property Types:**
- Private Parcel
- Public Parcel

**Surface Types:**
- Roofs

## DESIGN ASSUMPTIONS

- Design is based on *2017 Seattle SW Manual*, Volume 3 Section 5.5.2 "Single Family Residential (SFR) Cisterns".
- Sizing is based on sizing factors for the On-site Performance Standard from the *2017 Seattle Stormwater Manual* Section 5.5.2.6.
- Flow control orifice assumed to be 0.25-inch-diameter at 4-inch-elevation.
- Designs include a filter screen or other debris barrier to prevent insects, leaves, and other larger debris from entering the system.
- Overflow conveyance to an approved discharge or another Action (e.g., bioretention installation, etc.) provided by gravity flow pipe.



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# CISTERN
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

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### SUSTAIN MODEL REPRESENTATION

Hydrologic:
- Model explicitly represents ponding, orifice flow, and overflow.

Treatment:
- Model will assume no treatment provided unless Program includes manual operation of orifice valve by property owner.

### PERFORMANCE PARAMETERS*

| Target Pollutants | Median Percent Removal | Median Effluent Concentration |
|---|---|---|
| Total Copper | -- | -- |
| Dissolved Copper | -- | -- |
| Total Zinc | -- | -- |
| Dissolved Zinc | -- | -- |
| Total Phosphorus | -- | -- |
| Total Nitrogen | -- | -- |
| Total Suspended Solids | -- | -- |
| Total PCBs | -- | -- |
| Total PBDEs | -- | -- |
| Total PAHs | -- | -- |
| Bis(2-ethylhexyl)phthalate | -- | -- |
| Fecal Coliform | -- | -- |

* Action provides negligible water quality benefit

### UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property without Acquisition |
|---|---|
| Total Project | $26,000 |
| Total Direct Construction | $18,000 |
| Total Indirect Non-Construction | $8,000 |
| Operation and Maintenance | $2,100/year |
| Property Acquisition [c] | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.

### PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Contributing drainage areas must not be pollution-generating.
- Cisterns are subject to local code requirements, such as Seattle Municipal Code Title 23 – Land Use Code due to height in excess of 4.5 feet.
- Rainwater shall be used for outdoor irrigation uses only.
- Additional feasibility and siting considerations can be found in the *2017 Seattle Stormwater Manual* Volume 3 Section 5.5.2 and Appendix C.



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# WETPOND
## Water Quality Benefits Evaluation Action Fact Sheet

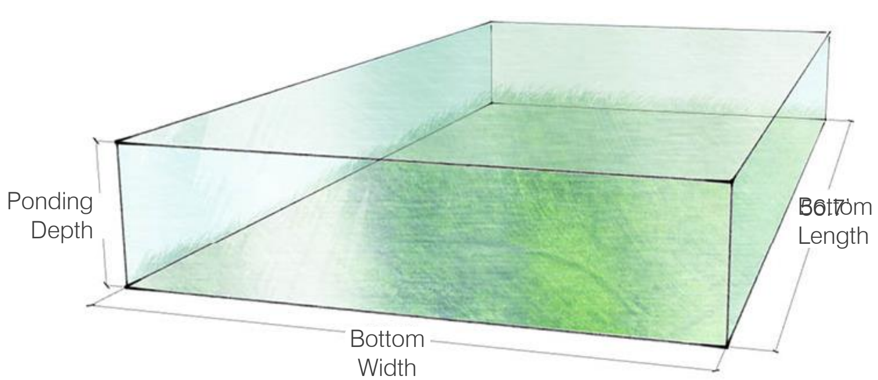
Phase 2

01/14/2022



Photo accessed on 7/2/2020 from
https://www.redmond.gov/487/Stormwater-Ponds

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

A constructed stormwater pond that retains a permanent pool of water ("wetpool"), at least during the wet season, for settling of particulate pollutants. Provides water quality treatment and peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 553 SF |
| Unit Drainage Area | 63,075 SF |
| Ponding Depth | 48 in |
| Bottom Length | 33.3 ft |
| Bottom Width | 16.6 ft |
| Side Slope | 3H : 1V |
| Water Quality Design Flow Rate (Off-line) | 0.118 cfs |

## TREATMENT AREAS

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Sidewalks
- Driveway
- Parking Lots
- Local Roads
- Arterial Roads
- Highways

## DESIGN ASSUMPTIONS

- Design and sizing are based on *2016 King County Surface Water Design Manual* Section 6.4.1 "Wetponds".
- Sized as Basic facility.
- Off-line design assumes flow splitter will be used to divert flows up to the Water Quality Design Flow Rate to the Action.
- Off-line Water Quality Design Flow Rate is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Two-celled facility:
  - Pre-settling cell requires minimum sediment storage depth of 1-foot
  - Diving berm is submerged 1-foot below the Water Quality design water surface
- No infiltration to surrounding soils.
- 12-inch-diameter outlet pipe back-sloped and extended 1 foot below the WQ design water surface.



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## SUSTAIN MODEL REPRESENTATION

Hydrologic:
- Model explicitly represents ponding and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:
- Water that flows through the Action (up to the water quality design flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (see Performance Parameters table below).

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | Median Effluent Concentration |
|---|---|---|
| Total Copper | 45.0% | 6.0 µg/L |
| Dissolved Copper | 22.7% | 4.3 µg/L |
| Total Zinc | 62.5% | 24.2 µg/L |
| Dissolved Zinc | 36.8% | 19.6 µg/L |
| Total Phosphorus | 49.5% | 0.177 mg-P/L |
| Total Nitrogen | 27.6% | 1.260 mg/L |
| Total Suspended Solids | 76.2% | 16.7 mg/L |
| Total PCBs | 76.2%[a] | 443 pg/L[a] |
| Total PBDEs | 65.5%[a] | 0.042 ng/L[a] |
| Total PAHs | 76.2%[a] | 0.0021 µg/L[a] |
| Bis(2-ethylhexyl)phthalate | 61.7%[a] | 0.055 µg/L[a] |
| Fecal Coliform | 60.0% | 2381 CFU |

a. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

## UNIT ACTION COSTS

| Costs/Unit Action[a, b] | On Property with Acquisition | On Property/Highway without Acquisition |
|---|---|---|
| Total Project | $1,581,000 | $683,000 |
| Total Direct Construction | $383,000 | $383,000 |
| Total Indirect Non-Construction | $1,198,000 | $300,000 |
| Operation and Maintenance | $2,000/year | $2,000/year |
| Property Acquisition[c] | $718,000 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.



## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Both cells of the wetpond must retain a permanent pool of water throughout the wet season.
- Setback is required from tract line is 5 feet from emergency overflow water surface.
- Access and maintenance roads are required and must extend to both the wetpond inlet and outlet structures.
- See comprehensive list of infeasibility criteria in Section 6.2.3 and Section 6.4.1.2 of the *2016 King County Surface Water Design Manual.*



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# WETVAULT
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022



Photo accessed on 7/2/2020 from:
http://romtecutilities.com/wet-dry-panel-vault-installation

## ACTION DESCRIPTION

An underground structure similar to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants. Provides water quality treatment and peak flow reduction.

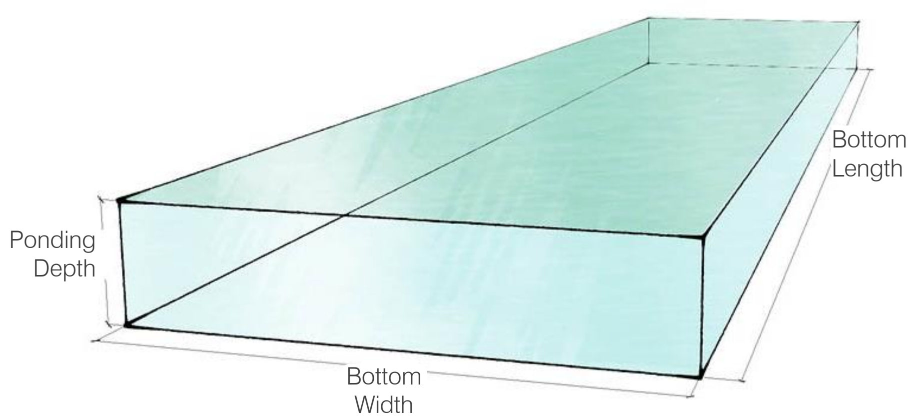
## TREATMENT AREAS

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads
- Highways

## UNIT ACTION SCHEMATIC




## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 1,615 SF |
| Unit Drainage Area | 63,010 SF |
| Ponding Depth | 48 in |
| Bottom Length | 80 ft |
| Bottom Width | 20.2 ft |
| Side Slope | Vertical |
| Water Quality Design Flow Rate (Off-line) | 0.118 cfs |

## DESIGN ASSUMPTIONS

- Design and sizing are based on *2016 King County Surface Water Design Manual* Section 6.4.2 “Basic Wetvaults”.
- Off-line Water Quality Design Flow Rate is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Off-line design assumes flow splitter will be used to divert flows up to the Water Quality (WQ) Design Flow Rate to the Action
- Additional minimum sediment storage of 6 inches required.
- Two-celled facility with cells separated by baffle wall.
- Lockable grates instead of solid manhole covers included in design to increase air contact with the wetpool.
- 12-inch-diameter outlet pipe back-sloped and extended 1 foot below the WQ design water surface.
- 8-inch-diameter gravity drain controlled by a valve.



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# WETVAULT
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022



## SUSTAIN MODEL REPRESENTATION

Hydrologic:
- Model explicitly represents ponding and overflow.

Treatment:
- Water that flows through the Action (up to the water quality design flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (see Performance Parameters table below).

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | Median Effluent Concentration |
|---|---|---|
| Total Copper | 45.0%[b] | 6.0 µg/L[b] |
| Dissolved Copper | 22.7%[b] | 4.3 µg/L[b] |
| Total Zinc | 62.5%[b] | 24.2 µg/L[b] |
| Dissolved Zinc | 36.8%[b] | 19.6 µg/L[b] |
| Total Phosphorus | 49.5%[b] | 0.177 mg-P/L[b] |
| Total Nitrogen | 27.6%[b] | 1.260 mg/L[b] |
| Total Suspended Solids | 76.2%[b] | 16.7 mg/L[b] |
| Total PCBs | 76.2%[a] | 443 pg/L[a] |
| Total PBDEs | 65.5%[a] | 0.042 ng/L[a] |
| Total PAHs | 76.2%[a] | 0.0021 µg/L[a] |
| Bis(2-ethylhexyl)phthalate | 61.7%[a] | 0.055 µg/L[a] |
| Fecal Coliform | 60.0%[b] | 2381 CFU[b] |

a. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.
b. Performance based on wet pond performance which provide similar unit processes for pollutant removal.

## UNIT ACTION COSTS

| Costs/Unit Action[a, b] | On Property with Acquisition | On Property without Acquisition | In Right of Way/ Highway |
|---|---|---|---|
| Total Project | $5,728,000 | $5,055,000 | $5,806,000 |
| Total Direct Construction | $2,852,000 | $2,852,000 | $3,314,000 |
| Total Indirect Non-Construction | $2,876,000 | $2,203,000 | $2,493,000 |
| Operation and Maintenance | $2,900/year | $2,900/year | $2,900/year |
| Property Acquisition[c] | $538,000 | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Relatively small catchments (less than 10 acres of impervious surface) with high land values typically most practical because vaults are relatively expensive.
- Must have a flow length-to-width ratio greater than 3:1 minimum.
- 5-foot setback to tract/easement lines required.
- 10-foot setback for buildings adjacent to the vault required.
- For privately owned and maintained vaults, building foundations may serve as one or more of the vault walls.
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 5.1.3 and Section 6.4.



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# HIGH RATE UNDERGROUND FILTER SYSTEM
## Water Quality Benefits Evaluation Action Fact Sheet

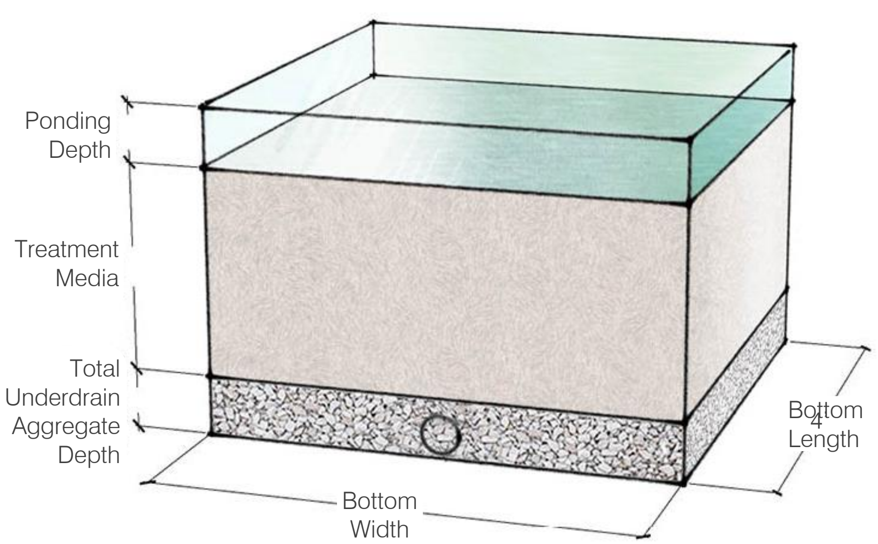
Phase 2

01/14/2022




Filterra® Bioretention System
Photo accessed on 7/2/2020 from
www.conteches.com

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in highly urbanized settings and may be proprietary. Provides water quality treatment.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 16 SF |
| Unit Drainage Area | 34,956 SF |
| Ponding Depth | 2 in |
| Bottom Length | 4 ft |
| Bottom Width | 4 ft |
| Side Slope | Vertical |
| Treatment Media Depth | 21 in |
| Treatment Media Porosity | 40% |
| Treatment Media Design Infiltration Rate | 175 in/hr |
| Total Underdrain Aggregate Depth | 6 in |
| Underdrain Invert Height | 0 in |
| Underdrain Diameter | 4 in |
| Underdrain Aggregate Porosity | 40% |
| Native Soil Design Infiltration Rate [a] | N/A |
| Water Quality Design Flow Rate (Off-line) | 0.081 cfs |

N/A: Not Applicable

a. Liner prevents infiltration to native soil

## TREATMENT AREAS

**Land Uses:**
- Commercial
- Industrial
- Highway

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads

## DESIGN ASSUMPTIONS

- Design is based on standards for Contech® Filterra® Bioscape External Bypass configuration.
- Sizing is based on Washington Department of Ecology (Ecology) General Use Level Designation (GULD) approved infiltration rate of 175 inches/hour for Enhanced Water Quality Treatment.
- Off-line Water Quality Design Flow Rate based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Proprietary Filterra® engineered media assumed. Other proprietary media and facilities may be used. Refer to Ecology's Emerging stormwater treatment technologies (TAPE) for a full list of GULD approved media for Enhanced Water Quality Treatment.
- No infiltration to native soil.



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# HIGH RATE UNDERGROUND FILTER SYSTEM

## Water Quality Benefits Evaluation Action Fact Sheet

01/14/2022



## SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, underdrain flow, and overflow.

Treatment:

- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal [a] | Median Effluent Concentration [a] |
|---|---|---|
| Total Copper | 47.9% | 4.1 mg/L |
| Dissolved Copper | 34.0% | 3.5 mg/L |
| Total Zinc | 55.6% | 52.3 mg/L |
| Dissolved Zinc | 54.0% | 78.0 mg/L |
| Total Phosphorus | 41.5% | 0.046 mg-P/L |
| Total Nitrogen | 34.4% | 0.525 mg/L |
| Total Suspended Solids | 86.6% | 3.6 mg/L |
| Total PCBs | 90.0% | 3,199 pg/L |
| Total PBDEs | 74.5%[b] | 0.0090 ng/L[b] |
| Total PAHs | 86.6%[b] | 0.00045 µg/L[b] |
| Bis(2-ethylhexyl)phthalate | 70.2%[b] | 0.012 µg/L[b] |
| Fecal Coliform | NF | NF |

NF: No data found
a. Performance based on proprietary Filterra® engineered media.
b. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property | | Public Right of Way with Portland Cement Concrete Pavements | | Public Right of Way with Hot Mix Asphalts | |
|---|---|---|---|---|---|---|
| | With Acquisition | Without Acquisition | Urban ROW | Highway ROW | Urban ROW | Highway ROW |
| Total Project | $107,000 | $106,000 | $195,000 | $145,000 | $140,000 | $129,000 |
| Total Direct Construction | $64,000 | $64,000 | $120,000 | $89,000 | $86,000 | $79,000 |
| Total Indirect Non-Construction | $43,000 | $42,000 | $75,000 | $56,000 | $54,000 | $50,000 |
| Operation and Maintenance | $2,900/year | $2,900/year | $2,900/year | $2,900/year | $2,900/year | $2,900/year |
| Property Acquisition [c] | $900 | $0 | $0 | $0 | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Must be designed, assembled, installed, operated and maintained according to the manufacturer's manuals, documents, and Ecology GULD approval.
- The distance from the point of entry of water to the most distant point on the surface of the treatment media shall not exceed 12-feet.
- 5-foot setback to tract/easement lines.
- 10-foot setback for buildings adjacent to stormwater facility.
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 5.1.3 and Section 6.7.



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# REGIONAL VEGETATED MEDIA FILTRATION FACILTY
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022



Manchester Stormwater Park
Photo accessed on 7/2/2020 from
http://nwcascade.com/projects/manchester-stormwater-park/

## ACTION DESCRIPTION

A large-scale vegetated media filtration facility designed to treat stormwater runoff from a large drainage area. Provides water quality treatment.

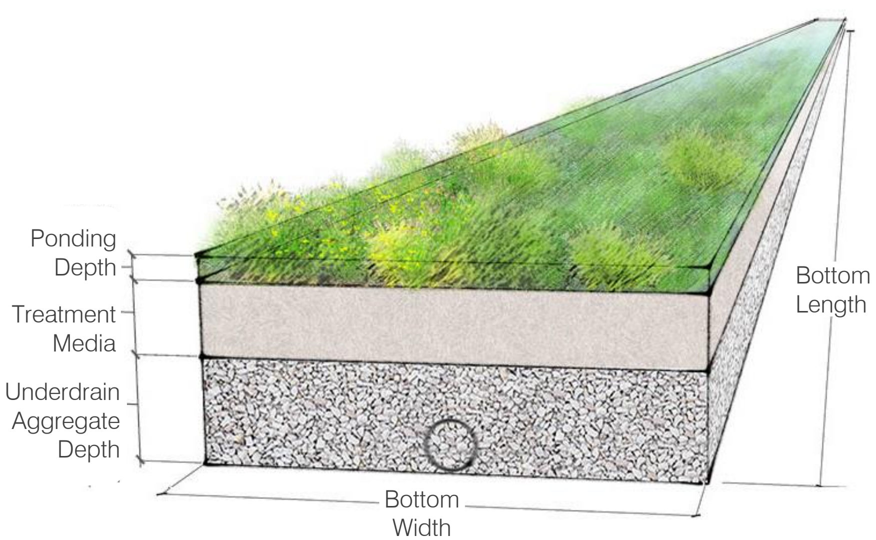
## TREATMENT AREAS

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural
- Forest

**Property Types:**
- Private Parcel
- Public Parcel

**Surface Types:**
- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads
- Highways

## UNIT ACTION SCHEMATIC




## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 5,940 SF |
| Unit Drainage Area | 17,249,760 SF |
| Ponding Depth | 8.4 in |
| Bottom Length | 84.9 ft |
| Bottom Width | 70 ft |
| Treatment Media Depth | 21.6 in |
| Treatment Media Porosity | 40% |
| Treatment Media Design Infiltration Rate | 175 in/hr |
| Total Underdrain Aggregate Depth | 18 in |
| Underdrain Invert Height | 0 in |
| Underdrain Diameter | 12 in |
| Underdrain Aggregate Porosity | 40% |
| Native Soil Design Infiltration Rate [a] | N/A |

N/A: Not Applicable

a. Liner prevents infiltration to native soil

## DESIGN ASSUMPTIONS

- Design based on *Kitsap County Manchester Stormwater Retrofit Drainage Report, April 2014* (Manchester).
- Manchester design used proprietary Filterra® treatment media. Refer to Ecology's Emerging stormwater treatment technologies (TAPE) website for additional media types that are General Use Level Designation (GULD) approved for Enhanced Water Quality Treatment.
- Unit Footprint Area matches Manchester design bottom footprint area.
- Unit Drainage Area based on Manchester contributing drainage area, scaled as follows:
  - Scaled up by factor of approximately 7 based on the ratio of Ecology's currently approved GULD infiltration rate for Filterra® media for Enhanced Water Quality Treatment of 175 inches/hour to the infiltration rate of 24.8 inches/hour used for Manchester design
  - Scaled down by factor of safety of 1.3 to account for commercial and transportation areas within the Manchester contributing drainage area
- No infiltration to native soil (Manchester facility is concrete-lined).

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# REGIONAL VEGETATED MEDIA FILTRATION FACILTY
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022

## SUSTAIN MODEL REPRESENTATION

Hydrologic:
- Model explicitly represents ponding, underdrain flow, and overflow.

Treatment:
- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).

## PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal [a] | Median Effluent Concentration [a] |
|---|---|---|
| Total Copper | 47.9% | 4.1 mg/L |
| Dissolved Copper | 34.0% | 3.5 mg/L |
| Total Zinc | 55.6% | 52.3 mg/L |
| Dissolved Zinc | 54.0% | 78.0 mg/L |
| Total Phosphorus | 41.5% | 0.046 mg-P/L |
| Total Nitrogen | 34.4% | 0.525 mg/L |
| Total Suspended Solids | 86.6% | 3.6 mg/L |
| Total PCBs | 90.0% | 3,199 pg/L |
| Total PBDEs | 74.5%[b] | 0.0090 ng/L[b] |
| Total PAHs | 86.6%[b] | 0.00045 µg/L[b] |
| Bis(2-ethylhexyl)phthalate | 70.2%[b] | 0.012 µg/L[b] |
| Fecal Coliform | NF | NF |

NF: No data found
a. Performance based on proprietary Filterra® engineered media.
b. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property with Acquisition | On Property without Acquisition |
|---|---|---|
| Total Project | $7,224,000 | $6,038,000 |
| Total Direct Construction | $2,965,000 | $2,965,000 |
| Total Indirect Non-Construction | $4,259,000 | $3,073,000 |
| Operation and Maintenance | $12,000/year | $12,000/year |
| Property Acquisition [c] | $910,760 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.



## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Must be designed, assembled, installed, operated and maintained according to the manufacturer's manuals, documents, and Ecology GULD approval.
- The distance from the point of entry of water to the most distant point on the surface of the treatment media shall not exceed 12-feet.
- 5-foot setback to tract/easement lines.
- 10-foot setback for buildings adjacent to stormwater facility.
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 6.7.



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## ATTACHMENT B

Decision Log

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## King County Water Quality Benefits Evaluation, Phase 2

Decision Log

| Decision | | | | | Approved by Design Team | | |
|---|---|---|---|---|---|---|---|
| Decision No. | Date | Topic | Description | Lead | Yes/No | Comments | Date |
| 1 | 3/25/2021 | Model time step | Use 15-min time steps for all modeling in MGSFlood, per KCSWDM Ch 6.2.1. | RKI | Yes | Design Team Meeting | 3/25/2021 |
| 2 | 3/25/2021 | Level 2 Flow Control | For Actions sized to Level 2 Flow Control in Phase I, model post-developed drainage area as impervious only (vs KC WRIA 9 land use used in Phase I) and seek to hold the Action size equal to the Phase I sizing, while altering the contributing drainage area, in order to maintain Phase I costs if practicable. | RKI | Yes | Design Team Meeting | 3/25/2021 |
| 3 | 3/25/2021 | Pre-treatment standard | OUTSTANDING ITEM: Revisit pre-treatment standard for pre-treatment Actions at a later date | HEC | Yes | Design Team Meeting; no longer outstanding (see Decision #21) | 3/25/2021 |
| 4 | 3/25/2021 | Model version | To model rain garden, bioretention and bioretention planter, use original Bioretention model in MGSFlood instead of beta Ecology bioretention module. Discussed that this means the storage/infiltration benefits associated with elevated underdrains will be neglected. | RKI | Yes | Design Team Meeting | 3/25/2021 |
| 5 | 3/25/2021 | Action modeling | Model rain gardens with a 12-in soil layer with 25% porosity (Phase I) and 6 in/hr infiltration rate | RKI | Yes | Design Team Meeting; Phase I assumed 3" compost tilled into 8" native soil. Increasing tilling depth will not affect basis of estimate. | 3/25/2021 |
| 6 | 3/25/2021 | Action modeling | Do not include the rain garden area as part of the contributing drainage area (i.e., postdeveloped simulations will have larger total drainage area than predeveloped simulations). This is the default setting, post developed area will not need to be modified in MGSFlood. | RKI | Yes | Design Team Meeting, agreed upon decision based on the City of Seattle Stormwater Manual using the same assumption in developing sizing factors for designers to use. | 3/25/2021 |
| 7 | 3/25/2021 | Level 2 Flow Control | For Actions sized for Level 2 Flow Control, assume till soils for pre-developed drainage basin (even for infiltration-based Actions in outwash soils). This decision was made for consistency with Phase I and to acknowledge that soil conditions across a contributing drainage area may vary from the soil conditions at the Action site itself. | RKI | Yes | Agreed upon with Jeff Burkey via email | 3/31/2021 |
| 8 | 3/25/2021 | Action modeling | Model drywell as an infiltration pond, using equivalent depth to address gravel porosity in drywell (i.e., 40% porosity X 6-ft depth = 2.4-ft equivalent depth) | RKI | Yes | Design Team Meeting; Modeling as an infiltration trench produces computational errors in MGSFlood | 3/25/2021 |
| 9 | 3/25/2021 | Action modeling | Do not explicitly model permeable pavement; the Action will be designed to the King County standard and thus will treat to the required standard. Confirm standard section will meet the KC standard so that the costs are based on the corerct section design. | RKI | Yes | Design Team Meeting | 3/25/2021 |
| 10 | 3/25/2021 | Action modeling | Update modeled Length:Width ratios to match HDR's cost spreadsheets from Phase I | RKI | Yes | Design Team Meeting | 3/25/2021 |

## King County Water Quality Benefits Evaluation, Phase 2

Decision Log

| Decision | | | | | Approved by Design Team | | |
|---|---|---|---|---|---|---|---|
| Decision No. | Date | Topic | Description | Lead | Yes/No | Comments | Date |
| 11 | 3/25/2021 | Action modeling | Model drywell and cistern to Modified Level 1 Flow Control Standard (i.e., match the 2- and 10-year peak discharge rates from pre-developed forested to post developed) | RKI | Yes | Agreed upon with Jeff Burkey via email. Determined, however, during preliminary modeling, that the standard is impracticable for cisterns. Therefore, maintained the Phase 1 sizing for cisterns. See Decision #18. | 3/31/2021 |
| 12 | 3/25/2021 | Action modeling | Assume 6-in freeboard for bioretention planter (minimum required for King County) | RKI | Yes | Design team meeting; Phase I HDR cost spreadsheet assumed 12-inch freeboard | 3/25/2021 |
| 13 | 4/2/2021 | Action modeling | RKI to use low (32in) and high values (60in) for Puget East climate region in MGSFlood. RKI to produce relationships between Mean Annual Precipitation and Contributing Drainage Area for the affected Actions (all Actions being explicitly modeled). | RKI | Yes | Modeling Team Meeting | 4/2/2021 |
| 14 | 4/14/2021 | Action modeling | Use 0.5-in minimum diameter orifice for flow control facilities. | HEC | Yes | Originally we assumed o.25" minimum diameter orifice for flow control facilities based on KCSWDM Ch 5.1.4.1 Control Structures, Design Criteria, however after team discussion we noted that 0.5-in is more realistic regarding the Actions' drainage areas. | 4/14/2021 |
| 15 | 4/22/2021 | Action modeling | **Revision to Decision #4 (3/25/2021):** We ran a test to model the area underneath the underdrain as an infiltration trench upstream of the bioretention facility. The results indicated 7% additional contributing area could be treated when you account for the elevated underdrain by modeling in this way. To achieve the benefits of the elevated underdrain, a site would have to be relatively flat (i.e., <2%) or have subsurface weirs installed, which was not accounted for in the costs. Therefore, partial credit of 5% will be provided. | RKI | Yes | Design Team Meeting | 4/28/2021 |
| 16 | 4/28/2021 | Action Modeling | **Revision to Decision #13 (4/2/2021):** Based on Climate Region sensitivity analysis in MGSFlood, RKI to use Puget East 32, Puget East 40, and Puget East 60 MAP factors for low-, mid- and high- climate region factor values in MGSFlood. | RKI | Yes | Design Team Meeting | 4/28/2021 |

## King County Water Quality Benefits Evaluation, Phase 2

Decision Log

| Decision | | | | | Approved by Design Team | | |
|---|---|---|---|---|---|---|---|
| Decision No. | Date | Topic | Description | Lead | Yes/No | Comments | Date |
| 17 | 4/29/2021 | Action Modeling | For Infiltration Actions with sideslopes (bioretention, rain garden, infiltration ponds), these trapezoidal Actions will be modeled in MGSFlood to meet required standard, then transformed into a rectangular facility to represent a SUSTAIN model input. Transformation will occur by adjusting the ponding depth and bottom area in order to maintain the total volume (ponded + void volume) and the wetted perimeter consistent with the unaltered design cross-section. For non-infiltrating Actions with sideslopes, the transformation to a rectangular facility will occur by holding the total volume consistent during the transformation, and bottom footprint will be the average of the ponded and bottom area from the trapezoidal representation. For both types of Actions (infiltrating and non-infiltrating), after the transformation, bottom areas will be adjusted to meet the required standard (e.g., Basic Water Quality or Level 2 Flow Control) | RKI | Yes | Modeling Team Meeting | 4/29/2021 |
| 18 | 4/29/2021 | Action Modeling | **Revision to Decision #11 (3/25/2021):** Phase 1 sizing factors for cisterns (sized for Seattle Peak Control Standard) will be used for sizing in Phase 2 instead of explicitly modeling in MGSFlood using the Modified Level 1 Flow Control Standard (match 2- and 10-year peak discharge rates for pre-developed forested conditions and post-developed conditions). The Phase 1 design low-flow orifice size (0.25-in) produces an error in MGSFlood. | RKI | Yes | Design Team Meeting. While MGSFlood produces an error, the program still allows user to run the model. However, the proposed Modified Level 1 Flow Control Standard is unable to be met with the cistern configuration. | 5/5/2021 |
| 19 | 5/5/2021 | Action Modeling | **Revision to Decision #2 (3/25/2021):** Level 2 Flow Control facilties will be modeled using pre-unitized bottom areas from Phase 1, and maintaining the bottom footprint and adjusting the contributing area to meet the flow control standard. Unit Action footprint and respective Unit Action contributing area will be calculated by dividing both the bottom footprint and the new required drainage area by 10. The resulting Unit Action will be a footprint consistent with Phase 1, but a new contributing area. | HEC | Yes | Design Team Meeting | 5/5/2021 |
| 20 | 5/5/2021 | Action Modeling | For Actions with sideslopes (bioretention, rain garden, infiltration ponds and detention ponds), MGSFlood models that incorporate the precipitation/evaporation scaling factors will be based on facilities that have been transformed from trapezoidal ponds to rectangular ponds for SUSTAIN input. See Decision #17 for more information on Action transformation for SUSTAIN input. | RKI | Yes | Design Team Meeting | 5/5/2021 |
| 21 | 5/5/2021 | Action Modeling | **Revision to Decision #3 (3/25/2021):** For Actions paired with Bioretention Planter for pretreatment, model the planter using the bottom areas provided in Phase 1, and adjust the contributing area to match the water quality treatment standard (treat 91% of average annual runoff). | RKI | Yes | Design Team Meeting. The limiting factor in this modeling methodology is the bioretention planter; however team will confirm that downstream Action is able to handle the modeled flow through the bioretention planter. | 5/5/2021 |

## King County Water Quality Benefits Evaluation, Phase 2
Decision Log

| Decision | | | | | Approved by Design Team | | |
|---|---|---|---|---|---|---|---|
| Decision No. | Date | Topic | Description | Lead | Yes/No | Comments | Date |
| 22 | 5/11/2021 | Action Fact Sheets | The target audience for the Action Fact Sheets is the design community. Therefore, the Design Parameters table on the first page of each Fact Sheet will contain design values that were used for Action costing (second page of each Fact Sheet). The Action Fact Sheets are not targeted to SUSTAIN modelers and will therefore not present details of SUSTAIN modeling or Unit Action transformations as may be necessary to represent the Unit Action in SUSTAIN. SUSTAIN modeling will be documented separately. | RKI | Yes | Check-in meeting with Olivia and John on 5/11/21, ahead of major deliverable due on 5/17/21. | 5/11/2021 |

# ATTACHMENT C

Contech Filterra ® Bioscape External Bypass System Specifications

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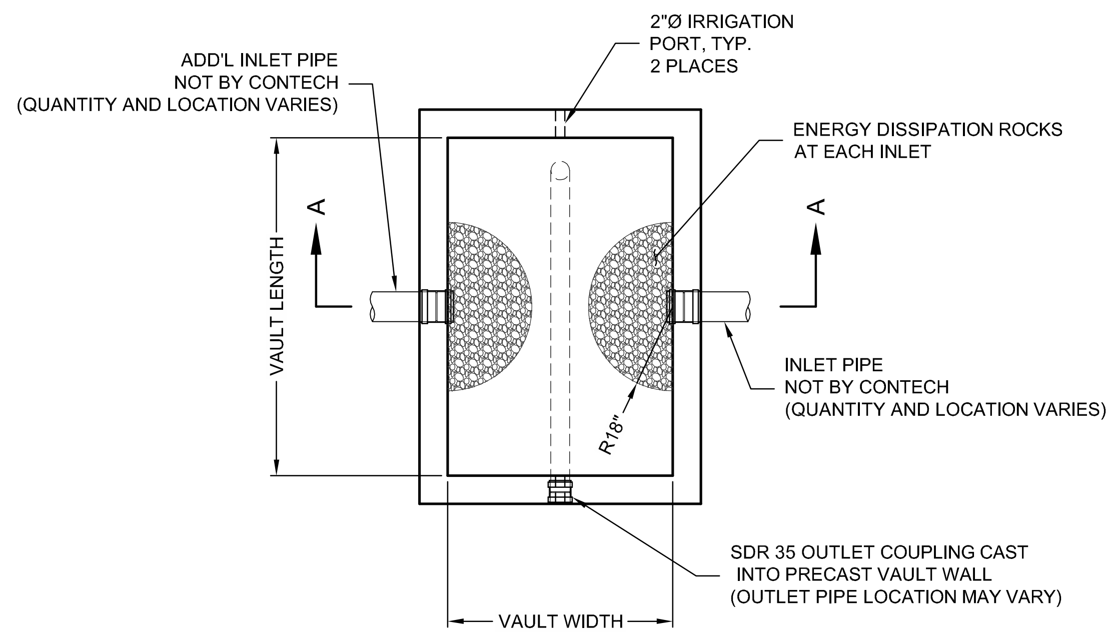
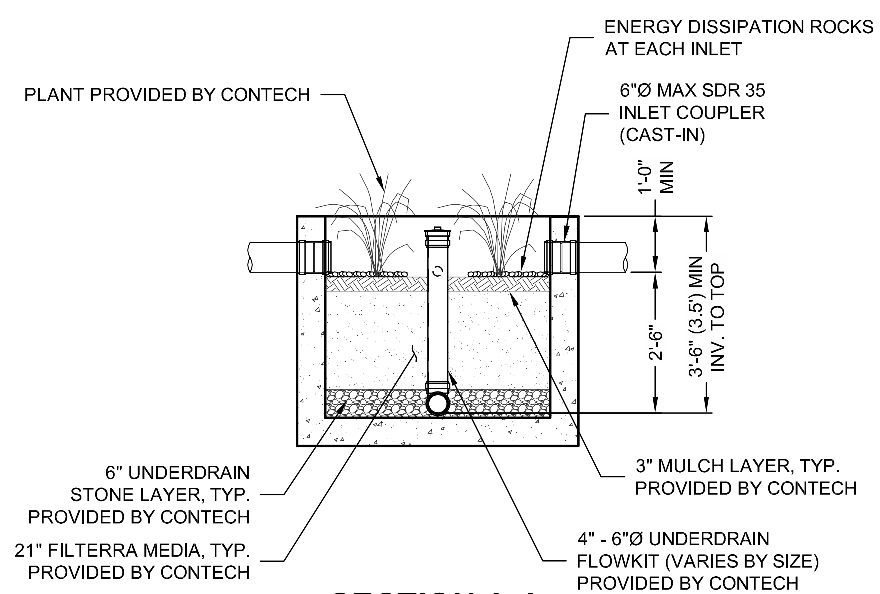



## PLAN VIEW




## SECTION A-A

INTERNAL PIPE CONFIGURATION MAY VARY
DEPENDING UPON OUTLET LOCATION.

## FTBSV-P CONFIGURATION

| DESIGNATION | AVAILABILITY | MEDIA BAY SIZE | VAULT SIZE (L x W) | OUTLET PIPE | MIN NO. OF INLET PIPES |
|---|---|---|---|---|---|
| FTBSV0404-P | ALL | 4 x 4 | 4 x 4 | 4" SDR 35 | 1 |
| FTBSV0604-P | N/A CA | 6 x 4 | 6 x 4 | 4" SDR 35 | 1 |
| FTBSV0606-P | ALL | 6 x 6 | 6 x 6 | 4" SDR 35 | 1 |
| FTBSV06504-P | CA ONLY | 6.5 x 4 | 6.5 x 4 | 4" SDR 35 | 1 |
| FTBSV078045-P | MID-ATL ONLY | 7.83 x 4.5 | 7.83 x 4.5 | 4" SDR 35 | 1 |
| FTBSV0804-P | N/A MID-ATL | 8 x 4 | 8 x 4 | 4" SDR 35 | 1 |
| FTBSV0806-P | ALL | 8 x 6 | 8 x 6 | 4" SDR 35 | 1 |
| FTBSV1006-P | ALL | 10 x 6 | 10 x 6 | 6" SDR 35 | 2 |
| FTBSV1206-P | ALL | 12 x 6 | 12 x 6 | 6" SDR 35 | 2 |
| FTBSV1307-P | ALL | 13 x 7 | 13 x 7 | 6" SDR 35 | 2 |
| FTBSV1408-P | CALL CONTECH | 14 x 8 | 14 x 8 | 6" SDR 35 | 3 |
| FTBSV1608-P | CALL CONTECH | 16 x 8 | 16 x 8 | 6" SDR 35 | 3 |
| FTBSV1808-P | CALL CONTECH | 18 x 8 | 18 x 8 | 6" SDR 35 | 3 |
| FTBSV2008-P | CALL CONTECH | 20 x 8 | 20 x 8 | 6" SDR 35 | 4 |
| FTBSV2208-P | CALL CONTECH | 22 x 8 | 22 x 8 | 6" SDR 35 | 4 |

N/A = NOT AVAILABLE





CONTECH
ENGINEERED SOLUTIONS LLC
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800-338-1122 513-645-7000 513-645-7993 FAX

FILTERRA BIOSCAPE VAULT OFFLINE
WITH PIPE INLET (FTBSV-P)
CONFIGURATION DETAIL

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# ATTACHMENT D

Contech Filterra ® General Use Level Designation for Basic (TSS) Enhanced, Phosphorus & Oil Treatment

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WASHINGTON STATE DEPARTMENT OF ECOLOGY

**February 2020**

# GENERAL USE LEVEL DESIGNATION FOR BASIC (TSS), ENHANCED, PHOSPHORUS & OIL TREATMENT

**For**

## CONTECH Engineered Solutions Filterra®

**Ecology's Decision:**

Based on Contech's submissions, including the Final Technical Evaluation Reports, dated August 2019, March 2014, December 2009, and additional information provided to Ecology dated October 9, 2009, Ecology hereby issues the following use level designations:

1. A General Use Level Designation for Basic, Enhanced, Phosphorus, and Oil Treatment for the Filterra® system constructed with a minimum media thickness of 21 inches (1.75 feet), at the following water quality design hydraulic loading rates:

| Treatment | Infiltration Rate (in/hr) for use in Sizing |
|---|---|
| Basic | 175 |
| Phosphorus | 100 |
| Oil | 50 |
| Enhanced | 175 |

2. The Filterra is not appropriate for oil spill-control purposes.
3. Ecology approves Filterra systems for treatment at the hydraulic loading rates listed above, and sized based on the water quality design flow rate for an off-line system. Calculate the water quality design flow rates using the following procedures:

- Western Washington: for treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using the latest version of the Western Washington Hydrology Model or other Ecology-approved continuous runoff model.
- Eastern Washington: For treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using one of the three flow rate based methods described in Chapter 2.2.5 of the Stormwater Management Manual for Eastern Washington (SWMMEW) or local manual.
- Entire State: For treatment installed downstream of detention, the water quality design flow rate is the full 2-year release rate of the detention facility.

4. This General Use Level Designation has no expiration date, but Ecology may revoke or amend the designation, and is subject to the conditions specified below.

**Ecology's Conditions of Use:**

Filterra systems shall comply with these conditions shall comply with the following conditions:

1. Design, assemble, install, operate, and maintain the Filterra systems in accordance with applicable Contech Filterra manuals and this Ecology Decision.
2. The minimum size filter surface-area for use in Washington is determined by using the design water quality flow rate (as determined in this Ecology Decision, Item 3, above) and the Infiltration Rate from the table above (use the lowest applicable Infiltration Rate depending on the level of treatment required). Calculate the required area by dividing the water quality design flow rate (cu-ft/sec) by the Infiltration Rate (converted to ft/sec) to obtain required surface area (sq-ft) of the Filterra unit.
3. Each site plan must undergo Contech Filterra review before Ecology can approve the unit for site installation. This will ensure that design parameters including site grading and slope are appropriate for use of a Filterra unit.
4. Filterra media shall conform to the specifications submitted to and approved by Ecology and shall be sourced from Contech Engineered Solutions, LLC with no substitutions.
5. Maintenance includes removing trash, degraded mulch, and accumulated debris from the filter surface and replacing the mulch layer. Use inspections to determine the site-specific maintenance schedules and requirements. Follow maintenance procedures given in the most recent version of the Filterra Operation and Maintenance Manual.
6. Maintenance: The required maintenance interval for stormwater treatment devices is often dependent upon the degree of pollutant loading from a particular drainage basin. Therefore, Ecology does not endorse or recommend a "one size fits all" maintenance cycle for a particular model/size of manufactured treatment device.
   - Contech designs Filterra systems for a target maintenance interval of 6 months in the Pacific Northwest. Maintenance includes removing and replacing the mulch layer above the media along with accumulated sediment, trash, and captured organic materials therein, evaluating plant health, and pruning the plant if deemed necessary.
   - Conduct maintenance following manufacturer's guidelines.
7. Filterra systems come in standard sizes.
8. Install the Filterra in such a manner that flows exceeding the maximum Filterra operating rate are conveyed around the Filterra mulch and media and will not resuspend captured sediment.
9. Discharges from the Filterra units shall not cause or contribute to water quality standards violations in receiving waters.

## Approved Alternate Configurations

### Filterra Internal Bypass - Pipe (FTIB-P)

1. The Filterra® Internal Bypass – Pipe allows for piped-in flow from area drains, grated inlets, trench drains, and/or roof drains. Design capture flows and peak flows enter the structure through an internal slotted pipe. Filterra® inverted the slotted pipe to allow design flows to drop through to a series of splash plates that then disperse the design flows over the top surface of the Filterra® planter area. Higher flows continue to bypass the slotted pipe and convey out the structure.
2. To select a FTIB-P unit, the designer must determine the size of the standard unit using the sizing guidance described above.

### Filterra Internal Bypass – Curb (FTIB-C)

1. The Filterra® Internal Bypass –Curb model (FTIB-C) incorporates a curb inlet, biofiltration treatment chamber, and internal high flow bypass in one single structure. Filterra® designed the FTIB-C model for use in a "Sag" or "Sump" condition and will accept flows from both directions along a gutter line. An internal flume tray weir component directs treatment flows entering the unit through the curb inlet to the biofiltration treatment chamber. Flows in excess of the water quality treatment flow rise above the flume tray weir and discharge through a standpipe orifice; providing bypass of untreated peak flows. Americast manufactures the FTIB-C model in a variety of sizes and configurations and you may use the unit on a continuous grade when a single structure providing both treatment and high flow bypass is preferred. The FTIB-C model can also incorporate a separate junction box chamber to allow larger diameter discharge pipe connections to the structure.
2. To select a FTIB-C unit, the designer must determine the size of the standard unit using the sizing guidance described above.

### Filterra® Shallow

1. The Filterra Shallow provides additional flexibility for design engineers and designers in situations where various elevation constraints prevent application of a standard Filterra configuration. Engineers can design this system up to six inches shallower than any of the previous Filterra unit configurations noted above.
2. Ecology requires that the Filterra Shallow provide a media contact time equivalent to that of the standard unit. This means that with a smaller depth of media, the surface area must increase.
3. To select a Filterra Shallow System unit, the designer must first identify the size of the standard unit using the modeling guidance described above.
4. Once the size of the standard Filterra unit is established using the sizing technique described above, use information from the following table to select the appropriate size Filterra Shallow System unit.

Shallow Unit Basic, Enhanced, and Oil Treatment Sizing

| Standard Depth | Equivalent Shallow Depth |
|---|---|
| 4x4 | 4x6 or 6x4 |
| 4x6 or 6x4 | 6x6 |
| 4x8 or 8x4 | 6x8 or 8x6 |
| 6x6 | 6x10 or 10x6 |
| 6x8 or 8x6 | 6x12 or 12x6 |
| 6x10 or 10x6 | 13x7 |

Notes:
1. Shallow Depth Boxes are less than the standard depth of 3.5 feet but no less than 3.0 feet deep (TC to INV).

**Applicant:** Contech Engineered Solutions, LLC.

**Applicant's Address:** 11815 NE Glenn Widing Drive
Portland, OR 97220

**Application Documents:**

- State of Washington Department of Ecology Application for Conditional Use Designation, Americast (September 2006)
- Quality Assurance Project Plan Filterra® Bioretention Filtration System Performance Monitoring, Americast (April 2008)
- Quality Assurance Project Plan Addendum Filterra® Bioretention Filtration System Performance Monitoring, Americast (June 2008)
- Draft Technical Evaluation Report Filterra® Bioretention Filtration System Performance Monitoring, Americast (August 2009)
- Final Technical Evaluation Report Filterra® Bioretention Filtration System Performance Monitoring, Americast (December 2009)
- Technical Evaluation Report Appendices Filterra® Bioretention Filtration System Performance Monitoring, Americast, (August 2009)
- Memorandum to Department of Ecology Dated October 9, 2009 from Americast, Inc. and Herrera Environmental Consultants
- Quality Assurance Project Plan Filterra® Bioretention System Phosphorus treatment and Supplemental Basic and Enhanced Treatment Performance Monitoring, Americast (November 2011)
- Filterra® letter August 24, 2012 regarding sizing for the Filterra® Shallow System.
- University of Virginia Engineering Department Memo by Joanna Crowe Curran, Ph. D dated March 16, 2013 concerning capacity analysis of Filterra® internal weir inlet tray.
- Terraphase Engineering letter to Jodi Mills, P.E. dated April 2, 2013 regarding Terraflume Hydraulic Test, Filterra® Bioretention System and attachments.
- Technical Evaluation Report, Filterra® System Phosphorus Treatment and Supplemental Basic Treatment Performance Monitoring. March 27th, 2014.
- State of Washington Department of Ecology Application for Conditional Use Level Designation, Contech Engineered Solutions (May 2015)

- Quality Assurance Project Plan Filterra® Bioretention System, Contech Engineered Solutions (May 2015)
- Filterra Bioretention System Armco Avenue General Use Level Designation Technical Evaluation Report, Contech Engineered Solutions (August 2019)

**Applicant's Use Level Request:**

General Level Use Designation for Basic (175 in/hr), Enhanced (175 in/hr), Phosphorus (100 in/hr), and Oil Treatment (50 in/hr).

**Applicant's Performance Claims:**

Field-testing and laboratory testing show that the Filterra® unit is promising as a stormwater treatment best management practice and can meet Ecology's performance goals for basic, enhanced, phosphorus, and oil treatment.

**Findings of Fact:**

Field Testing 2015-2019

1. Contech completed field testing of a 4 ft. x 4 ft. Filterra® unit at one site in Hillsboro, Oregon from September 2015 to July 2019. Throughout the monitoring period a total of 24 individual storm events were sampled, of which 23 qualified for TAPE sampling criteria.
2. Contech encountered several unanticipated events and challenges that prevented them from collecting continuous flow and rainfall data. An analysis of the flow data from the sampled events, including both the qualifying and non-qualifying events, demonstrated the system treated over 99 % of the influent flows. Peak flows during these events ranged from 25 % to 250 % of the design flow rate of 29 gallons per minute.
3. Of the 23 TAPE qualified sample events, 13 met requirements for TSS analysis. Influent concentrations ranged from 20.8 mg/L to 83 mg/L, with a mean concentration of 46.3 mg/L. The UCL95 mean effluent concentration was 15.9 mg/L, meeting the 20 mg/L performance goal for Basic Treatment.
4. All 23 TAPE qualified sample events met requirements for dissolved zinc analysis. Influent concentrations range from 0.0384 mg/L to 0.2680 mg/L, with a mean concentration of 0.0807 mg/L. The LCL 95 mean percent removal was 62.9 %, meeting the 60 % performance goal for Enhanced Treatment.
5. Thirteen of the 23 TAPE qualified sample events met requirements for dissolved copper analysis. Influent concentrations ranged from 0.00543 mg/L to 0.01660 mg/L, with a mean concentration of 0.0103 mg/L. The LCL 95 mean percent removal was 41.2 %, meeting the 30 % performance goal for Enhanced Treatment.
6. Total zinc concentrations were analyzed for all 24 sample events. Influent EMCs for total zinc ranged from 0.048 mg/L to 5.290 mg/L with a median of 0.162 mg/L. Corresponding effluent EMCs for total zinc ranged from 0.015 mg/L to 0.067 mg/L with a median of

0.029 mg/L.  Total event loadings for the study for total zinc were 316.85 g at the influent and 12.92 g at the effluent sampling location, resulting in a summation of loads removal efficiency of 95.9 %.

7. Total copper concentrations were analyzed for all 24 sample events.  Influent EMCs for total copper ranged from 0.003 mg/L to 35.600 mg/L with a median value of 0.043 mg/L. Corresponding effluent EMCs for total copper ranged from 0.002 mg/L to 0.015 mg/L with a median of 0.004 mg/L.  Total event loadings for total copper for the study were 1,810.06 g at the influent and 1.90 g at the effluent sampling location, resulting in a summation of loads removal efficiency of 99.9 %.

Field Testing 2013

1. Filterra completed field-testing of a 6.5 ft x 4 ft. unit at one site in Bellingham, Washington. Continuous flow and rainfall data collected from January 1, 2013 through July 23, 2013 indicated that 59 storm events occurred.  Water quality data was obtained from 22 storm events.  Not all the sampled storms produced information that met TAPE criteria for storm and/or water quality data.
2. The system treated 98.9 % of the total 8-month runoff volume during the testing period. Consequently, the system achieved the goal of treating 91 % of the volume from the site. Stormwater runoff bypassed Filterra treatment during four of the 59 storm events.
3. Of the 22 sampled events, 18 qualified for TSS analysis (influent TSS concentrations ranged from 25 to 138 mg/L). The data were segregated into sample pairs with influent concentration greater than and less than 100 mg/L. The UCL95 mean effluent concentration for the data with influent less than 100 mg/L was 5.2 mg/L, below the 20-mg/L threshold. Although the TAPE guidelines do not require an evaluation of TSS removal efficiency for influent concentrations below 100 mg/L, the mean TSS removal for these samples was 90.1 %. Average removal of influent TSS concentrations greater than 100 mg/L (three events) was 85 %. In addition, the system consistently exhibited TSS removal greater than 80 % at flow rates equivalent to a 100 in/hr infiltration rate and was observed at 150 in/hr.
4. Ten of the 22 sampled events qualified for TP analysis. Americast augmented the dataset using two sample pairs from previous monitoring at the site. Influent TP concentrations ranged from 0.11 to 0.52 mg/L. The mean TP removal for these twelve events was 72.6 %. The LCL95 mean percent removal was 66.0, well above the TAPE requirement of 50 %. Treatment above 50 % was evident at 100 in/hr infiltration rate and as high as 150 in/hr. Consequently, the Filterra test system met the TAPE Phosphorus Treatment goal at 100 in/hr. Influent ortho-P concentrations ranged from 0.005 to 0.012 mg/L; effluent ortho-P concentrations ranged from 0.005 to 0.013 mg/L. The reporting limit/resolution for the ortho-P test method is 0.01 mg/L, therefore the influent and effluent ortho-P concentrations were both at and near non-detect concentrations.

Field Testing 2008-2009

1. Filterra completed field-testing at two sites at the Port of Tacoma. Continuous flow and rainfall data collected during the 2008-2009 monitoring period indicated that 89 storm events occurred. The monitoring obtained water quality data from 27 storm events. Not all the sampled storms produced information that met TAPE criteria for storm and/or water quality data.

2. During the testing at the Port of Tacoma, 98.96 to 99.89 % of the annual influent runoff volume passed through the POT1 and POT2 test systems respectively. Stormwater runoff bypassed the POT1 test system during nine storm events and bypassed the POT2 test system during one storm event. Bypass volumes ranged from 0.13 % to 15.3% of the influent storm volume. Both test systems achieved the 91 % water quality treatment-goal over the 1-year monitoring period.

3. Consultants observed infiltration rates as high as 133 in/hr during the various storms. Filterra did not provide any paired data that identified percent removal of TSS, metals, oil, or phosphorus at an instantaneous observed flow rate.

4. The maximum storm average hydraulic loading rate associated with water quality data is <40 in/hr, with the majority of flow rates < 25 in/hr. The average instantaneous hydraulic loading rate ranged from 8.6 to 53 in/hr.

5. The field data showed a removal rate greater than 80 % for TSS with an influent concentration greater than 20 mg/L at an average instantaneous hydraulic loading rate up to 53 in/hr (average influent concentration of 28.8 mg/L, average effluent concentration of 4.3 mg/L).

6. The field data showed a removal rate generally greater than 54 % for dissolved zinc at an average instantaneous hydraulic loading rate up to 60 in/hr and an average influent concentration of 0.266 mg/L (average effluent concentration of 0.115 mg/L).

7. The field data showed a removal rate generally greater than 40 % for dissolved copper at an average instantaneous hydraulic loading rate up to 35 in/hr and an average influent concentration of 0.0070 mg/L (average effluent concentration of 0.0036 mg/L).

8. The field data showed an average removal rate of 93 % for total petroleum hydrocarbon (TPH) at an average instantaneous hydraulic loading rate up to 53 in/hr and an average influent concentration of 52 mg/L (average effluent concentration of 2.3 mg/L). The data also shows achievement of less than 15 mg/L TPH for grab samples. Filterra provided limited visible sheen data due to access limitations at the outlet monitoring location.

9. The field data showed low percentage removals of total phosphorus at all storm flows at an average influent concentration of 0.189 mg/L (average effluent concentration of 0.171 mg/L). We may relate the relatively poor treatment performance of the Filterra system at this location to influent characteristics for total phosphorus that are unique to the Port of Tacoma site. It appears that the Filterra system will not meet the 50 % removal performance goal when the majority of phosphorus in the runoff is expected to be in the dissolved form.

Laboratory Testing

1. Filterra performed laboratory testing on a scaled down version of the Filterra unit. The lab data showed an average removal from 83-91 % for TSS with influents ranging from 21 to 320 mg/L, 82-84 % for total copper with influents ranging from 0.94 to 2.3 mg/L, and 50-61 % for orthophosphate with influents ranging from 2.46 to 14.37 mg/L.
2. Filterra conducted permeability tests on the soil media.
3. Lab scale testing using Sil-Co-Sil 106 showed removals ranging from 70.1 % to 95.5 % with a median removal of 90.7 %, for influent concentrations ranging from 8.3 to 260 mg/L. Filterra ran these laboratory tests at an infiltration rate of 50 in/hr.
4. Supplemental lab testing conducted in September 2009 using Sil-Co-Sil 106 showed an average removal of 90.6 %. These laboratory tests were run at infiltration rates ranging from 25 to 150 in/hr for influent concentrations ranging from 41.6 to 252.5 mg/L. Regression analysis results indicate that the Filterra system's TSS removal performance is independent of influent concentration in the concentration rage evaluated at hydraulic loading rates of up to 150 in/hr.

**Contact Information:**

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Applicant's Website: http://www.conteches.com

Ecology web link: http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html

Ecology: Douglas C. Howie, P.E.
Department of Ecology
Water Quality Program
(360) 407-6444
douglas.howie@ecy.wa.gov

| Date | Revision |
|---|---|
| December 2009 | GULD for Basic, Enhanced, and Oil granted, CULD for Phosphorus |
| September 2011 | Extended CULD for Phosphorus Treatment |
| September 2012 | Revised design storm discussion, added Shallow System. |
| January 2013 | Revised format to match Ecology standards, changed Filterra contact information |
| February 2013 | Added FTIB-P system |
| March 2013 | Added FTIB-C system |
| April 2013 | Modified requirements for identifying appropriate size of unit |

| | |
|---|---|
| June 2013 | Modified description of FTIB-C alternate configuration |
| March 2014 | GULD awarded for Phosphorus Treatment. GULD updated for a higher flow-rate for Basic Treatment. |
| June 2014 | Revised sizing calculation methods |
| March 2015 | Revised Contact Information |
| June 2015 | CULD for Basic and Enhanced at 100 in/hr infiltration rate |
| September 2019 | GULD for Basic and Enhanced at 175 in/hr infiltration rate |
| February 2020 | Revised sizing language to note sizing based on off-line calculations. |

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# ATTACHMENT E

Phase 2 Modeling Assumptions Matrices for MGSFlood Modeling

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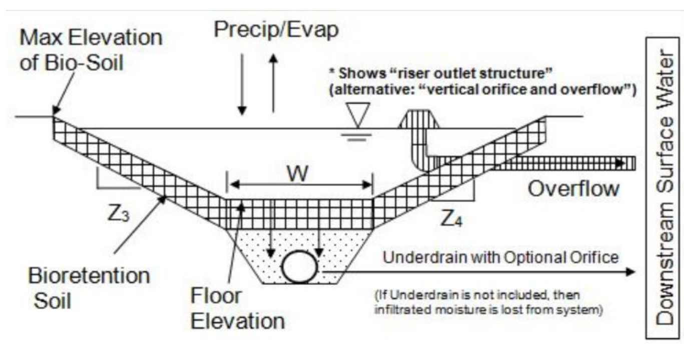
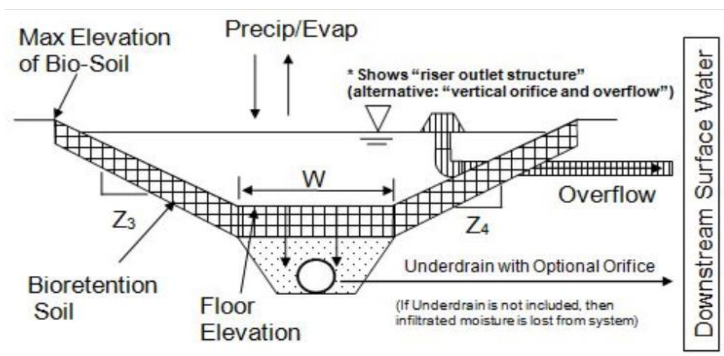
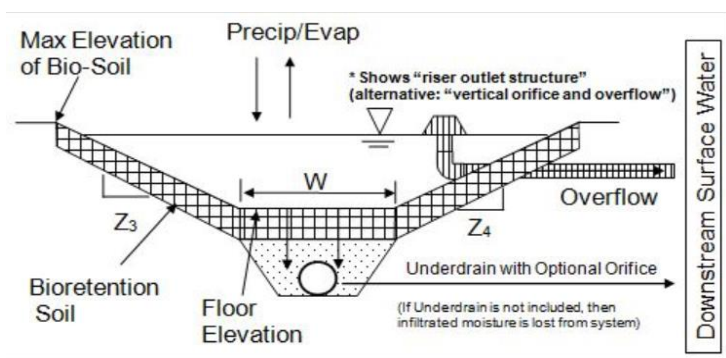
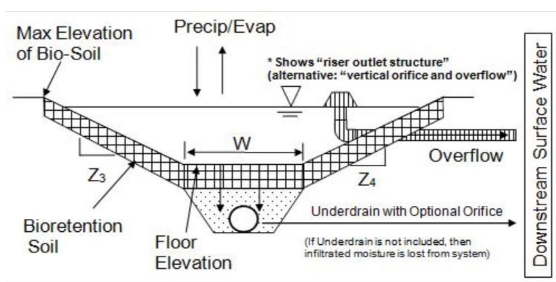
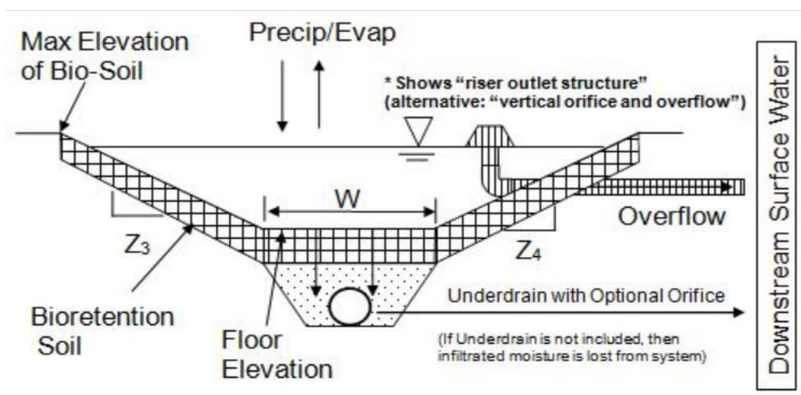
| Inputs and Assumptions | | Notes |
|---|---|---|
| **Action Description** | | |
| Action Name | Rain Garden | |
| Soil Type | Till | |
| **Phase 1 Assumptions** | | |
| Sizing Standard | Seattle SW Manual Volume 3 Section 5.4.4.6 Sizing Factors (Table 5.19, Sloped sides), Water Quality Treatment Standard | |
| Drainage Area | 532 SF | |
| **Model Assumptions** | | |
| Model Software | MGSFlood v. 4.54 | |
| Time Step | 15 minute | KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Climate Region | Puget East 32, Puget East 40, Puget East 60 in MAP | Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log) |
| Time Series | 158 years | |
| Phase 2 Sizing Standard | Basic Water Quality Treatment Standard | Rain Gardens are not in the Basic or Enhanced Basic WQ Menu for King County, but will be sized to the standard to treat 91% of total annual runoff |
| Modeling Methodology | Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Adjust contribution area to meet required standard. | |
| Drainage Area | Do not include the rain garden area as part of the contributing drainage area (i.e., postdeveloped simulations will have larger total drainage area than predeveloped simulations). This is the default setting, post developed area will not need to be modified. | Section 15 of the MGS Flood Manual. "Precipitation and evapotranspiration are applied to the facility so the area occupied by the bioretention facility should not be included in the Subbasin Area input."<br>Assume that the rain garden Action lies outside the drainage area, no need for drainage area adjustments. |
| Pre developed | Impervious | |
| Post developed | Impervious | |
| **Action Configuration** | | |
| MGSFlood Module | Bioretention | Ecology Bioretention (beta version) will not be used, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Module Schematic |  | |
| Ponding Depth | 0.5 ft | Phase 1 Action Fact Sheet |
| Freeboard Depth | 0.5 ft | From Rain Garden Installation Cost Estimate spreadsheet (HDR) |
| Overflow Diameter | 12 in | Note that HDR cost estimate assumes 6-in-diameter. Cost difference between 6 in and 12 in should be negligible, but the 6 in diameter overflow could artificially impact model results, especially for high mean annual precip |
| Bioretention Soil Porosity | 25% | Phase 1 Action Fact Sheet |
| Bioretention Soil Thickness | 1 ft | 3" compost tilled into 12" depth, modeled as 12" layer (confimed in 3/25/21 meeting with HEC, see Design Decision Log) |
| Bioretention Soil Infiltration Rate | 6 in/hr | Confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Native Soil Infiltration Rate | 0.3 in/hr | Phase 1 Action Fact Sheet |
| Infiltration Area | Bottom and Sides | Phase 1 Action Fact Sheet |
| Side Slopes | 3H:1V (Long sides), Vertical (Short sides) | Phase 1 Action Fact Sheet |
| Bottom Area | 25 sq ft | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length:Width | 2:1 | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length | 7.08 ft | |
| Bottom Width | 3.54 ft | |
| Underdrain | N/A | Phase 1 Action Fact Sheet |

| Inputs and Assumptions | | Notes |
|---|---|---|
| **Action Description** | | |
| Action Name | Rain Garden | |
| Soil Type | Outwash | |
| **Phase 1 Assumptions** | | |
| Sizing Standard | Seattle SW Manual Volume 3 Section 5.4.4.6 Sizing Factors (Table 5.19, Sloped sides), Water Quality Treatment Standard | |
| Drainage Area | 2500 SF | |
| **Model Assumptions** | | |
| Model Software | MGSFlood v. 4.54 | |
| Time Step | 15 minute | KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Climate Region | Puget East 32, Puget East 40, Puget East 60 in MAP | Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log) |
| Time Series | 158 years | |
| Phase 2 Sizing Standard | Basic Water Quality Treatment Standard | Rain Gardens are not in the Basic or Enhanced Basic WQ Menu for King County, but will be sized to the standard to treat 91% of total annual runoff |
| Modeling Methodology | Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Adjust contribution area to meet required standard. | |
| Drainage Area | Do not include the rain garden area as part of the contributing drainage area (i.e., postdeveloped simulations will have larger total drainage area than predeveloped simulations). This is the default setting, post developed area will not need to be modified. | Section 15 of the MGS Flood Manual. "Precipitation and evapotranspiration are applied to the facility so the area occupied by the bioretention facility should not be included in the Subbasin Area input."<br>Assume that the rain garden Action lies outside the drainage area, no need for drainage area adjustments. |
| Pre developed | Impervious | |
| Post developed | Impervious | |
| **Action Configuration** | | |
| MGSFlood Module | Bioretention | Ecology Bioretention (beta version) will not be used, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Model Schematic |  | |
| Ponding Depth | 0.5 ft | Phase 1 Action Fact Sheet |
| Freeboard Depth | 0.5 ft | From Rain Garden Installation Cost Estimate spreadsheet (HDR) |
| Overflow Diameter | 12 in | Note that HDR cost estimate assumes 6-in-diameter. Cost difference between 6 in and 12 in should be negligible, but the 6 in diameter overflow could artificially impact model results, especially for high mean annual precip |
| Bioretention Soil Porosity | 25% | Phase 1 Action Fact Sheet |
| Bioretention Soil Thickness | 1 ft | 3" compost tilled into 12" depth, modeled as 12" layer (confimed in 3/25/21 meeting with HEC, see Design Decision Log) |
| Bioretention Soil Infiltration Rate | 6 in/hr | Confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Native Soil Infiltration Rate | 2.5 in/hr | Phase 1 Action Fact Sheet |
| Infiltration Area | Bottom and Sides | Phase 1 Action Fact Sheet |
| Side Slopes | 3H:1V (Long sides), Vertical (Short sides) | Phase 1 Action Fact Sheet |
| Bottom Area | 25 sq ft | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length:Width | 2:1 | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length | 7.08 ft | |
| Bottom Width | 3.54 ft | |
| Underdrain | N/A | Phase 1 Action Fact Sheet |

RKI planning engineering | King County

| Inputs and Assumptions | | Notes |
|---|---|---|
| **Action Description** | | |
| Action Name | Bioretention Planter | |
| Soil Type | N/A | |
| **Phase 1 Assumptions** | | |
| Sizing Standard | Seattle SW Manual Volume 3 Section 5.8.2.6 Sizing Factors (Table 5.45, Vertical sides), Water Quality Treatment Standard | |
| Drainage Area | 1923 SF | |
| **Model Assumptions** | | |
| Model Software | MGSFlood v. 4.54 | |
| Time Step | 15 minute | KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Climate Region | Puget East 32, Puget East 40, Puget East 60 in MAP | Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log) |
| Time Series | 158 years | |
| Phase 2 Sizing Standard | Basic Water Quality Treatment Standard | Bioretention is not in the Basic or Enhanced Basic WQ Menu for King County, but will be sized to the standard to treat 91% of total annual runoff |
| Modeling Methodology | Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Adjust contribution area to meet required standard. | |
| Drainage Area | Do not include the bioretention area as part of the contributing drainage area (i.e., postdeveloped simulations will have larger total drainage area than predeveloped simulations). This is the default setting, post developed area will not need to be modified. | Section 15 of the MGS Flood Manual. "Precipitation and evapotranspiration are applied to the facility so the area occupied by the bioretention facility should not be included in the Subbasin Area input."<br>Assume that the bioretention Action lies outside the drainage area, no need for drainage area adjustments. |
| Pre developed | Impervious | |
| Post developed | Impervious | |
| **Action Configuration** | | |
| MGSFlood Module | Bioretention | Ecology Bioretention (beta version) will not be used, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Model Schematic |  | |
| Ponding Depth | 0.5 ft | Phase 1 Action Fact Sheet |
| Freeboard Depth | 0.5 ft | KCSWDM Appendix A |
| Overflow Diameter | 12 in | Note that HDR cost estimate assumes 8-in-diameter. Cost difference between 6 in and 12 in should be negligible, but the 6 in diameter overflow could artificially impact model results, especially for high mean annual precip |
| Bioretention Soil Porosity | 30% | Phase 1 Action Fact Sheet |
| Bioretention Soil Thickness | 1.5 ft | Phase 1 Action Fact Sheet |
| Bioretention Soil Infiltration Rate | 6 in/hr | Phase 1 Action Fact Sheet |
| Native Soil Infiltration Rate | N/A | Phase 1 Action Fact Sheet |
| Infiltration Area | N/A | |
| Side Slopes | Vertical | Phase 1 Action Fact Sheet |
| Bottom Area | 25 sq ft | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length:Width | 3:1 | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length | 8.67 ft | |
| Bottom Width | 2.89 ft | |
| Underdrain | Yes | Phase 1 Action Fact Sheet |

| Inputs and Assumptions | | Notes |
|---|---|---|
| **Action Description** | | |
| Action Name | Bioretention | |
| Soil Type | Till | |
| **Phase 1 Assumptions** | | |
| Sizing Standard | Seattle SW Manual Volume 3 Section 5.4.4.6 Sizing Factors (Table 5.20, Sloped sides), Water Quality Treatment Standard | |
| Drainage Area | 8500 SF | |
| **Model Assumptions** | | |
| Model Software | MGSFlood v. 4.54 | |
| Time Step | 15 minute | KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Climate Region | Puget East 32, Puget East 40, Puget East 60 in MAP | Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log) |
| Time Series | 158 years | |
| Phase 2 Sizing Standard | Basic Water Quality Treatment Standard | Bioretention is not in the Basic or Enhanced Basic WQ Menu for King County, but will be sized to the standard to treat 91% of total annual runoff |
| Modeling Methodology | Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Adjust contribution area to meet required standard. A post-modeling scaling factor of +5% will be applied to the contributing area to account for the elevated underdrain. | A test model run was conducted to estimate treatment below the underdrain. The results indicated 7% additional drainage area could be treated when accounting for the elevated underdrain. To achieve the benefits of the elevated underdrain, a site would have to be relatively flat (i.e., <2%) or have subsurface weirs installed, which was not accounted for in the costs. We will provide partial credit of 5% for elevated underdrains. (See Design Decision log) |
| Drainage Area | Do not include the bioretention area as part of the contributing drainage area (i.e., postdeveloped simulations will have larger total drainage area than predeveloped simulations). This is the default setting, post developed area will not need to be modified. | Section 15 of the MGS Flood Manual. "Precipitation and evapotranspiration are applied to the facility so the area occupied by the bioretention facility should not be included in the Subbasin Area input." Assume that the bioretention Action lies outside the drainage area, no need for drainage area adjustments. |
| Pre developed | Impervious | |
| Post developed | Impervious | |
| **Action Configuration** | | |
| MGSFlood Module | Bioretention | Ecology Bioretention (beta version) will not be used, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Model Schematic |  | |
| Ponding Depth | 0.5 ft | Phase 1 Action Fact Sheet |
| Freeboard Depth | 0.5 ft | From Bioretention Installation Cost Estimate spreadsheet (HDR) |
| Overflow Diameter | 12 in | Note that HDR cost estimate assumes 8-in-diameter. Cost difference between 6 in and 12 in should be negligible, but the 6 in diameter overflow could artificially impact model results, especially for high mean annual precip |
| Bioretention Soil Porosity | 30% | Phase 1 Action Fact Sheet |
| Bioretention Soil Thickness | 1.5 ft | Phase 1 Action Fact Sheet |
| Bioretention Soil Infiltration Rate | 6 in/hr | Phase 1 Action Fact Sheet |
| Native Soil Infiltration Rate | 0.3 in/hr | Phase 1 Action Fact Sheet |
| Infiltration Area | Bottom and Sides | Phase 1 Action Fact Sheet |
| Side Slopes | 3H:1V (Long sides), Vertical (Short sides) | Phase 1 Action Fact Sheet |
| Bottom Area | 85 sq ft | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length:Width | 3:1 | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length | 16 ft | |
| Bottom Width | 5.33 ft | |
| Underdrain | Yes | MGS Flood does not allow for an elevated underdrain. The drainage area resulting from the MGS Flood modeling will be increased by 5% to account for the elevated underdrain. See modeling methodology assumptions. |

| Inputs and Assumptions | | Notes |
|---|---|---|
| **Action Description** | | |
| Action Name | Bioretention | |
| Soil Type | Outwash | |
| **Phase 1 Assumptions** | | |
| Sizing Standard | Seattle SW Manual Volume 3 Section 5.4.4.6 Sizing Factors (Table 5.19, Sloped sides for Outwash), Water Quality Treatment Standard | |
| Drainage Area | 9928 SF | |
| **Model Assumptions** | | |
| Model Software | MGSFlood v. 4.54 | |
| Time Step | 15 minute | KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Climate Region | Puget East 32, Puget East 40, Puget East 60 in MAP | Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log) |
| Time Series | 158 years | |
| Phase 2 Sizing Standard | Basic Water Quality Treatment Standard | Bioretention is not in the Basic or Enhanced Basic WQ Menu for King County, but will be sized to the standard to treat 91% of total annual runoff |
| Modeling Methodology | Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Adjust contribution area to meet required standard. | |
| Drainage Area | Do not include the bioretention area as part of the contributing drainage area (i.e., postdeveloped simulations will have larger total drainage area than predeveloped simulations). This is the default setting, post developed area will not need to be modified. | Section 15 of the MGS Flood Manual. "Precipitation and evapotranspiration are applied to the facility so the area occupied by the bioretention facility should not be included in the Subbasin Area input."<br>Assume that the bioretention Action lies outside the drainage area, no need for drainage area adjustments. |
| Pre developed | Impervious | |
| Post developed | Impervious | |
| **Action Configuration** | | |
| MGSFlood Module | Bioretention | Ecology Bioretention (beta version) will not be used, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Model Schematic |  | |
| Ponding Depth | 0.5 ft | Phase 1 Action Fact Sheet |
| Freeboard Depth | 0.5 ft | From Bioretention Installation Cost spreadsheets (HDR) |
| Overflow Diameter | 12 in | Note that HDR cost estimate assumes 8-in-diameter. Cost difference between 6 in and 12 in should be negligible, but the 6 in diameter overflow could artificially impact model results, especially for high mean annual precip |
| Bioretention Soil Porosity | 30% | Phase 1 Action Fact Sheet |
| Bioretention Soil Thickness | 1.5 ft | Phase 1 Action Fact Sheet |
| Bioretention Soil Infiltration Rate | 6 in/hr | Phase 1 Action Fact Sheet |
| Native Soil Infiltration Rate | 2.5 in/hr | Phase 1 Action Fact Sheet |
| Infiltration Area | Bottom and Sides | Phase 1 Action Fact Sheet |
| Side Slopes | 3H:1V (Long sides), Vertical (Short sides) | Phase 1 Action Fact Sheet |
| Bottom Area | 85 sq ft | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length:Width | 3:1 | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length | 16 ft | |
| Bottom Width | 5.33 ft | |
| Underdrain | N/A | |

| Inputs and Assumptions | | Notes |
|---|---|---|
| **Action Description** | | |
| Action Name | Drywell | |
| Soil Type | Till | |
| **Phase 1 Assumptions** | | |
| Sizing Standard | Seattle SW Manual Sizing Factors (Table 5.15, 6' Drywell Depth, 0.3 in/hr infiltration [extrapolated], Peak Control Standard) | |
| Drainage Area | 171 SF | |
| **Model Assumptions** | | |
| Model Software | MGSFlood v. 4.54 | |
| Time Step | 15 minute | KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Climate Region | Puget East 32, Puget East 40, Puget East 60 in MAP | Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log) |
| Time Series | 158 years | |
| Phase 2 Sizing Standard | Modified Level 1 Flow Control (match pre-developed [forested] and post-developed peak discharge rates for the 2- and 10- year return periods) | Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log) |
| Modeling Methodology | Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Use effective depth to account for gravel (i.e. gravel porosity X drywell depth) and equivalent bottom area to account for lateral infiltration. Adjust contribution area to meet required standard. | Effective depth assumption confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Drainage Area | Assume the drywell is in the drainage area (i.e., postdeveloped simulations the same total drainage area than predeveloped simulations). This is the default setting, postdeveloped area will not need to be modified. | Precipitation and evaporation at the drywell area is considered negligible. |
| Pre developed | Till Forest | Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log) |
| Post developed | Impervious | |
| **Action Configuration** | | |
| MGSFlood Module | Structure | |

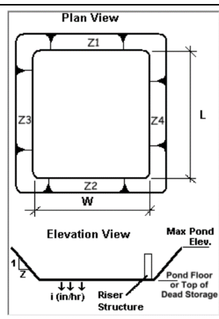



Figure 1

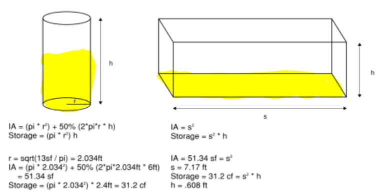
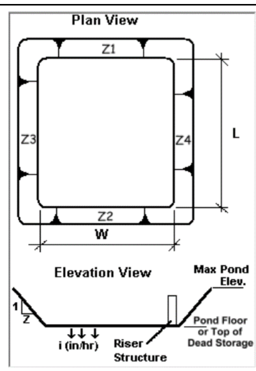
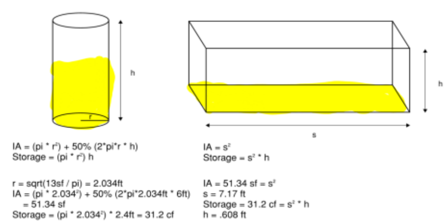
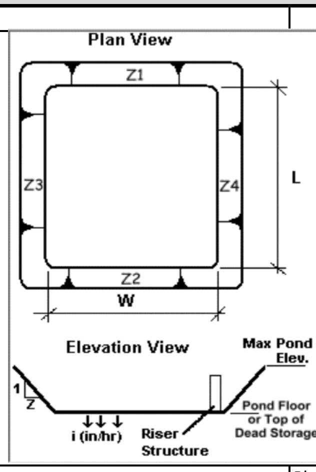


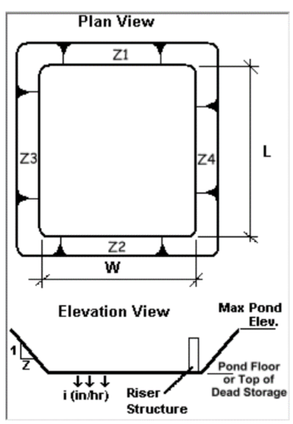

Figure 2

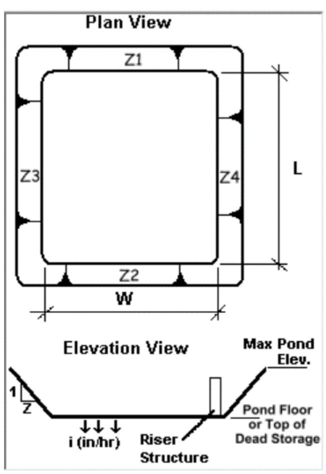
| | | |
|---|---|---|
| Model Schematic | Figure 1 | Figure 2 |
| Ponding Depth | 0.608 ft | Height calculated as shown in Figure 2. Storage of the cylindrical (actual) drywell will be set equal to the rectangular (modeled) drywell, and equations will be solved for model depth. Effective depth used for calculating the storage of the cylindrical drywell is 2.4 ft to account for the 40% porosity (40% * 6ft = 2.4 ft), confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Freeboard Depth | 0 ft | Although drywells are modeled using an infiltration vault in MGS Flood, drywells have no actual riser and no freeboard. |
| Overflow Diameter | 1,000 in | Although drywells are modeled using an infiltration vault in MGS Flood, drywells have no actual riser. A 1,000-in riser was used in the simulation to represent a free flowing overflow condition. |
| Minimum Orifice Diameter | N/A | |
| Native Soil Infiltration Rate | 0.3 in/hr | Phase 1 Action Fact Sheet |
| Side Slopes | Vertical | Phase 1 Action Fact Sheet |
| Bottom Area | 51.34 sf | Infiltration area (highlighted in yellow on Figure 2) of the cylindrical drywell will be set equal to the bottom area of a rectangular drywell, and we will solve for model bottom area. Only 50% of the sidewall area will be used for infiltration area. This assumption was made since lateral infiltration rates will be significantly less than infiltration through the bottom footprint. Based on 13 sf cylindrical bottom area from Phase 1 Cost and Modeling Assumptions spreadsheet (RKI). |
| Bottom Length:Width | 1:1 | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length | 7.17 ft | |
| Bottom Width | 7.17 ft | |

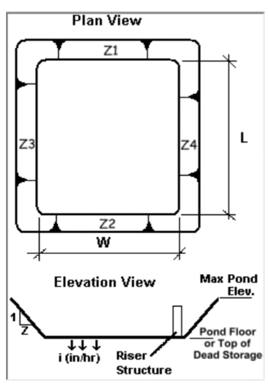
Developed By: RKI
Reviewed By: Lotus, Herrera

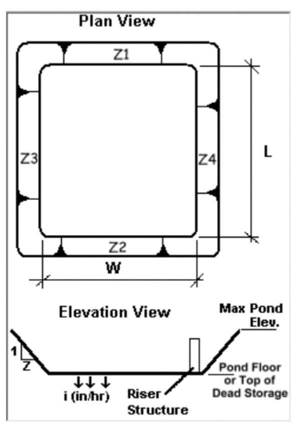
| Inputs and Assumptions | | Notes |
|---|---|---|
| **Action Description** | | |
| Action Name | Drywell | |
| Soil Type | Outwash | |
| **Phase 1 Assumptions** | | |
| Sizing Standard | Seattle SW Manual Sizing Factors (Table 5.15, 6' Drywell Depth, 2.5 in/hr infiltration, Peak Control Standard) | |
| Drainage Area | 333 SF | |
| **Model Assumptions** | | |
| Model Software | MGSFlood v. 4.54 | |
| Time Step | 15 minute | KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Climate Region | Puget East 32, Puget East 40, Puget East 60 in MAP | Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log) |
| Time Series | 158 years | |
| Phase 2 Sizing Standard | Modified Level 1 Flow Control (match pre-developed [forested] and post-developed peak discharge rates for the 2- and 10- year return periods) | Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log) |
| Modeling Methodology | Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Use effective depth to account for gravel (i.e. gravel porosity X drywell depth) and equivalent bottom area to account for lateral infiltration. Adjust contribution area to meet required standard. | Effective depth assumption confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Drainage Area | Assume the drywell is in the drainage area (i.e., postdeveloped simulations the same total drainage area than predeveloped simulations). This is the default setting, postdeveloped area will not need to be modified. | Precipitation and evaporation at the drywell area is considered negligible. |
| Pre developed | Till Forest | Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log) |
| Post developed | Impervious | |
| **Action Configuration** | | |
| MGSFlood Module | Structure | |
| Model Schematic |  Figure 1 |  Figure 2 |
| Ponding Depth | 0.608 ft | Height calculated as shown in Figure 2. Storage of the cylindrical (actual) drywell will be set equal to the rectangular (modeled) drywell, and equations will be solved for model depth. Effective depth used for calculating the storage of the cylindrical drywell is 2.4 ft to account for the 40% porosity (40% * 6ft = 2.4 ft), confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Freeboard Depth | 0 ft | Although drywells are modeled using an infiltration vault in MGS Flood, drywells have no actual riser and no freeboard. |
| Overflow Diameter | 1,000 in | Although drywells are modeled using an infiltration vault in MGS Flood, drywells have no actual riser. A 1,000-in riser was used in the simulation to represent a free flowing overflow condition. |
| Minimum Orifice Diameter | N/A | |
| Native Soil Infiltration Rate | 2.5 in/hr | Phase 1 Action Fact Sheet |
| Side Slopes | Vertical | Phase 1 Action Fact Sheet |
| Bottom Area | 51.34 sf | Infiltration area (highlighted in yellow on Figure 2) of the cylindrical drywell will be set equal to the bottom area of a rectangular drywell, and we will solve for model bottom area. Only 50% of the sidewall area will be used for infiltration area. This assumption was made since lateral infiltration rates will be significantly less than infiltration through the bottom footprint. See Design Decision log. Based on 13 sf cylindrical bottom area from Phase 1 Cost and Modeling Assumptions spreadsheet (RKI). |
| Bottom Length:Width | 1:1 | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length | 7.17 ft | |
| Bottom Width | 7.17 ft | |

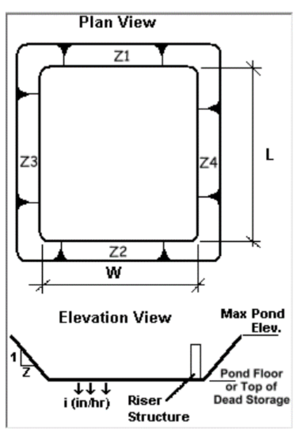
| Inputs and Assumptions | | Notes |
|---|---|---|
| **Action Description** | | |
| Action Name | Detention Vault | |
| Soil Type | N/A | |
| **Phase 1 Assumptions** | | |
| Sizing Standard | Level 2 Flow Control (Forest Duration Standard) | Modeled in WWHM in Phase 1 |
| Drainage Area | 43560 SF | |
| **Model Assumptions** | | |
| Model Software | MGSFlood v. 4.54 | |
| Time Step | 15 minute | KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Climate Region | Puget East 32, Puget East 40, Puget East 60 in MAP | Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log) |
| Time Series | 158 years | |
| Phase 2 Sizing Standard | Level 2 Flow Control (Forest Duration Standard: match 50% of the 2-year peak flow up to the 50-year peak flow; match pre- and post-developed peak discharge rates for the 2- and 10- year return periods) | |
| Modeling Methodology | Use facility sizing from Phase 1 and design assumptions below (Action Configuration). Adjust orifice controls and drainage area to meet required standard. Divide by the Phase 2 modeled contributing area to obtain Unit Action Footprint. | |
| Drainage Area | Do not include the vault area as part of the drainage area (i.e., postdeveloped simulations will have the same total drainage area as the predeveloped simulations). This is the default setting, post developed area will not be modified. | Section 8 of the MGS Flood Manual. MGS Flood does not calculate for precipitation and evaporation in the vault area, no need for drainage area adjustments. |
| Pre-developed | Till Forest | Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log) |
| Post-developed | Impervious | |
| **Action Configuration** | | |
| MGSFlood Module | Structure | |
| Model Schematic |  | |
| Ponding Depth | 6 ft | Phase 1 Action Fact Sheet |
| Freeboard Depth | 1 ft | Phase 1 Action Fact Sheet, internal height of 7ft |
| Overflow Diameter | 18 in | Based on KC Modeling for WRIA 9, HRU 11 |
| Minimum Orifice Diameter | 0.5 in | Confirmed by team 4/14/21 (see Design Decision log.) |
| Minimum Notch Width | 0.25 in | Minimum allowed by MGS Flood |
| Native Soil Infiltration Rate | N/A | |
| Side Slopes | Vertical | Phase 1 Action Fact Sheet |
| Bottom Area | 25,920 sq ft | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length:Width | 2:1 | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length | 227.7 ft | |
| Bottom Width | 113.8 ft | |

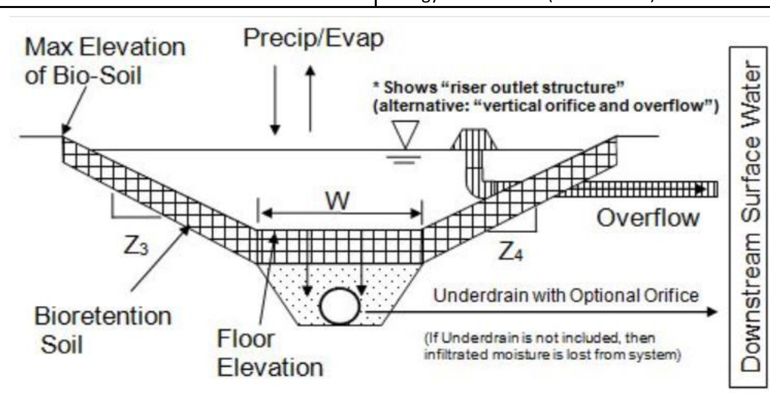
| Inputs and Assumptions | | Notes |
|---|---|---|
| **Action Description** | | |
| Action Name | Detention Pond | |
| Soil Type | N/A | |
| **Phase 1 Assumptions** | | |
| Sizing Standard | Level 2 Flow Control (Forest Duration Standard) | Modeled in WWHM in Phase 1 |
| Drainage Area | 43560 SF | |
| **Model Assumptions** | | |
| Model Software | MGSFlood v. 4.54 | |
| Time Step | 15 minute | KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Climate Region | Puget East 32, Puget East 40, Puget East 60 in MAP | Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log) |
| Time Series | 158 years | |
| Phase 2 Sizing Standard | Level 2 Flow Control (Forest Duration Standard: match 50% of the 2-year peak flow up to the 50-year peak flow; match pre- and post-developed peak discharge rates for the 2- and 10- year return periods) | |
| Modeling Methodology | Use facility sizing from Phase 1 and design assumptions below (Action Configuration). Adjust orifice controls and drainage area to meet required standard. Divide by the Phase 2 modeled contributing area to obtain Unit Action Footprint. | |
| Drainage Area | Do not include the pond area as part of the drainage area (i.e., postdeveloped simulations will have the same total drainage area as the predeveloped simulations). This is the default setting, post developed area will not be modified. | |
| Pre-developed | Till Forest | Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log) |
| Post-developed | Impervious | |
| **Action Configuration** | | |
| MGSFlood Module | Structure | |
| Model Schematic |  | |
| Ponding Depth | 4 ft | Phase 1 Action Fact Sheet |
| Freeboard Depth | 0.5 ft | From Detention Pond Installation cost estimate spreadsheet |
| Overflow Diameter | 18 in | Based on KC Modeling for WRIA 9, HRU 11 |
| Minimum Orifice Diameter | 0.5 in | Confirmed by team 4/14/21 (see Design Decision log.) |
| Minimum Notch Width | 0.25 in | Minimum allowed by MGS Flood |
| Native Soil Infiltration Rate | N/A | |
| Side Slopes | 3H:1V (Long sides), Vertical (Short sides) | Phase 1 Action Fact Sheet |
| Bottom Area | 45,000 sq ft | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length:Width | 2:1 | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length | 300 ft | |
| Bottom Width | 150 ft | |

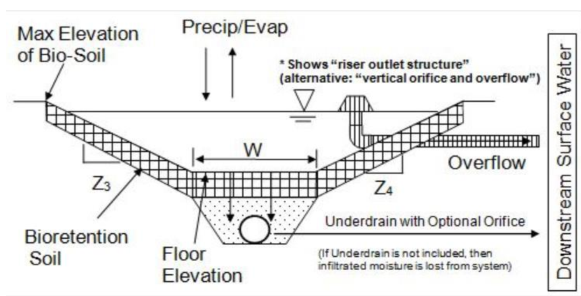
| Inputs and Assumptions | | Notes |
|---|---|---|
| **Action Description** | | |
| Action Name | Infiltration Pond | |
| Soil Type | Till | |
| **Phase 1 Assumptions** | | |
| Sizing Standard | Level 2 Flow Control (Forest Duration Standard) | Modeled in WWHM in Phase 1 |
| Drainage Area | 43560 SF | |
| **Model Assumptions** | | |
| Model Software | MGSFlood v. 4.54 | |
| Time Step | 15 minute | KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Climate Region | Puget East 32, Puget East 40, Puget East 60 in MAP | Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log) |
| Time Series | 158 years | |
| Phase 2 Sizing Standard | Level 2 Flow Control (Forest Duration Standard: match 50% of the 2-year peak flow up to the 50-year peak flow; match pre- and post-developed peak discharge rates for the 2- and 10- year return periods) | |
| Modeling Methodology | Use facility sizing from Phase 1 and design assumptions below (Action Configuration). Adjust orifice controls and drainage area to meet required standard. Divide by the Phase 2 modeled contributing area to obtain Unit Action Footprint. | |
| Drainage Area | Do not include the pond area as part of the drainage area (i.e., postdeveloped simulations will have the same total drainage area as the predeveloped simulations). This is the default setting, post developed area will not be modified. | |
| Pre-developed | Till Forest | Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log) |
| Post-developed | Impervious | |
| **Action Configuration** | | |
| MGSFlood Module | Structure | |
| Model Schematic |  | |
| Ponding Depth | 4 ft | Phase 1 Action Fact Sheet |
| Freeboard Depth | 1 ft | From Infiltration Pond Cost spreadsheets (HDR) |
| Overflow Diameter | 18 in | Based on KC Modeling for WRIA 9, HRU 11 |
| Minimum Orifice Diameter | 0.5 in | Confirmed by team 4/14/21 (see Design Decision log.) |
| Minimum Notch Width | 0.25 in | Minimum allowed by MGS Flood |
| Native Soil Infiltration Rate | 0.3 in/hr | Phase 1 Action Fact Sheet |
| Side Slopes | 3H:1V (Long sides), Vertical (Short sides) | Phase 1 Action Fact Sheet |
| Bottom Area | 27,850 sq ft | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length:Width | 2:1 | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length | 236 ft | |
| Bottom Width | 118 ft | |

| Inputs and Assumptions | | Notes |
|---|---|---|
| **Action Description** | | |
| Action Name | Infiltration Pond | |
| Soil Type | Outwash | |
| **Phase 1 Assumptions** | | |
| Sizing Standard | Level 2 Flow Control (Forest Duration Standard) | Modeled in WWHM in Phase 1 |
| Drainage Area | 43560 SF | |
| **Model Assumptions** | | |
| Model Software | MGSFlood v. 4.54 | |
| Time Step | 15 minute | KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Climate Region | Puget East 32, Puget East 40, Puget East 60 in MAP | Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log) |
| Time Series | 158 years | |
| Phase 2 Sizing Standard | Level 2 Flow Control (Forest Duration Standard: match 50% of the 2-year peak flow up to the 50-year peak flow; match pre- and post-developed peak discharge rates for the 2- and 10- year return periods) | |
| Modeling Methodology | Use facility sizing from Phase 1 and design assumptions below (Action Configuration). Adjust orifice controls and drainage area to meet required standard. Divide by the Phase 2 modeled contributing area to obtain Unit Action Footprint. | |
| Drainage Area | Do not include the pond area as part of the drainage area (i.e., postdeveloped simulations will have the same total drainage area as the predeveloped simulations). This is the default setting, post developed area will not be modified. | |
| Pre-developed | Till Forest | Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log) |
| Post-developed | Impervious | |
| **Action Configuration** | | |
| MGSFlood Module | Structure | |
| Model Schematic |  | |
| Ponding Depth | 4 ft | Phase 1 Action Fact Sheet |
| Freeboard Depth | 1 ft | From Infiltration Pond Cost spreadsheets (HDR) |
| Overflow Diameter | 18 in | Based on KC Modeling for WRIA 9, HRU 11 |
| Minimum Orifice Diameter | 0.5 in | Confirmed by team 4/14/21 (see Design Decision log.) |
| Minimum Notch Width | 0.25 in | Minimum allowed by MGS Flood |
| Native Soil Infiltration Rate | 2.5 in/hr | Phase 1 Action Fact Sheet |
| Side Slopes | 3H:1V (Long sides), Vertical (Short sides) | Phase 1 Action Fact Sheet |
| Bottom Area | 14,790 sq ft | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length:Width | 2:1 | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length | 172 ft | |
| Bottom Width | 86 ft | |

| **Inputs and Assumptions** | | **Notes** |
|---|---|---|
| **Action Description** | | |
| Action Name | Infiltration Vault | |
| Soil Type | Till | |
| **Phase 1 Assumptions** | | |
| Sizing Standard | Level 2 Flow Control (Forest Duration Standard) | Modeled in WWHM in Phase 1 |
| Drainage Area | 43560 SF | |
| **Model Assumptions** | | |
| Model Software | MGSFlood v. 4.54 | |
| Time Step | 15 minute | KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Climate Region | Puget East 32, Puget East 40, Puget East 60 in MAP | Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log) |
| Time Series | 158 years | |
| Phase 2 Sizing Standard | Level 2 Flow Control (Forest Duration Standard: match 50% of the 2-year peak flow up to the 50-year peak flow; match pre- and post-developed peak discharge rates for the 2- and 10- year return periods) | |
| Modeling Methodology | Use facility sizing from Phase 1 and design assumptions below (Action Configuration). Adjust orifice controls and drainage area to meet required standard. Divide by the Phase 2 modeled contributing area to obtain Unit Action Footprint. | |
| Drainage Area | Do not include the vault area as part of the contributing drainage area (i.e., postdeveloped simulations will have the same total drainage area as the predeveloped simulations). This is the default setting, post developed area will not be modified. | Section 8 of the MGS Flood Manual. MGS Flood does not calculate for precipitation and evaporation in the vault area, no need for drainage area adjustments. |
| Pre-developed | Till Forest | Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log) |
| Post-developed | Impervious | |
| **Action Configuration** | | |
| MGSFlood Module | Structure | |
| Model Schematic |  | |
| Ponding Depth | 6 ft | Phase 1 Action Fact Sheet |
| Freeboard Depth | 1 ft | Phase 1 Action Fact Sheet |
| Overflow Diameter | 18 in | Based on KC Modeling for WRIA 9, HRU 11 |
| Minimum Orifice Diameter | 0.5 in | Confirmed by team 4/14/21 (see Design Decision log.) |
| Minimum Notch Width | 0.25 in | Minimum allowed by MGS Flood |
| Native Soil Infiltration Rate | 0.3 in/hr | Phase 1 Action Fact Sheet |
| Side Slopes | Vertical | Phase 1 Action Fact Sheet |
| Bottom Area | 18,360 sq ft | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length:Width | 2:1 | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length | 191.6 ft | |
| Bottom Width | 95.8 ft | |

| Inputs and Assumptions | | Notes |
|---|---|---|
| **Action Description** | | |
| Action Name | Infiltration Vault | |
| Soil Type | Outwash | |
| **Phase 1 Assumptions** | | |
| Sizing Standard | Level 2 Flow Control (Forest Duration Standard) | Modeled in WWHM in Phase 1 |
| Drainage Area | 43560 SF | |
| **Model Assumptions** | | |
| Model Software | MGSFlood v. 4.54 | |
| Time Step | 15 minute | KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Climate Region | Puget East 32, Puget East 40, Puget East 60 in MAP | Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log) |
| Time Series | 158 years | |
| Phase 2 Sizing Standard | Level 2 Flow Control (Forest Duration Standard: match 50% of the 2-year peak flow up to the 50-year peak flow; match pre- and post-developed peak discharge rates for the 2- and 10- year return periods) | |
| Modeling Methodology | Use facility sizing from Phase 1 and design assumptions below (Action Configuration). Adjust orifice controls and drainage area to meet required standard. Divide by the Phase 2 modeled contributing area to obtain Unit Action Footprint. | |
| Drainage Area | Do not include the vault area as part of the contributing drainage area (i.e., postdeveloped simulations will have the same total drainage area as the predeveloped simulations). This is the default setting, post developed area will not be modified. | Section 8 of the MGS Flood Manual. MGS Flood does not calculate for precipitation and evaporation in the vault area, no need for drainage area adjustments. |
| Pre-developed | Till Forest | Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log) |
| Post-developed | Impervious | |
| **Action Configuration** | | |
| MGSFlood Module | Structure | |
| Model Schematic |  | |
| Ponding Depth | 6 ft | Phase 1 Action Fact Sheet |
| Freeboard Depth | 1 ft | Phase 1 Action Fact Sheet |
| Overflow Diameter | 18 in | Based on KC Modeling for WRIA 9, HRU 11 |
| Minimum Orifice Diameter | 0.5 in | Confirmed by team 4/14/21 (see Design Decision log.) |
| Minimum Notch Width | 0.25 in | Minimum allowed by MGS Flood |
| Native Soil Infiltration Rate | 2.5 in/hr | Phase 1 Action Fact Sheet |
| Side Slopes | Vertical | Phase 1 Action Fact Sheet |
| Bottom Area | 11,560 sq ft | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length:Width | 2:1 | Phase 1 Cost and Modeling Assumptions spreadsheet (RKI) |
| Bottom Length | 152.1 ft | |
| Bottom Width | 76 ft | |

| Inputs and Assumptions | | Notes |
|---|---|---|
| **Action Description** | | |
| Action Name | Drywell with Bioretention Planter as Pretreatment | |
| Soil Type | Outwash | |
| **Phase 1 Assumptions** | | |
| Sizing Standard | 1.3% Sizing Factor for Water Quality Treatment Standard | |
| Drainage Area | 333 SF | |
| **Model Assumptions** | | |
| Model Software | MGSFlood v. 4.54 | |
| Time Step | 15 minute | KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Climate Region | Puget East 32, Puget East 40, Puget East 60 in MAP | Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log) |
| Time Series | 158 years | |
| Phase 2 Sizing Standard | Basic Water Quality Treatment Standard | Bioretention is not in the Basic or Enhanced Basic WQ Menu for King County, but will be sized to the standard to treat 91% of total annual runoff |
| Modeling Methodology | Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Adjust contribution area to meet required standard. | |
| Drainage Area | Do not include the bioretention area as part of the contributing drainage area (i.e., postdeveloped simulations will have larger total drainage area than predeveloped simulations). This is the default setting, post developed area will not need to be modified. | Section 15 of the MGS Flood Manual. "Precipitation and evapotranspiration are applied to the facility so the area occupied by the bioretention facility should not be included in the Subbasin Area input."<br>Assume that the bioretention Action lies outside the drainage area, no need for drainage area adjustments. |
| Pre developed | Impervious | |
| Post developed | Impervious | |
| **Action Configuration** | | |
| MGSFlood Module | Bioretention | Ecology Bioretention (beta version) will not be used |
| Model Schematic |  | |
| Ponding Depth | 0.5 ft | Phase 1 Action Fact Sheet |
| Freeboard Depth | 0.5 ft | KCSWDM Appendix A |
| Overflow Diameter | 12 in | Note that HDR cost estimate assumes 8-in-diameter. Cost difference between 6 in and 12 in should be negligible, but the 6 in diameter overflow could artificially impact model results, especially for high mean annual precip |
| Bioretention Soil Porosity | 30% | Phase 1 Action Fact Sheet - Bioretention Planter |
| Bioretention Soil Thickness | 1.5 ft | Phase 1 Action Fact Sheet - Bioretention Planter |
| Bioretention Soil Infiltration Rate | 6 in/hr | Phase 1 Action Fact Sheet - Bioretention Planter |
| Native Soil Infiltration Rate | N/A | Phase 1 Action Fact Sheet - Bioretention Planter |
| Infiltration Area | N/A | |
| Side Slopes | Vertical | Phase 1 Action Fact Sheet - Bioretention Planter |
| Bottom Area | 4.3 sq ft | Phase 1 Cost and Modeling Assumptions Technical Memo (RKI) |
| Bottom Length:Width | 3:1 | Assumed, same as Bioretention Planter Action |
| Bottom Length | 3.59 ft | |
| Bottom Width | 1.19 ft | |
| Underdrain | Yes | Phase 1 Action Fact Sheet - Bioretention Planter |

| **Inputs and Assumptions** | | **Notes** |
|---|---|---|
| **Action Description** | | |
| Action Name | Deep UIC Well with Bioretention Planter as Pretreatment | |
| Soil Type | Outwash | |
| **Phase 1 Assumptions** | | |
| Sizing Standard | 1.3% Sizing Factor for Water Quality Treatment Standard | |
| Drainage Area | 44550 SF | |
| **Model Assumptions** | | |
| Model Software | MGSFlood v. 4.54 | |
| Time Step | 15 minute | KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log) |
| Climate Region | Puget East 32, Puget East 40, Puget East 60 in MAP | Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log) |
| Time Series | 158 years | |
| Phase 2 Sizing Standard | Basic Water Quality Treatment Standard | Bioretention is not in the Basic or Enhanced Basic WQ Menu for King County, but will be sized to the standard to treat 91% of total annual runoff |
| Modeling Methodology | Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Adjust contribution area to meet required standard. | |
| Drainage Area | Do not include the bioretention area as part of the contributing drainage area (i.e., postdeveloped simulations will have larger total drainage area than predeveloped simulations). This is the default setting, post developed area will not need to be modified. | Section 15 of the MGS Flood Manual. "Precipitation and evapotranspiration are applied to the facility so the area occupied by the bioretention facility should not be included in the Subbasin Area input."<br>Assume that the bioretention Action lies outside the drainage area, no need for drainage area adjustments. |
| Pre developed | Impervious | |
| Post developed | Impervious | |
| **Action Configuration** | | |
| MGSFlood Module | Bioretention | Ecology Bioretention (beta version) will not be used |
| Model Schematic |  | |
| Ponding Depth | 0.5 ft | Phase 1 Action Fact Sheet |
| Freeboard Depth | 0.5 ft | KCSWDM Appendix A |
| Overflow Diameter | 12 in | Note that HDR cost estimate assumes 8-in-diameter. Cost difference between 6 in and 12 in should be negligible, but the 6 in diameter overflow could artificially impact model results, especially for high mean annual precip |
| Bioretention Soil Porosity | 30% | Phase 1 Action Fact Sheet - Bioretention Planter |
| Bioretention Soil Thickness | 1.5 ft | Phase 1 Action Fact Sheet - Bioretention Planter |
| Bioretention Soil Infiltration Rate | 6 in/hr | Phase 1 Action Fact Sheet - Bioretention Planter |
| Native Soil Infiltration Rate | N/A | Phase 1 Action Fact Sheet - Bioretention Planter |
| Infiltration Area | N/A | |
| Side Slopes | Vertical | Phase 1 Action Fact Sheet - Bioretention Planter |
| Bottom Area | 579 sq ft | Phase 1 Cost and Modeling Assumptions Technical Memo (RKI) |
| Bottom Length:Width | 3:1 | Assumed, same as Bioretention Planter Action |
| Bottom Length | 41.68 ft | |
| Bottom Width | 13.89 ft | |
| Underdrain | Yes | Phase 1 Action Fact Sheet - Bioretention Planter |

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## ATTACHMENT F

MGSFlood Modeling Output Reports

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# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 04/27/2021 11:36 AM**
**Report Generation Date: 04/27/2021 11:44 AM**

| | |
|---|---|
| Input File Name: | Rain_Garden_Till_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Rain Garden on Till Soils |
| Comments: | Puget East 40 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

************************ WATERSHED DEFINITION **************************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.019 | 0.019 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.001 |
| Total (acres) | 0.019 | 0.019 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.019
----------------------------------------------
Subbasin Total 0.019

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 0.019 |
| Subbasin Total | 0.019 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

| | |
|---|---|
| Base Elevation (ft) | : 100.00 |
| Riser Crest Elevation (ft) | : 100.50 |
| Storage Depth (ft) | : 0.50 |
| Bottom Length (ft) | : 7.1 |
| Bottom Width (ft) | : 3.5 |
| Side Slopes (ft/ft) | : L1= 0.00 L2= 0.00 W1= 3.00 W2= 3.00 |
| Bottom Area (sq-ft) | : 25. |
| Area at Riser Crest El (sq-ft) | : 46. |
| (acres) | : 0.001 |
| Volume at Riser Crest (cu-ft) | : 24. |
| (ac-ft) | : 0.001 |

Infiltration on Bottom and Sideslopes Selected

Soil Properties

| | |
|---|---|
| Biosoil Thickness (ft) | : 1.00 |
| Biosoil Saturated Hydraulic Conductivity (in/hr) | : 6.00 |
| Biosoil Porosity (Percent) | : 25.00 |
| Maximum Elevation of Bioretention Soil | : 101.00 |
| Native Soil Hydraulic Conductivity (in/hr) | : 0.30 |

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 12.00 |
| Common Length (ft) | : 0.000 |

Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

************************FLOOD FREQUENCY AND DURATION STATISTICS*********************

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

************ Subbasin: Subbasin 1 ************

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

| Tr (yrs) | Flood Peak (cfs) |
|---|---|
| 2-Year | 6.895E-03 |
| 5-Year | 8.955E-03 |
| 10-Year | 1.007E-02 |
| 25-Year | 1.268E-02 |
| 50-Year | 1.614E-02 |
| 100-Year | 1.866E-02 |
| 200-Year | 1.934E-02 |
| 500-Year | 2.025E-02 |

********** Link: New Bio Lnk1 ********** Link Inflow Frequency Stats

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

| Tr (yrs) | Flood Peak (cfs) |
|---|---|
| 2-Year | 6.895E-03 |
| 5-Year | 8.955E-03 |
| 10-Year | 1.007E-02 |
| 25-Year | 1.268E-02 |
| 50-Year | 1.614E-02 |
| 100-Year | 1.866E-02 |
| 200-Year | 1.934E-02 |
| 500-Year | 2.025E-02 |

********** Link: New Bio Lnk1 ********** Link WSEL Stats

WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)
Tr (yrs) WSEL Peak (ft)

========================================

| | |
|---|---|
| 1.05-Year | 100.502 |
| 1.11-Year | 100.502 |
| 1.25-Year | 100.503 |
| 2.00-Year | 100.504 |
| 3.33-Year | 100.505 |
| 5-Year | 100.506 |
| 10-Year | 100.507 |
| 25-Year | 100.508 |
| 50-Year | 100.509 |
| 100-Year | 100.510 |

*************Groundwater Recharge Summary ***************

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 7.814 |
| Total: | 7.814 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.049 ac-ft/year**

*************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 8.29
Inflow Volume Including PPT-Evap (ac-ft): 8.59
Total Runoff Infiltrated (ac-ft): 7.81, 91.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.76

Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 6.895E-03 | 2-Year | 5.235E-03 |
| 5-Year | 8.955E-03 | 5-Year | 7.413E-03 |
| 10-Year | 1.007E-02 | 10-Year | 8.968E-03 |
| 25-Year | 1.268E-02 | 25-Year | 9.988E-03 |
| 50-Year | 1.614E-02 | 50-Year | 1.195E-02 |
| 100-Year | 1.866E-02 | 100-Year | 1.298E-02 |
| 200-Year | 1.934E-02 | 200-Year | 1.424E-02 |
| 500-Year | 2.025E-02 | 500-Year | 1.593E-02 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -67.7%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -54.8%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): -53.3%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

---
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS
---

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -90.5% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -67.7% PASS

---
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
---

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/10/2021 5:08 PM**
**Report Generation Date: 05/10/2021 5:08 PM**

| | |
|---|---|
| Input File Name: | Rain_Garden_Till_SUSTAIN_PugetEast32.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Rain Garden on Till Soils |
| Comments: | Puget East 32 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 13

Full Period of Record Available used for Routing
Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961032 Puget East 32 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.023 | 0.023 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.002 |
| Total (acres) | 0.023 | 0.024 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 0.023 |
| Subbasin Total | 0.023 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.023
----------------------------------------------
Subbasin Total 0.023

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.14
Storage Depth (ft) : 0.14
Bottom Length (ft) : 7.1
Bottom Width (ft) : 11.2
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 79.
Area at Riser Crest El (sq-ft) : 79.
(acres) : 0.002
Volume at Riser Crest (cu-ft) : 31.
(ac-ft) : 0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.00
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 25.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.30

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 12.00
Common Length (ft) : 0.000

Riser Crest Elevation : 100.14 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

*********** Subbasin: Subbasin 1 *************

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

| Tr (yrs) | Flood Peak (cfs) |
|---|---|
| 2-Year | 7.286E-03 |
| 5-Year | 9.854E-03 |
| 10-Year | 1.149E-02 |
| 25-Year | 1.430E-02 |
| 50-Year | 1.816E-02 |
| 100-Year | 2.280E-02 |
| 200-Year | 2.358E-02 |
| 500-Year | 2.458E-02 |

********** Link: New Bio Lnk1 ********** Link Inflow Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

| Tr (yrs) | Flood Peak (cfs) |
|---|---|
| 2-Year | 7.286E-03 |
| 5-Year | 9.854E-03 |
| 10-Year | 1.149E-02 |
| 25-Year | 1.430E-02 |
| 50-Year | 1.816E-02 |
| 100-Year | 2.280E-02 |
| 200-Year | 2.358E-02 |
| 500-Year | 2.458E-02 |

********** Link: New Bio Lnk1 ********** Link WSEL Stats
WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)
Tr (yrs) WSEL Peak (ft)

========================================

| | |
|---|---|
| 1.05-Year | 100.142 |
| 1.11-Year | 100.142 |
| 1.25-Year | 100.143 |
| 2.00-Year | 100.145 |
| 3.33-Year | 100.146 |
| 5-Year | 100.147 |
| 10-Year | 100.148 |
| 25-Year | 100.149 |
| 50-Year | 100.151 |
| 100-Year | 100.154 |

*************Groundwater Recharge Summary ***************

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 7.585 |
| Total: | 7.585 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.048 ac-ft/year**

*************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 7.70
Inflow Volume Including PPT-Evap (ac-ft): 8.33
Total Runoff Infiltrated (ac-ft): 7.59, 91.07%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.74

Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.07%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 7.286E-03 | 2-Year | 6.077E-03 |
| 5-Year | 9.854E-03 | 5-Year | 8.478E-03 |
| 10-Year | 1.149E-02 | 10-Year | 1.036E-02 |
| 25-Year | 1.430E-02 | 25-Year | 1.175E-02 |
| 50-Year | 1.816E-02 | 50-Year | 1.373E-02 |
| 100-Year | 2.280E-02 | 100-Year | 1.761E-02 |
| 200-Year | 2.358E-02 | 200-Year | 2.054E-02 |
| 500-Year | 2.458E-02 | 500-Year | 2.440E-02 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

| | | |
|---|---|---|
| Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): | -61.8% | PASS |
| Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): | -44.2% | PASS |
| Maximum Excursion from Q2 to Q50 (Must be less than 10%): | -18.7% | PASS |
| Percent Excursion from Q2 to Q50 (Must be less than 50%): | 0.0% | PASS |

---

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

---

****** LID Duration Performance ******

| | | |
|---|---|---|
| Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): | -89.8% | PASS |
| Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): | -61.8% | PASS |

---

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

---

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/10/2021 5:02 PM**
**Report Generation Date: 05/10/2021 5:02 PM**

| | |
|---|---|
| Input File Name: | Rain_Garden_Till_SUSTAIN_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Rain Garden on Till Soils |
| Comments: | Puget East 40 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

*********************** WATERSHED DEFINITION **************************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.019 | 0.019 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.002 |
| Total (acres) | 0.019 | 0.020 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.019
----------------------------------------------
Subbasin Total 0.019

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 0.019 |
| Subbasin Total | 0.019 |

**************************** LINK DATA ********************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA ********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**-------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

| | | |
|---|---|---|
| Base Elevation (ft) | : | 100.00 |
| Riser Crest Elevation (ft) | : | 100.14 |
| Storage Depth (ft) | : | 0.14 |
| Bottom Length (ft) | : | 7.1 |
| Bottom Width (ft) | : | 11.2 |
| Side Slopes (ft/ft) | : | L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : | 79. |
| Area at Riser Crest El (sq-ft) | : | 79. |
| (acres) | : | 0.002 |
| Volume at Riser Crest (cu-ft) | : | 31. |
| (ac-ft) | : | 0.001 |

Infiltration on Bottom and Sideslopes Selected

Soil Properties

| | | |
|---|---|---|
| Biosoil Thickness (ft) | : | 1.00 |
| Biosoil Saturated Hydraulic Conductivity (in/hr) | : | 6.00 |
| Biosoil Porosity (Percent) | : | 25.00 |
| Maximum Elevation of Bioretention Soil | : | 101.00 |
| Native Soil Hydraulic Conductivity (in/hr) | : | 0.30 |

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 12.00 |
| Common Length (ft) | : 0.000 |

Riser Crest Elevation : 100.14 ft

Hydraulic Structure Geometry

Number of Devices: 0

************************FLOOD FREQUENCY AND DURATION STATISTICS**********************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

************ Subbasin: Subbasin 1 ************

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

| Tr (yrs) | Flood Peak (cfs) |
|---|---|
| 2-Year | 6.895E-03 |
| 5-Year | 8.955E-03 |
| 10-Year | 1.007E-02 |
| 25-Year | 1.268E-02 |
| 50-Year | 1.614E-02 |
| 100-Year | 1.866E-02 |
| 200-Year | 1.934E-02 |
| 500-Year | 2.025E-02 |

********** Link: New Bio Lnk1 ********** Link Inflow Frequency Stats

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

| Tr (yrs) | Flood Peak (cfs) |
|---|---|
| 2-Year | 6.895E-03 |
| 5-Year | 8.955E-03 |
| 10-Year | 1.007E-02 |
| 25-Year | 1.268E-02 |
| 50-Year | 1.614E-02 |
| 100-Year | 1.866E-02 |
| 200-Year | 1.934E-02 |
| 500-Year | 2.025E-02 |

********** Link: New Bio Lnk1 ********** Link WSEL Stats

WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)
Tr (yrs) WSEL Peak (ft)

========================================

| | |
|---|---|
| 1.05-Year | 100.142 |
| 1.11-Year | 100.142 |
| 1.25-Year | 100.143 |
| 2.00-Year | 100.145 |
| 3.33-Year | 100.146 |
| 5-Year | 100.146 |
| 10-Year | 100.147 |
| 25-Year | 100.148 |
| 50-Year | 100.150 |
| 100-Year | 100.152 |

*************Groundwater Recharge Summary ***************

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 8.294 |
| Total: | 8.294 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.052 ac-ft/year**

*************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 8.29
Inflow Volume Including PPT-Evap (ac-ft): 9.11
Total Runoff Infiltrated (ac-ft): 8.29, 91.02%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.81

Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.02%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 6.895E-03 | 2-Year | 5.899E-03 |
| 5-Year | 8.955E-03 | 5-Year | 7.793E-03 |
| 10-Year | 1.007E-02 | 10-Year | 9.407E-03 |
| 25-Year | 1.268E-02 | 25-Year | 1.039E-02 |
| 50-Year | 1.614E-02 | 50-Year | 1.351E-02 |
| 100-Year | 1.866E-02 | 100-Year | 1.544E-02 |
| 200-Year | 1.934E-02 | 200-Year | 1.708E-02 |
| 500-Year | 2.025E-02 | 500-Year | 1.923E-02 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -62.7%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -43.5%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): -23.1%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

---
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

---

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -90.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -62.7% PASS

---
MEETS ALL LID DURATION DESIGN CRITERIA: PASS

---

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/10/2021 5:16 PM**
**Report Generation Date: 05/10/2021 5:16 PM**

| | |
|---|---|
| Input File Name: | Rain_Garden_Till_SUSTAIN_PugetEast60.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Rain Garden on Till Soils |
| Comments: | Puget East 60 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 20

Full Period of Record Available used for Routing

| | |
|---|---|
| Precipitation Station : | 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097 |
| Evaporation Station : | 961060 Puget East 60 in MAP |
| Evaporation Scale Factor : | 0.750 |

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.013 | 0.013 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.002 |
| Total (acres) | 0.013 | 0.014 |

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.013
----------------------------------------------
Subbasin Total 0.013

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 0.013 |
| Subbasin Total | 0.013 |

**************************** LINK DATA *******************************

---------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

---------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.14
Storage Depth (ft) : 0.14
Bottom Length (ft) : 7.1
Bottom Width (ft) : 11.2
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 79.
Area at Riser Crest El (sq-ft) : 79.
(acres) : 0.002
Volume at Riser Crest (cu-ft) : 31.
(ac-ft) : 0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.00
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 25.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.30

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 12.00
Common Length (ft) : 0.000

Riser Crest Elevation : 100.14 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

*********** Subbasin: Subbasin 1 ***********

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

| Tr (yrs) | Flood Peak (cfs) |
|---|---|
| 2-Year | 5.524E-03 |
| 5-Year | 7.060E-03 |
| 10-Year | 8.301E-03 |
| 25-Year | 1.049E-02 |
| 50-Year | 1.255E-02 |
| 100-Year | 1.472E-02 |
| 200-Year | 1.495E-02 |
| 500-Year | 1.525E-02 |

********** Link: New Bio Lnk1 ********** Link Inflow Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

| Tr (yrs) | Flood Peak (cfs) |
|---|---|
| 2-Year | 5.524E-03 |
| 5-Year | 7.060E-03 |
| 10-Year | 8.301E-03 |
| 25-Year | 1.049E-02 |
| 50-Year | 1.255E-02 |
| 100-Year | 1.472E-02 |
| 200-Year | 1.495E-02 |
| 500-Year | 1.525E-02 |

********** Link: New Bio Lnk1 ********** Link WSEL Stats
WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)
Tr (yrs) WSEL Peak (ft)

=======================================

| | |
|---|---|
| 1.05-Year | 100.142 |
| 1.11-Year | 100.142 |
| 1.25-Year | 100.143 |
| 2.00-Year | 100.144 |
| 3.33-Year | 100.144 |
| 5-Year | 100.145 |
| 10-Year | 100.146 |
| 25-Year | 100.146 |
| 50-Year | 100.147 |
| 100-Year | 100.148 |

**************Groundwater Recharge Summary ****************

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 9.434 |
| Total: | 9.434 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.060 ac-ft/year**

**************Water Quality Facility Data ****************

**----------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 9.06
Inflow Volume Including PPT-Evap (ac-ft): 10.36
Total Runoff Infiltrated (ac-ft): 9.43, 91.07%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.92

Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.07%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 5.524E-03 | 2-Year | 4.591E-03 |
| 5-Year | 7.060E-03 | 5-Year | 6.343E-03 |
| 10-Year | 8.301E-03 | 10-Year | 7.442E-03 |
| 25-Year | 1.049E-02 | 25-Year | 8.345E-03 |
| 50-Year | 1.255E-02 | 50-Year | 8.947E-03 |
| 100-Year | 1.472E-02 | 100-Year | 1.010E-02 |
| 200-Year | 1.495E-02 | 200-Year | 1.050E-02 |
| 500-Year | 1.525E-02 | 500-Year | 1.101E-02 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -69.1%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -40.1%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): -35.7%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

-------------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -90.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -69.1% PASS

-------------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
-------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/10/2021 3:45 PM**
**Report Generation Date: 05/10/2021 3:47 PM**

| | |
|---|---|
| Input File Name: | Rain_Garden_Outwash_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Rain Garden on Outwash Soils |
| Comments: | Puget East 40 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.065 | 0.065 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.001 |
| Total (acres) | 0.065 | 0.066 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------

| | |
|---|---|
| Impervious | 0.065 |
| Subbasin Total | 0.065 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.065
----------------------------------------------
Subbasin Total 0.065

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.50
Storage Depth (ft) : 0.50
Bottom Length (ft) : 7.1
Bottom Width (ft) : 3.5
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 3.00 W2= 3.00
Bottom Area (sq-ft) : 25.
Area at Riser Crest El (sq-ft) : 46.
(acres) : 0.001
Volume at Riser Crest (cu-ft) : 24.
(ac-ft) : 0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.00
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 25.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 2.50

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 12.00
Common Length (ft) : 0.000

Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

************************FLOOD FREQUENCY AND DURATION STATISTICS**********************

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

************ Subbasin: Subbasin 1 ************

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

| Tr (yrs) | Flood Peak (cfs) |
|---|---|
| 2-Year | 2.434E-02 |
| 5-Year | 3.161E-02 |
| 10-Year | 3.556E-02 |
| 25-Year | 4.476E-02 |
| 50-Year | 5.698E-02 |
| 100-Year | 6.588E-02 |
| 200-Year | 6.828E-02 |
| 500-Year | 7.146E-02 |

********** Link: New Bio Lnk1 ********** Link Inflow Frequency Stats

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

| Tr (yrs) | Flood Peak (cfs) |
|---|---|
| 2-Year | 2.434E-02 |
| 5-Year | 3.161E-02 |
| 10-Year | 3.556E-02 |
| 25-Year | 4.476E-02 |
| 50-Year | 5.698E-02 |
| 100-Year | 6.588E-02 |
| 200-Year | 6.828E-02 |
| 500-Year | 7.146E-02 |

********** Link: New Bio Lnk1 ********** Link WSEL Stats

WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)
Tr (yrs) WSEL Peak (ft)

========================================

| | |
|---|---|
| 1.05-Year | 100.509 |
| 1.11-Year | 100.510 |
| 1.25-Year | 100.511 |
| 2.00-Year | 100.515 |
| 3.33-Year | 100.517 |
| 5-Year | 100.519 |
| 10-Year | 100.520 |
| 25-Year | 100.524 |
| 50-Year | 100.529 |
| 100-Year | 100.532 |

*************Groundwater Recharge Summary ***************

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 26.911 |
| Total: | 26.911 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.170 ac-ft/year**

*************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 29.28
Inflow Volume Including PPT-Evap (ac-ft): 29.57
Total Runoff Infiltrated (ac-ft): 26.91, 91.02%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 2.67

Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.02%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 2.434E-02 | 2-Year | 1.989E-02 |
| 5-Year | 3.161E-02 | 5-Year | 2.809E-02 |
| 10-Year | 3.556E-02 | 10-Year | 3.186E-02 |
| 25-Year | 4.476E-02 | 25-Year | 4.143E-02 |
| 50-Year | 5.698E-02 | 50-Year | 5.360E-02 |
| 100-Year | 6.588E-02 | 100-Year | 6.263E-02 |
| 200-Year | 6.828E-02 | 200-Year | 6.485E-02 |
| 500-Year | 7.146E-02 | 500-Year | 6.778E-02 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -70.0%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -49.2%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 1.1%
PASS

-----------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS
-----------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -90.5% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -70.0% PASS

-----------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
-----------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/10/2021 3:56 PM**
**Report Generation Date: 05/10/2021 3:56 PM**

| | |
|---|---|
| Input File Name: | Rain_Garden_Outwash_SUSTAIN_PugetEast32.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Rain Garden on Outwash Soils |
| Comments: | Puget East 32 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 13

Full Period of Record Available used for Routing
Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961032 Puget East 32 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.078 | 0.078 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.001 |
| Total (acres) | 0.078 | 0.080 |

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.078
-------------------------------------------
Subbasin Total 0.078

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 0.078 |
| ---------------------------------------------- | |
| Subbasin Total | 0.078 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

| | |
|---|---|
| Base Elevation (ft) | : 100.00 |
| Riser Crest Elevation (ft) | : 100.14 |
| Storage Depth (ft) | : 0.14 |
| Bottom Length (ft) | : 7.1 |
| Bottom Width (ft) | : 9.2 |
| Side Slopes (ft/ft) | : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : 65. |
| Area at Riser Crest El (sq-ft) | : 65. |
| (acres) | : 0.001 |
| Volume at Riser Crest (cu-ft) | : 25. |
| (ac-ft) | : 0.001 |

Infiltration on Bottom and Sideslopes Selected

Soil Properties

| | |
|---|---|
| Biosoil Thickness (ft) | : 1.00 |
| Biosoil Saturated Hydraulic Conductivity (in/hr) | : 6.00 |
| Biosoil Porosity (Percent) | : 25.00 |
| Maximum Elevation of Bioretention Soil | : 101.00 |
| Native Soil Hydraulic Conductivity (in/hr) | : 2.50 |

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 12.00 |
| Common Length (ft) | : 0.000 |

Riser Crest Elevation : 100.14 ft

Hydraulic Structure Geometry

Number of Devices: 0

************************FLOOD FREQUENCY AND DURATION STATISTICS*********************

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

************ Subbasin: Subbasin 1 ************

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

| Tr (yrs) | Flood Peak (cfs) |
|---|---|
| 2-Year | 2.524E-02 |
| 5-Year | 3.414E-02 |
| 10-Year | 3.982E-02 |
| 25-Year | 4.953E-02 |
| 50-Year | 6.291E-02 |
| 100-Year | 7.899E-02 |
| 200-Year | 8.168E-02 |
| 500-Year | 8.517E-02 |

********** Link: New Bio Lnk1 ********** Link Inflow Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

| Tr (yrs) | Flood Peak (cfs) |
|---|---|
| 2-Year | 2.524E-02 |
| 5-Year | 3.414E-02 |
| 10-Year | 3.982E-02 |
| 25-Year | 4.953E-02 |
| 50-Year | 6.291E-02 |
| 100-Year | 7.899E-02 |
| 200-Year | 8.168E-02 |
| 500-Year | 8.517E-02 |

********** Link: New Bio Lnk1 ********** Link WSEL Stats
WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)
Tr (yrs) WSEL Peak (ft)

=======================================

| | |
|---|---|
| 1.05-Year | 100.148 |
| 1.11-Year | 100.149 |
| 1.25-Year | 100.151 |
| 2.00-Year | 100.156 |
| 3.33-Year | 100.158 |
| 5-Year | 100.160 |
| 10-Year | 100.162 |
| 25-Year | 100.166 |
| 50-Year | 100.172 |
| 100-Year | 100.177 |

**************Groundwater Recharge Summary ***************

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 24.722 |
| Total: | 24.722 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.156 ac-ft/year**

**************Water Quality Facility Data ***************

**--------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**--------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 26.68
Inflow Volume Including PPT-Evap (ac-ft): 27.17
Total Runoff Infiltrated (ac-ft): 24.72, 91.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 2.52

Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 2.524E-02 | 2-Year | 2.132E-02 |
| 5-Year | 3.414E-02 | 5-Year | 3.095E-02 |
| 10-Year | 3.982E-02 | 10-Year | 3.640E-02 |
| 25-Year | 4.953E-02 | 25-Year | 4.630E-02 |
| 50-Year | 6.291E-02 | 50-Year | 6.014E-02 |
| 100-Year | 7.899E-02 | 100-Year | 7.655E-02 |
| 200-Year | 8.168E-02 | 200-Year | 7.979E-02 |
| 500-Year | 8.517E-02 | 500-Year | 8.402E-02 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -64.4%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -43.3%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

-------------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -89.9% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -64.4% PASS

-------------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
-------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/10/2021 3:51 PM**
**Report Generation Date: 05/10/2021 3:51 PM**

| | |
|---|---|
| Input File Name: | Rain_Garden_Outwash_SUSTAIN_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Rain Garden on Outwash Soils |
| Comments: | Puget East 40 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.065 | 0.065 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.001 |
| Total (acres) | 0.065 | 0.067 |

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.065
----------------------------------------------
Subbasin Total 0.065

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.065
----------------------------------------------
Subbasin Total 0.065

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.14
Storage Depth (ft) : 0.14
Bottom Length (ft) : 7.1
Bottom Width (ft) : 9.2
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 65.
Area at Riser Crest El (sq-ft) : 65.
(acres) : 0.001
Volume at Riser Crest (cu-ft) : 25.
(ac-ft) : 0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.00
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 25.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 2.50

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 12.00
Common Length (ft) : 0.000

Riser Crest Elevation : 100.14 ft

Hydraulic Structure Geometry

Number of Devices: 0

************************FLOOD FREQUENCY AND DURATION STATISTICS**********************

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

************ Subbasin: Subbasin 1 ************

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

| Tr (yrs) | Flood Peak (cfs) |
|---|---|
| 2-Year | 2.434E-02 |
| 5-Year | 3.161E-02 |
| 10-Year | 3.556E-02 |
| 25-Year | 4.476E-02 |
| 50-Year | 5.698E-02 |
| 100-Year | 6.588E-02 |
| 200-Year | 6.828E-02 |
| 500-Year | 7.146E-02 |

********** Link: New Bio Lnk1 ********** Link Inflow Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

| Tr (yrs) | Flood Peak (cfs) |
|---|---|
| 2-Year | 2.434E-02 |
| 5-Year | 3.161E-02 |
| 10-Year | 3.556E-02 |
| 25-Year | 4.476E-02 |
| 50-Year | 5.698E-02 |
| 100-Year | 6.588E-02 |
| 200-Year | 6.828E-02 |
| 500-Year | 7.146E-02 |

********** Link: New Bio Lnk1 ********** Link WSEL Stats
WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)
Tr (yrs) WSEL Peak (ft)

========================================

| | |
|---|---|
| 1.05-Year | 100.149 |
| 1.11-Year | 100.150 |
| 1.25-Year | 100.151 |
| 2.00-Year | 100.155 |
| 3.33-Year | 100.157 |
| 5-Year | 100.159 |
| 10-Year | 100.160 |
| 25-Year | 100.165 |
| 50-Year | 100.169 |
| 100-Year | 100.173 |

**************Groundwater Recharge Summary ***************

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 27.242 |
| Total: | 27.242 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.172 ac-ft/year**

**************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 29.28
Inflow Volume Including PPT-Evap (ac-ft): 29.92
Total Runoff Infiltrated (ac-ft): 27.24, 91.05%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 2.78

Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.05%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 2.434E-02 | 2-Year | 2.019E-02 |
| 5-Year | 3.161E-02 | 5-Year | 2.843E-02 |
| 10-Year | 3.556E-02 | 10-Year | 3.225E-02 |
| 25-Year | 4.476E-02 | 25-Year | 4.203E-02 |
| 50-Year | 5.698E-02 | 50-Year | 5.427E-02 |
| 100-Year | 6.588E-02 | 100-Year | 6.399E-02 |
| 200-Year | 6.828E-02 | 200-Year | 6.672E-02 |
| 500-Year | 7.146E-02 | 500-Year | 7.032E-02 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -68.4%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -47.5%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 1.1%
PASS

-------------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -90.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -68.4% PASS

-------------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
-------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/10/2021 4:51 PM**
**Report Generation Date: 05/10/2021 4:51 PM**

| | |
|---|---|
| Input File Name: | Rain_Garden_Outwash_SUSTAIN_PugetEast60.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Rain Garden on Outwash Soils |
| Comments: | Puget East 60 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 20

Full Period of Record Available used for Routing
Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961060 Puget East 60 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

*********************** WATERSHED DEFINITION **************************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.047 | 0.047 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.001 |
| Total (acres) | 0.047 | 0.048 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.047
----------------------------------------------
Subbasin Total 0.047

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 0.047 |
| Subbasin Total | 0.047 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

| | |
|---|---|
| Base Elevation (ft) | : 100.00 |
| Riser Crest Elevation (ft) | : 100.14 |
| Storage Depth (ft) | : 0.14 |
| Bottom Length (ft) | : 7.1 |
| Bottom Width (ft) | : 9.2 |
| Side Slopes (ft/ft) | : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : 65. |
| Area at Riser Crest El (sq-ft) | : 65. |
| (acres) | : 0.001 |
| Volume at Riser Crest (cu-ft) | : 25. |
| (ac-ft) | : 0.001 |

Infiltration on Bottom and Sideslopes Selected

Soil Properties

| | |
|---|---|
| Biosoil Thickness (ft) | : 1.00 |
| Biosoil Saturated Hydraulic Conductivity (in/hr) | : 6.00 |
| Biosoil Porosity (Percent) | : 25.00 |
| Maximum Elevation of Bioretention Soil | : 101.00 |
| Native Soil Hydraulic Conductivity (in/hr) | : 2.50 |

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 12.00 |
| Common Length (ft) | : 0.000 |

Riser Crest Elevation : 100.14 ft

Hydraulic Structure Geometry

Number of Devices: 0

***********************FLOOD FREQUENCY AND DURATION STATISTICS*********************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

************ Subbasin: Subbasin 1 ************

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

| Tr (yrs) | Flood Peak (cfs) |
|---|---|
| 2-Year | 2.056E-02 |
| 5-Year | 2.628E-02 |
| 10-Year | 3.090E-02 |
| 25-Year | 3.904E-02 |
| 50-Year | 4.670E-02 |
| 100-Year | 5.479E-02 |
| 200-Year | 5.565E-02 |
| 500-Year | 5.676E-02 |

********** Link: New Bio Lnk1 ********** Link Inflow Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

| Tr (yrs) | Flood Peak (cfs) |
|---|---|
| 2-Year | 2.056E-02 |
| 5-Year | 2.628E-02 |
| 10-Year | 3.090E-02 |
| 25-Year | 3.904E-02 |
| 50-Year | 4.670E-02 |
| 100-Year | 5.479E-02 |
| 200-Year | 5.565E-02 |
| 500-Year | 5.676E-02 |

********** Link: New Bio Lnk1 ********** Link WSEL Stats
WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)
Tr (yrs) WSEL Peak (ft)

========================================

| | |
|---|---|
| 1.05-Year | 100.147 |
| 1.11-Year | 100.148 |
| 1.25-Year | 100.150 |
| 2.00-Year | 100.153 |
| 3.33-Year | 100.155 |
| 5-Year | 100.157 |
| 10-Year | 100.159 |
| 25-Year | 100.162 |
| 50-Year | 100.165 |
| 100-Year | 100.169 |

*************Groundwater Recharge Summary ***************

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 31.648 |
| Total: | 31.648 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.200 ac-ft/year**

*************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 33.72
Inflow Volume Including PPT-Evap (ac-ft): 34.77
Total Runoff Infiltrated (ac-ft): 31.65, 91.03%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 3.27

Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.03%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 2.056E-02 | 2-Year | 1.681E-02 |
| 5-Year | 2.628E-02 | 5-Year | 2.338E-02 |
| 10-Year | 3.090E-02 | 10-Year | 2.774E-02 |
| 25-Year | 3.904E-02 | 25-Year | 3.630E-02 |
| 50-Year | 4.670E-02 | 50-Year | 4.423E-02 |
| 100-Year | 5.479E-02 | 100-Year | 5.178E-02 |
| 200-Year | 5.565E-02 | 200-Year | 5.327E-02 |
| 500-Year | 5.676E-02 | 500-Year | 5.525E-02 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -81.1%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -57.5%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

---
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

---

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -89.8% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -81.1% PASS

---
MEETS ALL LID DURATION DESIGN CRITERIA: PASS

---

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/11/2021 8:53 AM**
**Report Generation Date: 05/11/2021 8:53 AM**

| | |
|---|---|
| Input File Name: | Bioretention_Planter_PugetEast32.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Bioretention Planter |
| Comments: | Puget East 32 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 13

Full Period of Record Available used for Routing

| | |
|---|---|
| Precipitation Station : | 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097 |
| Evaporation Station : | 961032 Puget East 32 in MAP |
| Evaporation Scale Factor : | 0.750 |

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

*********************** WATERSHED DEFINITION ************************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.065 | 0.065 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.001 |
| Total (acres) | 0.065 | 0.065 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 0.065 |
| Subbasin Total | 0.065 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.065
----------------------------------------------
Subbasin Total 0.065

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.50
Storage Depth (ft) : 0.50
Bottom Length (ft) : 8.7
Bottom Width (ft) : 2.9
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 25.
Area at Riser Crest El (sq-ft) : 25.
(acres) : 0.001
Volume at Riser Crest (cu-ft) : 24.
(ac-ft) : 0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.00

Underdrain Present
Orifice NOT Present in Under Drain

Riser Geometry
Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

*************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge Equals Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year**

*************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 22.01
Inflow Volume Including PPT-Evap (ac-ft): 22.19
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 20.19, 91.00%
Primary Outflow To Downstream System (ac-ft): 22.18
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 2.083E-02 | 2-Year | 2.067E-02 |
| 5-Year | 2.817E-02 | 5-Year | 2.842E-02 |
| 10-Year | 3.285E-02 | 10-Year | 3.299E-02 |
| 25-Year | 4.086E-02 | 25-Year | 4.113E-02 |
| 50-Year | 5.191E-02 | 50-Year | 5.235E-02 |
| 100-Year | 6.517E-02 | 100-Year | 6.568E-02 |
| 200-Year | 6.739E-02 | 200-Year | 6.813E-02 |
| 500-Year | 7.027E-02 | 500-Year | 7.131E-02 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -10.8%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): 1.4% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%
FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 43.5%
PASS

-------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 7.8% FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 41.2% FAIL

-------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 04/27/2021 12:19 PM**
**Report Generation Date: 04/27/2021 12:19 PM**

| | |
|---|---|
| Input File Name: | Bioretention_Planter_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Bioretention Planter |
| Comments: | Puget East 40 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

*********************** WATERSHED DEFINITION ************************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.054 | 0.054 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.001 |
| Total (acres) | 0.054 | 0.055 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.054
----------------------------------------------
Subbasin Total 0.054

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 0.054 |
| Subbasin Total | 0.054 |

**************************** LINK DATA *********************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.50
Storage Depth (ft) : 0.50
Bottom Length (ft) : 8.7
Bottom Width (ft) : 2.9
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 25.
Area at Riser Crest El (sq-ft) : 25.
(acres) : 0.001
Volume at Riser Crest (cu-ft) : 24.
(ac-ft) : 0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.00

Underdrain Present
Orifice NOT Present in Under Drain

Riser Geometry
Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

*************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge Equals Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year**

*************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 24.26
Inflow Volume Including PPT-Evap (ac-ft): 24.49
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 22.29, 91.01%
Primary Outflow To Downstream System (ac-ft): 24.49
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.01%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 2.016E-02 | 2-Year | 2.004E-02 |
| 5-Year | 2.619E-02 | 5-Year | 2.637E-02 |
| 10-Year | 2.946E-02 | 10-Year | 2.966E-02 |
| 25-Year | 3.708E-02 | 25-Year | 3.744E-02 |
| 50-Year | 4.720E-02 | 50-Year | 4.766E-02 |
| 100-Year | 5.458E-02 | 100-Year | 5.531E-02 |
| 200-Year | 5.657E-02 | 200-Year | 5.745E-02 |
| 500-Year | 5.920E-02 | 500-Year | 6.026E-02 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -10.5% PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): 1.7% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0% FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 56.8% FAIL

-------------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 8.3% FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 46.4% FAIL

-------------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/11/2021 8:48 AM**
**Report Generation Date: 05/11/2021 8:48 AM**

Input File Name: Bioretention_Planter_PugetEast60.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention Planter
Comments: Puget East 60 in MAP

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 20

Full Period of Record Available used for Routing
Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961060 Puget East 60 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.039 | 0.039 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.001 |
| Total (acres) | 0.039 | 0.040 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.039
----------------------------------------------
Subbasin Total 0.039

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

-------Area (Acres) --------

| | |
|---|---|
| Impervious | 0.039 |
| Subbasin Total | 0.039 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.50
Storage Depth (ft) : 0.50
Bottom Length (ft) : 8.7
Bottom Width (ft) : 2.9
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 25.
Area at Riser Crest El (sq-ft) : 25.
(acres) : 0.001
Volume at Riser Crest (cu-ft) : 24.
(ac-ft) : 0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.00

Underdrain Present
Orifice NOT Present in Under Drain

Riser Geometry
Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge Equals Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year**

**************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 28.04
Inflow Volume Including PPT-Evap (ac-ft): 28.44
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 25.89, 91.05%
Primary Outflow To Downstream System (ac-ft): 28.44
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.05%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 1.710E-02 | 2-Year | 1.717E-02 |
| 5-Year | 2.185E-02 | 5-Year | 2.218E-02 |
| 10-Year | 2.569E-02 | 10-Year | 2.592E-02 |
| 25-Year | 3.247E-02 | 25-Year | 3.290E-02 |
| 50-Year | 3.883E-02 | 50-Year | 3.952E-02 |
| 100-Year | 4.556E-02 | 100-Year | 4.668E-02 |
| 200-Year | 4.627E-02 | 200-Year | 4.713E-02 |
| 500-Year | 4.720E-02 | 500-Year | 4.769E-02 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -15.2%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): 1.3% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%
FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 65.3% FAIL

-----------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
-----------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 7.4% FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 43.2% FAIL

-----------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
-----------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/10/2021 10:53 AM**
**Report Generation Date: 05/10/2021 10:53 AM**

| | |
|---|---|
| Input File Name: | Bioretention_Till_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Bioretention on Till soils |
| Comments: | Puget East 40 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

************************ WATERSHED DEFINITION ************************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.266 | 0.266 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.002 |
| Total (acres) | 0.266 | 0.268 |

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.266
----------------------------------------------
Subbasin Total 0.266

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 0.266 |
| Subbasin Total | 0.266 |

**************************** LINK DATA *********************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.50
Storage Depth (ft) : 0.50
Bottom Length (ft) : 16.0
Bottom Width (ft) : 5.3
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 3.00 W2= 3.00
Bottom Area (sq-ft) : 85.
Area at Riser Crest El (sq-ft) : 133.
(acres) : 0.003
Volume at Riser Crest (cu-ft) : 93.
(ac-ft) : 0.002

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.30

Underdrain Present
Orifice NOT Present in Under Drain

Riser Geometry
Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ****************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge Equals Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year**

**************Water Quality Facility Data ****************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 119.08
Inflow Volume Including PPT-Evap (ac-ft): 120.02
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 109.22, 91.00%
Primary Outflow To Downstream System (ac-ft): 120.02
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 9.898E-02 | 2-Year | 9.757E-02 |
| 5-Year | 0.129 | 5-Year | 0.128 |
| 10-Year | 0.145 | 10-Year | 0.145 |
| 25-Year | 0.182 | 25-Year | 0.182 |
| 50-Year | 0.232 | 50-Year | 0.231 |
| 100-Year | 0.268 | 100-Year | 0.266 |
| 200-Year | 0.278 | 200-Year | 0.277 |
| 500-Year | 0.291 | 500-Year | 0.292 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -7.2%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): 0.7% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 23.1% FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 43.2%
PASS

-------------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 11.2% FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 22.4% FAIL

-------------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/10/2021 11:07 AM**
**Report Generation Date: 05/10/2021 11:07 AM**

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| | |
|---|---|
| Input File Name: | Bioretention_Till_SUSTAIN_PugetEast32.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Bioretention on Till soils |
| Comments: | Puget East 32 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 13

Full Period of Record Available used for Routing
Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961032 Puget East 32 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.334 | 0.334 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.003 |
| Total (acres) | 0.334 | 0.337 |

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.334
----------------------------------------------
Subbasin Total 0.334

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 0.334 |
| Subbasin Total | 0.334 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.35
Storage Depth (ft) : 0.35
Bottom Length (ft) : 16.0
Bottom Width (ft) : 8.6
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 137.
Area at Riser Crest El (sq-ft) : 137.
(acres) : 0.003
Volume at Riser Crest (cu-ft) : 109.
(ac-ft) : 0.003

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.30

Underdrain Present
Orifice NOT Present in Under Drain

Riser Geometry
Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.35 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

*************Groundwater Recharge Summary **************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge Equals Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year**

*************Water Quality Facility Data **************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 113.78
Inflow Volume Including PPT-Evap (ac-ft): 114.76
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 104.42, 91.00%
Primary Outflow To Downstream System (ac-ft): 114.71
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.108 | 2-Year | 0.107 |
| 5-Year | 0.146 | 5-Year | 0.146 |
| 10-Year | 0.170 | 10-Year | 0.170 |
| 25-Year | 0.211 | 25-Year | 0.210 |
| 50-Year | 0.268 | 50-Year | 0.267 |
| 100-Year | 0.337 | 100-Year | 0.337 |
| 200-Year | 0.348 | 200-Year | 0.347 |
| 500-Year | 0.363 | 500-Year | 0.360 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -7.2% PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): 1.6% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 37.5% FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 38.0% PASS

----------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
----------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 5.1% FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 29.0% FAIL

----------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
----------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/10/2021 11:01 AM**
**Report Generation Date: 05/10/2021 11:01 AM**

| | |
|---|---|
| Input File Name: | Bioretention_Till_SUSTAIN_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Bioretention on Till soils |
| Comments: | Puget East 40 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.279 | 0.279 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.003 |
| Total (acres) | 0.279 | 0.282 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.279
----------------------------------------------
Subbasin Total 0.279

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 0.279 |
| Subbasin Total | 0.279 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.35
Storage Depth (ft) : 0.35
Bottom Length (ft) : 16.0
Bottom Width (ft) : 8.6
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 137.
Area at Riser Crest El (sq-ft) : 137.
(acres) : 0.003
Volume at Riser Crest (cu-ft) : 109.
(ac-ft) : 0.003

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.30

Underdrain Present
Orifice NOT Present in Under Drain

Riser Geometry
Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.35 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary *************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge Equals Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year**

**************Water Quality Facility Data *************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 125.04
Inflow Volume Including PPT-Evap (ac-ft): 126.35
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 115.04, 91.05%
Primary Outflow To Downstream System (ac-ft): 126.35
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.05%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.104 | 2-Year | 0.102 |
| 5-Year | 0.135 | 5-Year | 0.135 |
| 10-Year | 0.152 | 10-Year | 0.152 |
| 25-Year | 0.191 | 25-Year | 0.192 |
| 50-Year | 0.243 | 50-Year | 0.243 |
| 100-Year | 0.281 | 100-Year | 0.281 |
| 200-Year | 0.292 | 200-Year | 0.291 |
| 500-Year | 0.305 | 500-Year | 0.305 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -7.6%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): 1.2% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 23.1% FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 45.3%
PASS

-------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 5.6% FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 32.9% FAIL

-------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 11:50 AM**
**Report Generation Date: 05/12/2021 11:51 AM**

| | |
|---|---|
| Input File Name: | Bioretention_Till_SUSTAIN_PugetEast60.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Bioretention on Till soils |
| Comments: | Puget East 60 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 20

Full Period of Record Available used for Routing
Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961060 Puget East 60 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

*********************** WATERSHED DEFINITION ************************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.200 | 0.200 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.003 |
| Total (acres) | 0.200 | 0.203 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.200
----------------------------------------------
Subbasin Total 0.200

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 0.200 |
| ---------------------------------------------- | |
| Subbasin Total | 0.200 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.35
Storage Depth (ft) : 0.35
Bottom Length (ft) : 16.0
Bottom Width (ft) : 8.6
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 137.
Area at Riser Crest El (sq-ft) : 137.
(acres) : 0.003
Volume at Riser Crest (cu-ft) : 109.
(ac-ft) : 0.003

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.30

Underdrain Present
Orifice NOT Present in Under Drain

Riser Geometry
Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.35 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge Equals Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year**

**************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 143.82
Inflow Volume Including PPT-Evap (ac-ft): 145.96
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 132.95, 91.09%
Primary Outflow To Downstream System (ac-ft): 145.95
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.09%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 8.768E-02 | 2-Year | 8.784E-02 |
| 5-Year | 0.112 | 5-Year | 0.113 |
| 10-Year | 0.132 | 10-Year | 0.132 |
| 25-Year | 0.166 | 25-Year | 0.167 |
| 50-Year | 0.199 | 50-Year | 0.200 |
| 100-Year | 0.234 | 100-Year | 0.234 |
| 200-Year | 0.237 | 200-Year | 0.239 |
| 500-Year | 0.242 | 500-Year | 0.245 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -10.9%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): 1.2% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%
FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 53.7% FAIL

-----------------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
-----------------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 4.9% FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 37.6% FAIL

-----------------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
-----------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/13/2021 10:48 AM**
**Report Generation Date: 05/13/2021 10:49 AM**

| | |
|---|---|
| Input File Name: | Bioretention_Outwash_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Bioretention on Outwash soils |
| Comments: | Puget East 40 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.220 | 0.220 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.002 |
| Total (acres) | 0.220 | 0.222 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.220
----------------------------------------------
Subbasin Total 0.220

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 0.220 |
| Subbasin Total | 0.220 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.50
Storage Depth (ft) : 0.50
Bottom Length (ft) : 16.0
Bottom Width (ft) : 5.3
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 3.00 W2= 3.00
Bottom Area (sq-ft) : 85.
Area at Riser Crest El (sq-ft) : 133.
(acres) : 0.003
Volume at Riser Crest (cu-ft) : 93.
(ac-ft) : 0.002

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 2.50

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 12.00
Common Length (ft) : 0.000

Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

***********************FLOOD FREQUENCY AND DURATION STATISTICS*********************

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

*************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 90.455 |
| Total: | 90.455 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.573 ac-ft/year**

*************Water Quality Facility Data ***************

**----------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------

Inflow Volume (ac-ft): 98.50
Inflow Volume Including PPT-Evap (ac-ft): 99.40
Total Runoff Infiltrated (ac-ft): 90.46, 91.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 9.51
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

**************Compliance Point Results ****************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 8.188E-02 | 2-Year | 6.460E-02 |
| 5-Year | 0.106 | 5-Year | 9.229E-02 |
| 10-Year | 0.120 | 10-Year | 0.106 |
| 25-Year | 0.151 | 25-Year | 0.137 |
| 50-Year | 0.192 | 50-Year | 0.174 |
| 100-Year | 0.222 | 100-Year | 0.205 |
| 200-Year | 0.230 | 200-Year | 0.217 |
| 500-Year | 0.240 | 500-Year | 0.233 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -69.0%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -51.9%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): -13.6%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -89.7% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -69.0% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 11:53 AM**
**Report Generation Date: 05/12/2021 11:54 AM**

| | |
|---|---|
| Input File Name: | Bioretention_Outwash_SUSTAIN_PugetEast32.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Bioretention on Outwash soils |
| Comments: | Puget East 32 in MAP |

## PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 13

Full Period of Record Available used for Routing
Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961032 Puget East 32 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.263 | 0.263 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.005 |
| Total (acres) | 0.263 | 0.267 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.263
----------------------------------------------
Subbasin Total 0.263

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.263
----------------------------------------------
Subbasin Total 0.263

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.06
Storage Depth (ft) : 0.06
Bottom Length (ft) : 16.0
Bottom Width (ft) : 12.9
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 206.
Area at Riser Crest El (sq-ft) : 206.
(acres) : 0.005
Volume at Riser Crest (cu-ft) : 105.
(ac-ft) : 0.002

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 2.50

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 12.00
Common Length (ft) : 0.000

Riser Crest Elevation : 100.06 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

*************Groundwater Recharge Summary *************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 82.856 |
| Total: | 82.856 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.524 ac-ft/year**

************Water Quality Facility Data *************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------

Inflow Volume (ac-ft): 89.51
Inflow Volume Including PPT-Evap (ac-ft): 91.05
Total Runoff Infiltrated (ac-ft): 82.86, 91.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 8.50
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

**************Compliance Point Results ****************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 8.470E-02 | 2-Year | 6.964E-02 |
| 5-Year | 0.115 | 5-Year | 0.102 |
| 10-Year | 0.134 | 10-Year | 0.120 |
| 25-Year | 0.166 | 25-Year | 0.146 |
| 50-Year | 0.211 | 50-Year | 0.199 |
| 100-Year | 0.265 | 100-Year | 0.250 |
| 200-Year | 0.274 | 200-Year | 0.253 |
| 500-Year | 0.286 | 500-Year | 0.258 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -64.7%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -45.4%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

---
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

---

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -89.8% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -64.7% PASS

---
MEETS ALL LID DURATION DESIGN CRITERIA: PASS

---

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/13/2021 10:50 AM**
**Report Generation Date: 05/13/2021 10:50 AM**

| | |
|---|---|
| Input File Name: | Bioretention_Outwash_SUSTAIN_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Bioretention on Outwash soils - Vertical sides |
| Comments: | Puget East 40 in MAP |

Tested with vertical sides for SUSTAIN input analysis.

## PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.220 | 0.220 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.005 |
| Total (acres) | 0.220 | 0.224 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.220
----------------------------------------------

Subbasin Total 0.220

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.220
----------------------------------------------
Subbasin Total 0.220

**************************** LINK DATA ********************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA ********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.06
Storage Depth (ft) : 0.06
Bottom Length (ft) : 16.0
Bottom Width (ft) : 12.9
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 206.
Area at Riser Crest El (sq-ft) : 206.
(acres) : 0.005
Volume at Riser Crest (cu-ft) : 105.
(ac-ft) : 0.002

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 2.50

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 12.00

Common Length (ft) : 0.000
Riser Crest Elevation : 100.06 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary *************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 91.494 |
| Total: | 91.494 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.579 ac-ft/year**

**************Water Quality Facility Data *************

**----------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft):  98.50
Inflow Volume Including PPT-Evap (ac-ft):  100.53
Total Runoff Infiltrated (ac-ft):  91.49,  91.01%
Total Runoff Filtered (ac-ft):  0.00,  0.00%
Primary Outflow To Downstream System (ac-ft):  9.44
Secondary Outflow To Downstream System (ac-ft):  0.00
Volume Lost to ET (ac-ft):  0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.01%

*************************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 8.188E-02 | 2-Year | 6.659E-02 |
| 5-Year | 0.106 | 5-Year | 9.127E-02 |
| 10-Year | 0.120 | 10-Year | 0.107 |
| 25-Year | 0.151 | 25-Year | 0.135 |
| 50-Year | 0.192 | 50-Year | 0.181 |
| 100-Year | 0.222 | 100-Year | 0.210 |
| 200-Year | 0.230 | 200-Year | 0.219 |
| 500-Year | 0.240 | 500-Year | 0.231 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -68.8%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -49.1%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): -13.6%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

----------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA:   PASS
----------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -89.9% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -68.7% PASS

----------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA:   PASS
----------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/07/2021 9:50 AM**
**Report Generation Date: 05/07/2021 9:50 AM**

| | |
|---|---|
| Input File Name: | Bioretention_Outwash_SUSTAIN_PugetEast60.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Bioretention on Outwash soils |
| Comments: | Puget East 60 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 20

Full Period of Record Available used for Routing
Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961060 Puget East 60 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.157 | 0.157 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.005 |
| Total (acres) | 0.157 | 0.162 |

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 0.157 |
| Subbasin Total | 0.157 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 0.157 |
| Subbasin Total | 0.157 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

| | |
|---|---|
| Base Elevation (ft) | : 100.00 |
| Riser Crest Elevation (ft) | : 100.06 |
| Storage Depth (ft) | : 0.06 |
| Bottom Length (ft) | : 16.0 |
| Bottom Width (ft) | : 12.9 |
| Side Slopes (ft/ft) | : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : 206. |
| Area at Riser Crest El (sq-ft) | : 206. |
| (acres) | : 0.005 |
| Volume at Riser Crest (cu-ft) | : 105. |
| (ac-ft) | : 0.002 |

Infiltration on Bottom and Sideslopes Selected

Soil Properties

| | |
|---|---|
| Biosoil Thickness (ft) | : 1.50 |
| Biosoil Saturated Hydraulic Conductivity (in/hr) | : 6.00 |
| Biosoil Porosity (Percent) | : 30.00 |
| Maximum Elevation of Bioretention Soil | : 101.00 |
| Native Soil Hydraulic Conductivity (in/hr) | : 2.50 |

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 12.00 |
| Common Length (ft) | : 0.000 |

Riser Crest Elevation : 100.06 ft

Hydraulic Structure Geometry

Number of Devices: 0

***********************FLOOD FREQUENCY AND DURATION STATISTICS*********************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

*************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 105.993 |
| Total: | 105.993 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.671 ac-ft/year**

*************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------

Inflow Volume (ac-ft): 113.18
Inflow Volume Including PPT-Evap (ac-ft): 116.47
Total Runoff Infiltrated (ac-ft): 105.99, 91.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 10.96
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 6.901E-02 | 2-Year | 5.430E-02 |
| 5-Year | 8.819E-02 | 5-Year | 7.744E-02 |
| 10-Year | 0.104 | 10-Year | 8.516E-02 |
| 25-Year | 0.131 | 25-Year | 0.110 |
| 50-Year | 0.157 | 50-Year | 0.138 |
| 100-Year | 0.184 | 100-Year | 0.165 |
| 200-Year | 0.187 | 200-Year | 0.175 |
| 500-Year | 0.190 | 500-Year | 0.189 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -81.1%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -58.3%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): -18.7%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

---

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

---

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -89.8% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -81.1% PASS

---

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

---

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/11/2021 9:01 AM**
**Report Generation Date: 05/11/2021 9:01 AM**

| | |
|---|---|
| Input File Name: | Drywell_Till_PugetEast32.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Drywell in Till soils |
| Comments: | Puget East 32 in MAP |

## PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 13

Full Period of Record Available used for Routing
Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961032 Puget East 32 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.007 | 0.007 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 0.007 | 0.007 |

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Till Forest | 0.007 |
| Subbasin Total | 0.007 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins:  1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.007
----------------------------------------------
Subbasin Total 0.007

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links:  0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links:  1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type:  Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.61
Max Pond Elevation (ft) : 101.00
Storage Depth (ft) : 0.61
Pond Bottom Length (ft) : 7.2
Pond Bottom Width (ft) : 7.2
Pond Side Slopes (ft/ft) : L1= 0.00   L2= 0.00  W1= 0.00  W2= 0.00
Bottom Area (sq-ft) : 51.
Area at Riser Crest El (sq-ft) : 51.
(acres) : 0.001
Volume at Riser Crest (cu-ft) : 31.
(ac-ft) : 0.001
Area at Max Elevation  (sq-ft) : 51.
(acres) : 0.001
Vol at Max Elevation  (cu-ft) : 51.
(ac-ft) : 0.001

Constant Infiltration Option Used
Infiltration Rate (in/hr):  0.30

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 1000.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.61 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.931 |
| Total: | 0.931 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 2.453 |
| Total: | 2.453 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.006 ac-ft/year, Post Developed: 0.016 ac-ft/year**

**************Water Quality Facility Data ***************

**----------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 27. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 40. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 21.62

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 2.45
Inflow Volume Including PPT-Evap (ac-ft): 2.45
Total Runoff Infiltrated (ac-ft): 2.45, 100.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.01
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

**************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.000 | 2-Year | 0.000 |
| 5-Year | 1.438E-04 | 5-Year | 0.000 |
| 10-Year | 2.234E-04 | 10-Year | 1.344E-04 |
| 25-Year | 2.683E-04 | 25-Year | 1.683E-03 |
| 50-Year | 3.357E-04 | 50-Year | 2.260E-03 |
| 100-Year | 3.811E-04 | 100-Year | 2.812E-03 |
| 200-Year | 4.686E-04 | 200-Year | 3.099E-03 |
| 500-Year | 5.864E-04 | 500-Year | 3.472E-03 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.4%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99999.0%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%
FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 70.4% FAIL

-------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -99.9% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99999.0% PASS

---------------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
---------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 04/27/2021 12:33 PM**
**Report Generation Date: 05/12/2021 9:01 AM**

Input File Name: Drywell_Till_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Drywell in Till soils
Comments: Puget East 40 in MAP

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

*********************** WATERSHED DEFINITION ************************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.006 | 0.006 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 0.006 | 0.006 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Till Forest 0.006
----------------------------------------------
Subbasin Total 0.006

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins:  1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.006
----------------------------------------------
Subbasin Total 0.006

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links:  0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links:  1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type:  Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.61
Max Pond Elevation (ft) : 101.00
Storage Depth (ft) : 0.61
Pond Bottom Length (ft) : 7.2
Pond Bottom Width (ft) : 7.2
Pond Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 51.
Area at Riser Crest El (sq-ft) : 51.
(acres) : 0.001
Volume at Riser Crest (cu-ft) : 31.
(ac-ft) : 0.001
Area at Max Elevation (sq-ft) : 51.
(acres) : 0.001
Vol at Max Elevation (cu-ft) : 51.
(ac-ft) : 0.001

Constant Infiltration Option Used
Infiltration Rate (in/hr):  0.30

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 1000.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.61 ft

Hydraulic Structure Geometry

Number of Devices: 0

************************FLOOD FREQUENCY AND DURATION STATISTICS**********************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ****************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1.035 |
| Total: | 1.035 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 2.690 |
| Total: | 2.690 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.007 ac-ft/year, Post Developed: 0.017 ac-ft/year**

**************Water Quality Facility Data ****************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 27. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 40. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 21.50

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 2.69
Inflow Volume Including PPT-Evap (ac-ft): 2.69
Total Runoff Infiltrated (ac-ft): 2.69, 100.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.01
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

**************Compliance Point Results **************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 1.279E-04 | 2-Year | 0.000 |
| 5-Year | 2.084E-04 | 5-Year | 0.000 |
| 10-Year | 2.808E-04 | 10-Year | 1.143E-04 |
| 25-Year | 3.560E-04 | 25-Year | 1.666E-03 |
| 50-Year | 4.543E-04 | 50-Year | 2.317E-03 |
| 100-Year | 4.923E-04 | 100-Year | 2.558E-03 |
| 200-Year | 7.663E-04 | 200-Year | 2.784E-03 |
| 500-Year | 1.134E-03 | 500-Year | 3.089E-03 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.4% PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99999.0% PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0% FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 64.3% FAIL

-------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -99.9% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99999.0% PASS

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MEETS ALL LID DURATION DESIGN CRITERIA: PASS

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# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 12:03 PM**
**Report Generation Date: 05/12/2021 12:03 PM**

| | |
|---|---|
| Input File Name: | Drywell_Till_PugetEast60.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Drywell in Till soils |
| Comments: | Puget East 60 in MAP |

## PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 20

Full Period of Record Available used for Routing
Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961060 Puget East 60 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

************************ WATERSHED DEFINITION **************************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.005 | 0.005 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 0.005 | 0.005 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Till Forest | 0.005 |
| Subbasin Total | 0.005 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 0.005 |
| Subbasin Total | 0.005 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used

| | | |
|---|---|---|
| Pond Floor Elevation (ft) | : | 100.00 |
| Riser Crest Elevation (ft) | : | 100.61 |
| Max Pond Elevation (ft) | : | 101.00 |
| Storage Depth (ft) | : | 0.61 |
| Pond Bottom Length (ft) | : | 7.2 |
| Pond Bottom Width (ft) | : | 7.2 |
| Pond Side Slopes (ft/ft) | : | L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : | 51. |
| Area at Riser Crest El (sq-ft) | : | 51. |
| (acres) | : | 0.001 |
| Volume at Riser Crest (cu-ft) | : | 31. |
| (ac-ft) | : | 0.001 |
| Area at Max Elevation (sq-ft) | : | 51. |
| (acres) | : | 0.001 |
| Vol at Max Elevation (cu-ft) | : | 51. |
| (ac-ft) | : | 0.001 |

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.30

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 1000.00 |
| Common Length (ft) | : 0.000 |
| Riser Crest Elevation | : 100.61 ft |

Hydraulic Structure Geometry

Number of Devices:    0

************************FLOOD FREQUENCY AND DURATION STATISTICS**********************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins:  1
Number of Links:  0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins:  1
Number of Links:  1

**************Groundwater Recharge Summary ****************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1.232 |
| Total: | 1.232 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 3.592 |
| Total: | 3.592 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped:   0.008 ac-ft/year,  Post Developed:   0.023 ac-ft/year**

**************Water Quality Facility Data ****************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links:  0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links:  1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance):  30. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume:  46. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 24.37

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 3.60
Inflow Volume Including PPT-Evap (ac-ft): 3.60
Total Runoff Infiltrated (ac-ft): 3.59, 99.92%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.02
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.92%

**************Compliance Point Results ****************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 2.123E-04 | 2-Year | 0.000 |
| 5-Year | 3.289E-04 | 5-Year | 0.000 |
| 10-Year | 4.361E-04 | 10-Year | 1.019E-03 |
| 25-Year | 6.390E-04 | 25-Year | 1.902E-03 |
| 50-Year | 8.787E-04 | 50-Year | 2.415E-03 |
| 100-Year | 9.590E-04 | 100-Year | 2.484E-03 |
| 200-Year | 1.414E-03 | 200-Year | 2.588E-03 |
| 500-Year | 2.027E-03 | 500-Year | 2.725E-03 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.0%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -91.0%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%
FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 72.0% FAIL

---------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
---------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -99.9% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99999.0% PASS

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MEETS ALL LID DURATION DESIGN CRITERIA: PASS

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# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 12:07 PM**
**Report Generation Date: 05/12/2021 12:07 PM**

| | |
|---|---|
| Input File Name: | Drywell_Outwash_PugetEast32.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Drywell in Outwash soils |
| Comments: | Puget East 32 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 13

Full Period of Record Available used for Routing
Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961032 Puget East 32 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

*********************** WATERSHED DEFINITION ************************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.020 | 0.020 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 0.020 | 0.020 |

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Till Forest | 0.020 |
| Subbasin Total | 0.020 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------

| | |
|---|---|
| Impervious | 0.020 |
| ---------------------------------------------- | |
| Subbasin Total | 0.020 |

*************************** LINK DATA *********************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

*************************** LINK DATA *********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used

| | |
|---|---|
| Pond Floor Elevation (ft) | : 100.00 |
| Riser Crest Elevation (ft) | : 100.61 |
| Max Pond Elevation (ft) | : 101.00 |
| Storage Depth (ft) | : 0.61 |
| Pond Bottom Length (ft) | : 7.2 |
| Pond Bottom Width (ft) | : 7.2 |
| Pond Side Slopes (ft/ft) | : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : 51. |
| Area at Riser Crest El (sq-ft) | : 51. |
| (acres) | : 0.001 |
| Volume at Riser Crest (cu-ft) | : 31. |
| (ac-ft) | : 0.001 |
| Area at Max Elevation (sq-ft) | : 51. |
| (acres) | : 0.001 |
| Vol at Max Elevation (cu-ft) | : 51. |
| (ac-ft) | : 0.001 |

Constant Infiltration Option Used
Infiltration Rate (in/hr): 2.50

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 1000.00 |
| Common Length (ft) | : 0.000 |
| Riser Crest Elevation | : 100.61 ft |

Hydraulic Structure Geometry

Number of Devices: 0

************************FLOOD FREQUENCY AND DURATION STATISTICS**********************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ****************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 2.637 |
| Total: | 2.637 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 6.951 |
| Total: | 6.951 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.017 ac-ft/year, Post Developed: 0.044 ac-ft/year**

**************Water Quality Facility Data ****************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 76. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 114. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 7.10

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 6.95
Inflow Volume Including PPT-Evap (ac-ft): 6.95
Total Runoff Infiltrated (ac-ft): 6.95, 100.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.01
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 2.417E-04 | 2-Year | 0.000 |
| 5-Year | 4.075E-04 | 5-Year | 0.000 |
| 10-Year | 6.331E-04 | 10-Year | 6.217E-04 |
| 25-Year | 7.601E-04 | 25-Year | 5.758E-03 |
| 50-Year | 9.510E-04 | 50-Year | 6.941E-03 |
| 100-Year | 1.080E-03 | 100-Year | 7.820E-03 |
| 200-Year | 1.328E-03 | 200-Year | 9.739E-03 |
| 500-Year | 1.661E-03 | 500-Year | 1.231E-02 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.8%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.1%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%
FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 28.3%
PASS

-----------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
-----------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99999.0% PASS

-----------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
-----------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 04/27/2021 1:21 PM**
**Report Generation Date: 04/27/2021 1:21 PM**

| | |
|---|---|
| Input File Name: | Drywell_Outwash_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Drywell in Outwash soils |
| Comments: | Puget East 40 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.018 | 0.018 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 0.018 | 0.018 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Till Forest 0.018
----------------------------------------------
Subbasin Total 0.018

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 0.018 |
| Subbasin Total | 0.018 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used

| | |
|---|---|
| Pond Floor Elevation (ft) | : 100.00 |
| Riser Crest Elevation (ft) | : 100.61 |
| Max Pond Elevation (ft) | : 101.00 |
| Storage Depth (ft) | : 0.61 |
| Pond Bottom Length (ft) | : 7.2 |
| Pond Bottom Width (ft) | : 7.2 |
| Pond Side Slopes (ft/ft) | : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : 51. |
| Area at Riser Crest El (sq-ft) | : 51. |
| (acres) | : 0.001 |
| Volume at Riser Crest (cu-ft) | : 31. |
| (ac-ft) | : 0.001 |
| Area at Max Elevation (sq-ft) | : 51. |
| (acres) | : 0.001 |
| Vol at Max Elevation (cu-ft) | : 51. |
| (ac-ft) | : 0.001 |

Constant Infiltration Option Used
Infiltration Rate (in/hr): 2.50

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 1000.00 |
| Common Length (ft) | : 0.000 |
| Riser Crest Elevation | : 100.61 ft |

Hydraulic Structure Geometry

Number of Devices: 0

************************FLOOD FREQUENCY AND DURATION STATISTICS**********************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ****************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 3.086 |
| Total: | 3.086 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 8.025 |
| Total: | 8.025 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.020 ac-ft/year, Post Developed: 0.051 ac-ft/year**

**************Water Quality Facility Data ****************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 79. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 119. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 7.43

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 8.03
Inflow Volume Including PPT-Evap (ac-ft): 8.03
Total Runoff Infiltrated (ac-ft): 8.03, 100.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.01
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 3.814E-04 | 2-Year | 0.000 |
| 5-Year | 6.217E-04 | 5-Year | 0.000 |
| 10-Year | 8.376E-04 | 10-Year | 2.976E-04 |
| 25-Year | 1.062E-03 | 25-Year | 4.121E-03 |
| 50-Year | 1.355E-03 | 50-Year | 5.572E-03 |
| 100-Year | 1.469E-03 | 100-Year | 8.728E-03 |
| 200-Year | 2.286E-03 | 200-Year | 1.038E-02 |
| 500-Year | 3.384E-03 | 500-Year | 1.251E-02 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.8%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -98.9%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%
FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 41.1%
PASS

-----------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
-----------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99999.0% PASS

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MEETS ALL LID DURATION DESIGN CRITERIA: PASS

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# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/10/2021 1:28 PM**
**Report Generation Date: 05/10/2021 1:29 PM**

| | |
|---|---|
| Input File Name: | Drywell_Outwash_PugetEast60.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Drywell in Outwash soils |
| Comments: | Puget East 60 in MAP |

## PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 20

Full Period of Record Available used for Routing
Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961060 Puget East 60 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.015 | 0.015 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 0.015 | 0.015 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------

| | |
|---|---|
| Till Forest | 0.015 |
| Subbasin Total | 0.015 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.015
----------------------------------------------
Subbasin Total 0.015

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.61
Max Pond Elevation (ft) : 101.00
Storage Depth (ft) : 0.61
Pond Bottom Length (ft) : 7.2
Pond Bottom Width (ft) : 7.2
Pond Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 51.
Area at Riser Crest El (sq-ft) : 51.
(acres) : 0.001
Volume at Riser Crest (cu-ft) : 31.
(ac-ft) : 0.001
Area at Max Elevation (sq-ft) : 51.
(acres) : 0.001
Vol at Max Elevation (cu-ft) : 51.
(ac-ft) : 0.001

Constant Infiltration Option Used
Infiltration Rate (in/hr): 2.50

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 1000.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.61 ft

Hydraulic Structure Geometry

Number of Devices: 0

************************FLOOD FREQUENCY AND DURATION STATISTICS**********************

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ****************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 3.597 |
| Total: | 3.597 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 10.499 |
| Total: | 10.499 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.023 ac-ft/year, Post Developed: 0.066 ac-ft/year**

**************Water Quality Facility Data ****************

**----------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 89. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 133. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 8.29

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 10.50
Inflow Volume Including PPT-Evap (ac-ft): 10.50
Total Runoff Infiltrated (ac-ft): 10.50, 100.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.01
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

**************Compliance Point Results ****************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 6.199E-04 | 2-Year | 0.000 |
| 5-Year | 9.603E-04 | 5-Year | 0.000 |
| 10-Year | 1.273E-03 | 10-Year | 1.034E-03 |
| 25-Year | 1.866E-03 | 25-Year | 4.087E-03 |
| 50-Year | 2.566E-03 | 50-Year | 4.961E-03 |
| 100-Year | 2.800E-03 | 100-Year | 6.385E-03 |
| 200-Year | 4.129E-03 | 200-Year | 6.501E-03 |
| 500-Year | 5.920E-03 | 500-Year | 6.618E-03 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.8%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -98.2%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%
FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 62.2% FAIL

-------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99.8% PASS

---------------------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA:	PASS
---------------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/11/2021 2:29 PM**
**Report Generation Date: 05/12/2021 11:01 AM**

Input File Name: Detention_Vault_PugetEast32.fld
Project Name: WQBE Phase 2
Analysis Title: Detention Vault
Comments: Puget East 32 in MAP

## PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 13

Full Period of Record Available used for Routing
Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961032 Puget East 32 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

*********************** WATERSHED DEFINITION **************************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 4.114 | 4.114 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 4.114 | 4.114 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Till Forest 4.114
----------------------------------------------
Subbasin Total 4.114

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 4.114 |
| Subbasin Total | 4.114 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used

| | | |
|---|---|---|
| Pond Floor Elevation (ft) | : | 100.00 |
| Riser Crest Elevation (ft) | : | 106.00 |
| Max Pond Elevation (ft) | : | 107.00 |
| Storage Depth (ft) | : | 6.00 |
| Pond Bottom Length (ft) | : | 227.7 |
| Pond Bottom Width (ft) | : | 113.8 |
| Pond Side Slopes (ft/ft) | : | L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : | 25920. |
| Area at Riser Crest El (sq-ft) | : | 25,920. |
| (acres) | : | 0.595 |
| Volume at Riser Crest (cu-ft) | : | 155,521. |
| (ac-ft) | : | 3.570 |
| Area at Max Elevation (sq-ft) | : | 25920. |
| (acres) | : | 0.595 |
| Vol at Max Elevation (cu-ft) | : | 181,442. |
| (ac-ft) | : | 4.165 |

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.00

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 18.00 |
| Common Length (ft) | : 0.000 |
| Riser Crest Elevation | : 106.00 ft |

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---

| | |
|---|---|
| Device Type | : Circular Orifice |
| Control Elevation (ft) | : 100.00 |
| Diameter (in) | : 0.64 |
| Orientation | : Horizontal |
| Elbow | : No |

--- Device Number 2 ---

| | |
|---|---|
| Device Type | : Vertical Rectangular Orifice |
| Control Elevation (ft) | : 104.49 |
| Length (in) | : 0.37 |
| Height (in) | : 18.15 |
| Orientation | : Vertical |
| Elbow | : No |

***********************FLOOD FREQUENCY AND DURATION STATISTICS*********************

**---------------------SCENARIO: PREDEVELOPED**

Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Subbasins: 1
Number of Links: 1

*************Groundwater Recharge Summary ***************

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 531.743 |
| Total: | 531.743 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge is Greater than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 3.365 ac-ft/year, Post Developed: 0.000 ac-ft/year**

*************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 15271. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 22906. cu-ft

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 1401.77
Inflow Volume Including PPT-Evap (ac-ft): 1401.77
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 1400.80
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 4.873E-02 | 2-Year | 1.994E-02 |
| 5-Year | 8.218E-02 | 5-Year | 2.823E-02 |
| 10-Year | 0.128 | 10-Year | 5.189E-02 |
| 25-Year | 0.153 | 25-Year | 0.106 |
| 50-Year | 0.192 | 50-Year | 0.135 |
| 100-Year | 0.218 | 100-Year | 0.143 |
| 200-Year | 0.268 | 200-Year | 0.164 |
| 500-Year | 0.335 | 500-Year | 0.192 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -20.0%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -20.0%
PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

-------------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 918.2% FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 1521.3% FAIL

-------------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 11:02 AM**
**Report Generation Date: 05/12/2021 11:02 AM**

| | |
|---|---|
| Input File Name: | Detention_Vault_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Detention Vault |
| Comments: | Puget East 40 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 6.579 | 6.579 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 6.579 | 6.579 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Till Forest | 6.579 |
| Subbasin Total | 6.579 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins:  1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 6.579
----------------------------------------------
Subbasin Total 6.579

**************************** LINK DATA *********************************

----------------------SCENARIO: PREDEVELOPED
Number of Links:  0

**************************** LINK DATA *********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links:  1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type:  Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 106.00
Max Pond Elevation (ft) : 107.00
Storage Depth (ft) : 6.00
Pond Bottom Length (ft) : 227.7
Pond Bottom Width (ft) : 113.8
Pond Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 25920.
Area at Riser Crest El (sq-ft) : 25,920.
(acres) : 0.595
Volume at Riser Crest (cu-ft) : 155,521.
(ac-ft) : 3.570
Area at Max Elevation (sq-ft) : 25920.
(acres) : 0.595
Vol at Max Elevation (cu-ft) : 181,442.
(ac-ft) : 4.165

Constant Infiltration Option Used
Infiltration Rate (in/hr):  0.00

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 18.00
Common Length (ft) : 0.000
Riser Crest Elevation : 106.00 ft

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---

| | |
|---|---|
| Device Type | : Circular Orifice |
| Control Elevation (ft) | : 100.00 |
| Diameter (in) | : 1.16 |
| Orientation | : Horizontal |
| Elbow | : No |

--- Device Number 2 ---

| | |
|---|---|
| Device Type | : Vertical Rectangular Orifice |
| Control Elevation (ft) | : 103.60 |
| Length (in) | : 0.37 |
| Height (in) | : 28.77 |
| Orientation | : Vertical |
| Elbow | : No |

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ****************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1134.393 |
| Total: | 1134.393 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge is Greater than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 7.180 ac-ft/year, Post Developed: 0.000 ac-ft/year**

**************Water Quality Facility Data ****************

**----------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 29141. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 43711. cu-ft

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 2949.64
Inflow Volume Including PPT-Evap (ac-ft): 2949.64
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 2948.85
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.140 | 2-Year | 6.636E-02 |
| 5-Year | 0.228 | 5-Year | 0.146 |
| 10-Year | 0.308 | 10-Year | 0.222 |
| 25-Year | 0.390 | 25-Year | 0.289 |
| 50-Year | 0.498 | 50-Year | 0.328 |
| 100-Year | 0.540 | 100-Year | 0.354 |
| 200-Year | 0.840 | 200-Year | 0.362 |
| 500-Year | 1.244 | 500-Year | 0.372 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -14.4%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -10.0%
PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

-----------------------------------------------------------------------------------------------

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

-----------------------------------------------------------------------------------------------

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 457.4% FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 728.0% FAIL

-----------------------------------------------------------------------------------------------

LID DURATION DESIGN CRITERIA: FAIL

-----------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/11/2021 2:56 PM**
**Report Generation Date: 05/12/2021 11:03 AM**

| | |
|---|---|
| Input File Name: | Detention_Vault_PugetEast60.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Detention Vault |
| Comments: | Puget East 60 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 20

Full Period of Record Available used for Routing
Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961060 Puget East 60 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 6.192 | 6.192 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 6.192 | 6.192 |

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Till Forest | 6.192 |
| Subbasin Total | 6.192 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 6.192 |
| Subbasin Total | 6.192 |

**************************** LINK DATA ********************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA ********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used

| | | |
|---|---|---|
| Pond Floor Elevation (ft) | : | 100.00 |
| Riser Crest Elevation (ft) | : | 106.00 |
| Max Pond Elevation (ft) | : | 107.00 |
| Storage Depth (ft) | : | 6.00 |
| Pond Bottom Length (ft) | : | 227.7 |
| Pond Bottom Width (ft) | : | 113.8 |
| Pond Side Slopes (ft/ft) | : | L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : | 25920. |
| Area at Riser Crest El (sq-ft) | : | 25,920. |
| (acres) | : | 0.595 |
| Volume at Riser Crest (cu-ft) | : | 155,521. |
| (ac-ft) | : | 3.570 |
| Area at Max Elevation (sq-ft) | : | 25920. |
| (acres) | : | 0.595 |
| Vol at Max Elevation (cu-ft) | : | 181,442. |
| (ac-ft) | : | 4.165 |

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.00

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 18.00 |
| Common Length (ft) | : 0.000 |
| Riser Crest Elevation | : 106.00 ft |

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---
Device Type : Circular Orifice
Control Elevation (ft) : 100.00
Diameter (in) : 1.67
Orientation : Horizontal
Elbow : No

--- Device Number 2 ---
Device Type : Vertical Rectangular Orifice
Control Elevation (ft) : 102.95
Length (in) : 0.35
Height (in) : 36.65
Orientation : Vertical
Elbow : No

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

***********Groundwater Recharge Summary *************

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1525.350 |
| Total: | 1525.350 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge is Greater than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 9.654 ac-ft/year, Post Developed: 0.000 ac-ft/year**

***********Water Quality Facility Data *************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 37571. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 56356. cu-ft

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 4452.16
Inflow Volume Including PPT-Evap (ac-ft): 4452.16
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 4451.41
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.263 | 2-Year | 0.155 |
| 5-Year | 0.407 | 5-Year | 0.290 |
| 10-Year | 0.540 | 10-Year | 0.376 |
| 25-Year | 0.791 | 25-Year | 0.473 |
| 50-Year | 1.088 | 50-Year | 0.525 |
| 100-Year | 1.188 | 100-Year | 0.592 |
| 200-Year | 1.751 | 200-Year | 0.789 |
| 500-Year | 2.511 | 500-Year | 1.052 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -25.3%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -11.6%
PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

-------------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******

| | | |
|---|---|---|
| Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): | 189.4% | FAIL |
| Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): | 294.1% | FAIL |

-------------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 10:59 AM**
**Report Generation Date: 05/12/2021 11:00 AM**

| | |
|---|---|
| Input File Name: | Detention_Pond_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Detention Pond |
| Comments: | Puget East 40 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 8.395 | 8.395 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 8.395 | 8.395 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Till Forest | 8.395 |
| Subbasin Total | 8.395 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 8.395 |
| Subbasin Total | 8.395 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used

| | | |
|---|---|---|
| Pond Floor Elevation (ft) | : | 100.00 |
| Riser Crest Elevation (ft) | : | 104.00 |
| Max Pond Elevation (ft) | : | 104.50 |
| Storage Depth (ft) | : | 4.00 |
| Pond Bottom Length (ft) | : | 300.0 |
| Pond Bottom Width (ft) | : | 150.0 |
| Pond Side Slopes (ft/ft) | : | L1= 0.00 L2= 0.00 W1= 3.00 W2= 3.00 |
| Bottom Area (sq-ft) | : | 45000. |
| Area at Riser Crest El (sq-ft) | : | 52,200. |
| (acres) | : | 1.198 |
| Volume at Riser Crest (cu-ft) | : | 194,400. |
| (ac-ft) | : | 4.463 |
| Area at Max Elevation (sq-ft) | : | 53100. |
| (acres) | : | 1.219 |
| Vol at Max Elevation (cu-ft) | : | 220,725. |
| (ac-ft) | : | 5.067 |

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.00

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 18.00 |
| Common Length (ft) | : 0.000 |
| Riser Crest Elevation | : 104.00 ft |

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---

| | |
|---|---|
| Device Type | : Circular Orifice |
| Control Elevation (ft) | : 100.00 |
| Diameter (in) | : 1.41 |
| Orientation | : Horizontal |
| Elbow | : No |

--- Device Number 2 ---

| | |
|---|---|
| Device Type | : Vertical Rectangular Orifice |
| Control Elevation (ft) | : 102.56 |
| Length (in) | : 0.87 |
| Height (in) | : 17.31 |
| Orientation | : Vertical |
| Elbow | : No |

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1447.524 |
| Total: | 1447.524 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge is Greater than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 9.162 ac-ft/year, Post Developed: 0.000 ac-ft/year**

**************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 37184. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 55777. cu-ft

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 3763.84
Inflow Volume Including PPT-Evap (ac-ft): 3763.84
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 3762.82
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.179 | 2-Year | 8.259E-02 |
| 5-Year | 0.292 | 5-Year | 0.183 |
| 10-Year | 0.393 | 10-Year | 0.280 |
| 25-Year | 0.498 | 25-Year | 0.365 |
| 50-Year | 0.636 | 50-Year | 0.413 |
| 100-Year | 0.689 | 100-Year | 0.512 |
| 200-Year | 1.072 | 200-Year | 0.536 |
| 500-Year | 1.587 | 500-Year | 0.563 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -16.1%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -10.1%
PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

-------------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******

| | | |
|---|---|---|
| Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): | 460.3% | FAIL |
| Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): | 731.3% | FAIL |

-------------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 3:40 PM**
**Report Generation Date: 05/12/2021 3:41 PM**

| | |
|---|---|
| Input File Name: | Detention_Pond_SUSTAIN_PugetEast32.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Detention Pond |
| Comments: | Puget East 32 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 13

Full Period of Record Available used for Routing
Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961032 Puget East 32 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 5.262 | 5.262 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 5.262 | 5.262 |

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------

| | |
|---|---|
| Till Forest | 5.262 |
| ---------------------------------------------- | |
| Subbasin Total | 5.262 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 5.262 |
| Subbasin Total | 5.262 |

**************************** LINK DATA *********************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used

| | |
|---|---|
| Pond Floor Elevation (ft) | : 100.00 |
| Riser Crest Elevation (ft) | : 104.00 |
| Max Pond Elevation (ft) | : 104.50 |
| Storage Depth (ft) | : 4.00 |
| Pond Bottom Length (ft) | : 300.0 |
| Pond Bottom Width (ft) | : 165.7 |
| Pond Side Slopes (ft/ft) | : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : 49710. |
| Area at Riser Crest El (sq-ft) | : 49,710. |
| (acres) | : 1.141 |
| Volume at Riser Crest (cu-ft) | : 198,840. |
| (ac-ft) | : 4.565 |
| Area at Max Elevation (sq-ft) | : 49710. |
| (acres) | : 1.141 |
| Vol at Max Elevation (cu-ft) | : 223,695. |
| (ac-ft) | : 5.135 |

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.00

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 18.00 |
| Common Length (ft) | : 0.000 |
| Riser Crest Elevation | : 104.00 ft |

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---
Device Type : Circular Orifice
Control Elevation (ft) : 100.00
Diameter (in) : 0.80
Orientation : Horizontal
Elbow : No

--- Device Number 2 ---
Device Type : Vertical Rectangular Orifice
Control Elevation (ft) : 102.95
Length (in) : 0.87
Height (in) : 12.55
Orientation : Vertical
Elbow : No

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

*************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 680.158 |
| Total: | 680.158 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge is Greater than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 4.305 ac-ft/year, Post Developed: 0.000 ac-ft/year**

*************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 19533. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 29299. cu-ft

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 1793.02
Inflow Volume Including PPT-Evap (ac-ft): 1793.02
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 1791.83
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 6.233E-02 | 2-Year | 2.573E-02 |
| 5-Year | 0.105 | 5-Year | 3.652E-02 |
| 10-Year | 0.163 | 10-Year | 6.640E-02 |
| 25-Year | 0.196 | 25-Year | 0.136 |
| 50-Year | 0.245 | 50-Year | 0.173 |
| 100-Year | 0.278 | 100-Year | 0.183 |
| 200-Year | 0.342 | 200-Year | 0.210 |
| 500-Year | 0.429 | 500-Year | 0.246 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -17.8%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -17.8%
PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

-------------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******

| | | |
|---|---|---|
| Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): | 913.3% | FAIL |
| Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): | 1520.2% | FAIL |

-------------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 3:28 PM**
**Report Generation Date: 05/12/2021 3:28 PM**

| | |
|---|---|
| Input File Name: | Detention_Pond_SUSTAIN_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Detention Pond |
| Comments: | Puget East 40 in MAP |

## PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 8.395 | 8.395 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 8.395 | 8.395 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Till Forest | 8.395 |
| Subbasin Total | 8.395 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 8.395 |
| ---------------------------------------------- | |
| Subbasin Total | 8.395 |

**************************** LINK DATA *********************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used

| | |
|---|---|
| Pond Floor Elevation (ft) | : 100.00 |
| Riser Crest Elevation (ft) | : 104.00 |
| Max Pond Elevation (ft) | : 104.50 |
| Storage Depth (ft) | : 4.00 |
| Pond Bottom Length (ft) | : 300.0 |
| Pond Bottom Width (ft) | : 165.7 |
| Pond Side Slopes (ft/ft) | : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : 49710. |
| Area at Riser Crest El (sq-ft) | : 49,710. |
| (acres) | : 1.141 |
| Volume at Riser Crest (cu-ft) | : 198,840. |
| (ac-ft) | : 4.565 |
| Area at Max Elevation (sq-ft) | : 49710. |
| (acres) | : 1.141 |
| Vol at Max Elevation (cu-ft) | : 223,695. |
| (ac-ft) | : 5.135 |

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.00

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 18.00 |
| Common Length (ft) | : 0.000 |
| Riser Crest Elevation | : 104.00 ft |

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---
Device Type : Circular Orifice
Control Elevation (ft) : 100.00
Diameter (in) : 1.41
Orientation : Horizontal
Elbow : No

--- Device Number 2 ---
Device Type : Vertical Rectangular Orifice
Control Elevation (ft) : 102.56
Length (in) : 0.87
Height (in) : 17.31
Orientation : Vertical
Elbow : No

************************FLOOD FREQUENCY AND DURATION STATISTICS**********************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ****************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1447.524 |
| Total: | 1447.524 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge is Greater than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 9.162 ac-ft/year, Post Developed: 0.000 ac-ft/year**

**************Water Quality Facility Data ****************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 37184. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 55777. cu-ft

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 3763.84
Inflow Volume Including PPT-Evap (ac-ft): 3763.84
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 3762.79
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%

**************Compliance Point Results *************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.179 | 2-Year | 8.155E-02 |
| 5-Year | 0.292 | 5-Year | 0.176 |
| 10-Year | 0.393 | 10-Year | 0.281 |
| 25-Year | 0.498 | 25-Year | 0.370 |
| 50-Year | 0.636 | 50-Year | 0.416 |
| 100-Year | 0.689 | 100-Year | 0.435 |
| 200-Year | 1.072 | 200-Year | 0.561 |
| 500-Year | 1.587 | 500-Year | 0.729 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -20.1%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -15.1%
PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

-------------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******

| | | |
|---|---|---|
| Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): | 466.0% | FAIL |
| Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): | 727.7% | FAIL |

-------------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
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# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 3:56 PM**
**Report Generation Date: 05/12/2021 3:56 PM**

| | |
|---|---|
| Input File Name: | Detention_Pond_SUSTAIN_PugetEast60.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Detention Pond |
| Comments: | Puget East 60 in MAP |

## PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 20

Full Period of Record Available used for Routing
Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961060 Puget East 60 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 7.987 | 7.987 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 7.987 | 7.987 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Till Forest | 7.987 |
| Subbasin Total | 7.987 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 7.987
----------------------------------------------
Subbasin Total 7.987

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 104.00
Max Pond Elevation (ft) : 104.50
Storage Depth (ft) : 4.00
Pond Bottom Length (ft) : 300.0
Pond Bottom Width (ft) : 165.7
Pond Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 49710.
Area at Riser Crest El (sq-ft) : 49,710.
(acres) : 1.141
Volume at Riser Crest (cu-ft) : 198,840.
(ac-ft) : 4.565
Area at Max Elevation (sq-ft) : 49710.
(acres) : 1.141
Vol at Max Elevation (cu-ft) : 223,695.
(ac-ft) : 5.135

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.00

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 18.00
Common Length (ft) : 0.000
Riser Crest Elevation : 104.00 ft

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---

| | |
|---|---|
| Device Type | : Circular Orifice |
| Control Elevation (ft) | : 100.00 |
| Diameter (in) | : 2.09 |
| Orientation | : Horizontal |
| Elbow | : No |

--- Device Number 2 ---

| | |
|---|---|
| Device Type | : Vertical Rectangular Orifice |
| Control Elevation (ft) | : 101.97 |
| Length (in) | : 0.82 |
| Height (in) | : 24.41 |
| Orientation | : Vertical |
| Elbow | : No |

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary** *************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1967.562 |
| Total: | 1967.562 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge is Greater than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 12.453 ac-ft/year, Post Developed: 0.000 ac-ft/year**

**************Water Quality Facility Data** *************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 48463. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 72695. cu-ft

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 5742.97
Inflow Volume Including PPT-Evap (ac-ft): 5742.97
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 5742.00
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%

**************Compliance Point Results *************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.339 | 2-Year | 0.201 |
| 5-Year | 0.525 | 5-Year | 0.376 |
| 10-Year | 0.697 | 10-Year | 0.487 |
| 25-Year | 1.021 | 25-Year | 0.612 |
| 50-Year | 1.404 | 50-Year | 0.680 |
| 100-Year | 1.532 | 100-Year | 0.797 |
| 200-Year | 2.259 | 200-Year | 1.007 |
| 500-Year | 3.238 | 500-Year | 1.286 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -24.7%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -10.6%
PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

-------------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 189.8% FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 293.6% FAIL

-------------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
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# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 1:29 PM**
**Report Generation Date: 05/12/2021 1:30 PM**

| | |
|---|---|
| Input File Name: | Infiltration_Pond_Till_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Infiltration Pond in Till Soils |
| Comments: | Puget East 40 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 8.401 | 8.401 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 8.401 | 8.401 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Till Forest 8.401
----------------------------------------------
Subbasin Total 8.401

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins:  1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 8.401 |
| ---------------------------------------------- | |
| Subbasin Total | 8.401 |

**************************** LINK DATA *********************************

----------------------SCENARIO: PREDEVELOPED
Number of Links:  0

**************************** LINK DATA *********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links:  1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type:  Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 104.00
Max Pond Elevation (ft) : 105.00
Storage Depth (ft) : 4.00
Pond Bottom Length (ft) : 236.0
Pond Bottom Width (ft) : 118.0
Pond Side Slopes (ft/ft) : L1= 0.00   L2= 0.00  W1= 3.00  W2= 3.00
Bottom Area (sq-ft) : 27848.
Area at Riser Crest El (sq-ft) : 33,512.
(acres) : 0.769
Volume at Riser Crest (cu-ft) : 122,720.
(ac-ft) : 2.817
Area at Max Elevation  (sq-ft) : 34928.
(acres) : 0.802
Vol at Max Elevation  (cu-ft) : 156,940.
(ac-ft) : 3.603

Constant Infiltration Option Used
Infiltration Rate (in/hr):  0.30

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 18.00
Common Length (ft) : 0.000
Riser Crest Elevation : 104.00 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1448.490 |
| Total: | 1448.490 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 3765.999 |
| Total: | 3765.999 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 9.168 ac-ft/year, Post Developed: 23.835 ac-ft/year**

**************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 37209. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 55814. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours):  53.15

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft):  3766.35
Inflow Volume Including PPT-Evap (ac-ft):  3766.35
Total Runoff Infiltrated (ac-ft):  3766.00,  100.00%
Total Runoff Filtered (ac-ft):  0.00,  0.00%
Primary Outflow To Downstream System (ac-ft):  0.35
Secondary Outflow To Downstream System (ac-ft):  0.00
Volume Lost to ET (ac-ft):  0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.99%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff Tr (Years) | Discharge (cfs) | Postdevelopment Runoff Tr (Years) | Discharge (cfs) |
|---|---|---|---|
| 2-Year | 0.179 | 2-Year | 0.000 |
| 5-Year | 0.292 | 5-Year | 0.000 |
| 10-Year | 0.393 | 10-Year | 0.000 |
| 25-Year | 0.498 | 25-Year | 0.000 |
| 50-Year | 0.636 | 50-Year | 0.000 |
| 100-Year | 0.689 | 100-Year | 0.000 |
| 200-Year | 1.073 | 200-Year | 0.445 |
| 500-Year | 1.588 | 500-Year | 1.045 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.9%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.6%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

----------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA:   PASS
----------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99.9% PASS

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MEETS ALL LID DURATION DESIGN CRITERIA: PASS

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# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 4:52 PM**
**Report Generation Date: 05/12/2021 4:52 PM**

| | |
|---|---|
| Input File Name: | Infiltration_Pond_Till_SUSTAIN_PugetEast32.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Infiltration Pond in Till Soils |
| Comments: | Puget East 32 in MAP |

## PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 13

Full Period of Record Available used for Routing
Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961032 Puget East 32 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

*********************** WATERSHED DEFINITION ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 10.213 | 10.213 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 10.213 | 10.213 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Till Forest | 10.213 |
| Subbasin Total | 10.213 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins:  1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 10.213
----------------------------------------------
Subbasin Total 10.213

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links:  0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links:  1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type:  Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 103.63
Max Pond Elevation (ft) : 105.00
Storage Depth (ft) : 3.63
Pond Bottom Length (ft) : 236.0
Pond Bottom Width (ft) : 139.8
Pond Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 32986.
Area at Riser Crest El (sq-ft) : 32,986.
(acres) : 0.757
Volume at Riser Crest (cu-ft) : 119,738.
(ac-ft) : 2.749
Area at Max Elevation (sq-ft) : 32986.
(acres) : 0.757
Vol at Max Elevation (cu-ft) : 164,929.
(ac-ft) : 3.786

Constant Infiltration Option Used
Infiltration Rate (in/hr):  0.30

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 18.00
Common Length (ft) : 0.000
Riser Crest Elevation : 103.63 ft

Hydraulic Structure Geometry

Number of Devices: 0

************************FLOOD FREQUENCY AND DURATION STATISTICS**********************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ****************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1320.051 |
| Total: | 1320.051 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 3479.621 |
| Total: | 3479.621 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 8.355 ac-ft/year, Post Developed: 22.023 ac-ft/year**

**************Water Quality Facility Data ****************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 37910. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 56864. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours):  47.52

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft):  3479.89
Inflow Volume Including PPT-Evap (ac-ft):  3479.89
Total Runoff Infiltrated (ac-ft):  3479.62,  100.00%
Total Runoff Filtered (ac-ft):  0.00,  0.00%
Primary Outflow To Downstream System (ac-ft):  0.27
Secondary Outflow To Downstream System (ac-ft):  0.00
Volume Lost to ET (ac-ft):  0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.99%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.121 | 2-Year | 0.000 |
| 5-Year | 0.204 | 5-Year | 0.000 |
| 10-Year | 0.317 | 10-Year | 0.000 |
| 25-Year | 0.381 | 25-Year | 0.000 |
| 50-Year | 0.476 | 50-Year | 0.000 |
| 100-Year | 0.540 | 100-Year | 0.000 |
| 200-Year | 0.665 | 200-Year | 0.325 |
| 500-Year | 0.832 | 500-Year | 0.763 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.9%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.7%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

----------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA:   PASS
----------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99.9% PASS

---------------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
---------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/13/2021 10:30 AM**
**Report Generation Date: 05/13/2021 10:31 AM**

| | |
|---|---|
| Input File Name: | Infiltration_Pond_Till_SUSTAIN_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Infiltration Pond in Till Soils |
| Comments: | Puget East 40 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 8.401 | 8.401 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 8.401 | 8.401 |

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Till Forest 8.401
----------------------------------------------
Subbasin Total 8.401

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 8.401
----------------------------------------------
Subbasin Total 8.401

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 103.63
Max Pond Elevation (ft) : 105.00
Storage Depth (ft) : 3.63
Pond Bottom Length (ft) : 236.0
Pond Bottom Width (ft) : 139.8
Pond Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 32986.
Area at Riser Crest El (sq-ft) : 32,986.
(acres) : 0.757
Volume at Riser Crest (cu-ft) : 119,738.
(ac-ft) : 2.749
Area at Max Elevation (sq-ft) : 32986.
(acres) : 0.757
Vol at Max Elevation (cu-ft) : 164,929.
(ac-ft) : 3.786

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.30

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 18.00
Common Length (ft) : 0.000
Riser Crest Elevation : 103.63 ft

Hydraulic Structure Geometry

Number of Devices: 0

************************FLOOD FREQUENCY AND DURATION STATISTICS**********************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ****************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1448.490 |
| Total: | 1448.490 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 3766.017 |
| Total: | 3766.017 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 9.168 ac-ft/year, Post Developed: 23.836 ac-ft/year**

**************Water Quality Facility Data ****************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 37209. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 55814. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours):  46.69

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft):  3766.35
Inflow Volume Including PPT-Evap (ac-ft):  3766.35
Total Runoff Infiltrated (ac-ft):  3766.02,  100.00%
Total Runoff Filtered (ac-ft):  0.00,  0.00%
Primary Outflow To Downstream System (ac-ft):  0.34
Secondary Outflow To Downstream System (ac-ft):  0.00
Volume Lost to ET (ac-ft):  0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.99%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.179 | 2-Year | 0.000 |
| 5-Year | 0.292 | 5-Year | 0.000 |
| 10-Year | 0.393 | 10-Year | 0.000 |
| 25-Year | 0.498 | 25-Year | 0.000 |
| 50-Year | 0.636 | 50-Year | 0.000 |
| 100-Year | 0.689 | 100-Year | 0.000 |
| 200-Year | 1.073 | 200-Year | 0.443 |
| 500-Year | 1.588 | 500-Year | 1.039 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.9%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.6%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

----------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA:   PASS
----------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99.9% PASS

-----------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
-----------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 4:57 PM**
**Report Generation Date: 05/12/2021 4:57 PM**

| | |
|---|---|
| Input File Name: | Infiltration_Pond_Till_SUSTAIN_PugetEast60.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Infiltration Pond in Till Soils |
| Comments: | Puget East 60 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 20

Full Period of Record Available used for Routing
Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961060 Puget East 60 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 5.683 | 5.683 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 5.683 | 5.683 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Till Forest 5.683
----------------------------------------------
Subbasin Total 5.683

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 5.683 |
| Subbasin Total | 5.683 |

**************************** LINK DATA *********************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**-------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used

| | | |
|---|---|---|
| Pond Floor Elevation (ft) | : | 100.00 |
| Riser Crest Elevation (ft) | : | 103.63 |
| Max Pond Elevation (ft) | : | 105.00 |
| Storage Depth (ft) | : | 3.63 |
| Pond Bottom Length (ft) | : | 236.0 |
| Pond Bottom Width (ft) | : | 139.8 |
| Pond Side Slopes (ft/ft) | : | L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : | 32986. |
| Area at Riser Crest El (sq-ft) | : | 32,986. |
| (acres) | : | 0.757 |
| Volume at Riser Crest (cu-ft) | : | 119,738. |
| (ac-ft) | : | 2.749 |
| Area at Max Elevation (sq-ft) | : | 32986. |
| (acres) | : | 0.757 |
| Vol at Max Elevation (cu-ft) | : | 164,929. |
| (ac-ft) | : | 3.786 |

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.30

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 18.00 |
| Common Length (ft) | : 0.000 |
| Riser Crest Elevation | : 103.63 ft |

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1400.077 |
| Total: | 1400.077 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 4086.118 |
| Total: | 4086.118 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 8.861 ac-ft/year, Post Developed: 25.862 ac-ft/year**

**************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 34486. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 51728. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 43.46

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 4086.58
Inflow Volume Including PPT-Evap (ac-ft): 4086.58
Total Runoff Infiltrated (ac-ft): 4086.12, 100.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.46
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.99%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.241 | 2-Year | 0.000 |
| 5-Year | 0.374 | 5-Year | 0.000 |
| 10-Year | 0.496 | 10-Year | 0.000 |
| 25-Year | 0.726 | 25-Year | 0.000 |
| 50-Year | 0.999 | 50-Year | 0.000 |
| 100-Year | 1.090 | 100-Year | 4.341E-02 |
| 200-Year | 1.607 | 200-Year | 0.655 |
| 500-Year | 2.304 | 500-Year | 1.477 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.9%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.5%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

----------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS
----------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99.9% PASS

-----------------------------------------------------------------------------------------------

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

-----------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 5:02 PM**
**Report Generation Date: 05/12/2021 5:02 PM**

| | |
|---|---|
| Input File Name: | Infiltration_Pond_Outwash_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Infiltration Pond in Outwash Soils |
| Comments: | Puget East 40 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 10.651 | 10.651 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 10.651 | 10.651 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Till Forest | 10.651 |
| Subbasin Total | 10.651 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 10.651 |
| ---------------------------------------------- | |
| Subbasin Total | 10.651 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used

| | | |
|---|---|---|
| Pond Floor Elevation (ft) | : | 100.00 |
| Riser Crest Elevation (ft) | : | 104.00 |
| Max Pond Elevation (ft) | : | 105.00 |
| Storage Depth (ft) | : | 4.00 |
| Pond Bottom Length (ft) | : | 172.0 |
| Pond Bottom Width (ft) | : | 86.0 |
| Pond Side Slopes (ft/ft) | : | L1= 0.00 L2= 0.00 W1= 3.00 W2= 3.00 |
| Bottom Area (sq-ft) | : | 14792. |
| Area at Riser Crest El (sq-ft) | : | 18,920. |
| (acres) | : | 0.434 |
| Volume at Riser Crest (cu-ft) | : | 67,424. |
| (ac-ft) | : | 1.548 |
| Area at Max Elevation (sq-ft) | : | 19952. |
| (acres) | : | 0.458 |
| Vol at Max Elevation (cu-ft) | : | 86,860. |
| (ac-ft) | : | 1.994 |

Constant Infiltration Option Used
Infiltration Rate (in/hr): 2.50

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 18.00 |
| Common Length (ft) | : 0.000 |
| Riser Crest Elevation | : 104.00 ft |

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1836.472 |
| Total: | 1836.472 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 4774.922 |
| Total: | 4774.922 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 11.623 ac-ft/year, Post Developed: 30.221 ac-ft/year**

**************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 47176. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 70764. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours):  13.96

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft):  4775.18
Inflow Volume Including PPT-Evap (ac-ft):  4775.18
Total Runoff Infiltrated (ac-ft):  4774.92,  100.00%
Total Runoff Filtered (ac-ft):  0.00,  0.00%
Primary Outflow To Downstream System (ac-ft):  0.26
Secondary Outflow To Downstream System (ac-ft):  0.00
Volume Lost to ET (ac-ft):  0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.99%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.227 | 2-Year | 0.000 |
| 5-Year | 0.370 | 5-Year | 0.000 |
| 10-Year | 0.498 | 10-Year | 0.000 |
| 25-Year | 0.632 | 25-Year | 0.000 |
| 50-Year | 0.806 | 50-Year | 0.000 |
| 100-Year | 0.874 | 100-Year | 0.000 |
| 200-Year | 1.360 | 200-Year | 1.559 |
| 500-Year | 2.014 | 500-Year | 3.660 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -100.0%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.9%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

-------------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA:   PASS
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -100.0% PASS

---------------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
---------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 5:27 PM**
**Report Generation Date: 05/12/2021 5:28 PM**

| | |
|---|---|
| Input File Name: | I_Pond_Outwash_SUSTAIN_PugetEast32.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Infiltration Pond in Outwash Soils |
| Comments: | Puget East 32 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 13

Full Period of Record Available used for Routing
Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961032 Puget East 32 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 11.768 | 11.768 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 11.768 | 11.768 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------

| | |
|---|---|
| Till Forest | 11.768 |
| ---------------------------------------------- | |
| Subbasin Total | 11.768 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins:  1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 11.768 |
| ---------------------------------------------- | |
| Subbasin Total | 11.768 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links:  0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links:  1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type:  Structure
Downstream Link: None

Prismatic Pond Option Used

| | |
|---|---|
| Pond Floor Elevation (ft) | : 100.00 |
| Riser Crest Elevation (ft) | : 103.52 |
| Max Pond Elevation (ft) | : 105.00 |
| Storage Depth (ft) | : 3.52 |
| Pond Bottom Length (ft) | : 172.0 |
| Pond Bottom Width (ft) | : 104.8 |
| Pond Side Slopes (ft/ft) | : L1= 0.00  L2= 0.00  W1= 0.00  W2= 0.00 |
| Bottom Area (sq-ft) | : 18031. |
| Area at Riser Crest El (sq-ft) | : 18,031. |
| (acres) | : 0.414 |
| Volume at Riser Crest (cu-ft) | : 63,468. |
| (ac-ft) | : 1.457 |
| Area at Max Elevation  (sq-ft) | : 18031. |
| (acres) | : 0.414 |
| Vol at Max Elevation  (cu-ft) | : 90,154. |
| (ac-ft) | : 2.070 |

Constant Infiltration Option Used
Infiltration Rate (in/hr):  2.50

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 18.00 |
| Common Length (ft) | : 0.000 |
| Riser Crest Elevation | : 103.52 ft |

Hydraulic Structure Geometry

Number of Devices: 0

************************FLOOD FREQUENCY AND DURATION STATISTICS**********************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ****************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1521.112 |
| Total: | 1521.112 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 4009.833 |
| Total: | 4009.833 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 9.627 ac-ft/year, Post Developed: 25.379 ac-ft/year**

**************Water Quality Facility Data ****************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 43684. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 65526. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours):  11.72

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft):  4009.92
Inflow Volume Including PPT-Evap (ac-ft):  4009.92
Total Runoff Infiltrated (ac-ft):  4009.83,  100.00%
Total Runoff Filtered (ac-ft):  0.00,  0.00%
Primary Outflow To Downstream System (ac-ft):  0.09
Secondary Outflow To Downstream System (ac-ft):  0.00
Volume Lost to ET (ac-ft):  0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

**************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.139 | 2-Year | 0.000 |
| 5-Year | 0.235 | 5-Year | 0.000 |
| 10-Year | 0.365 | 10-Year | 0.000 |
| 25-Year | 0.438 | 25-Year | 0.000 |
| 50-Year | 0.549 | 50-Year | 0.000 |
| 100-Year | 0.623 | 100-Year | 0.000 |
| 200-Year | 0.766 | 200-Year | 0.640 |
| 500-Year | 0.958 | 500-Year | 1.503 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -100.0%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.9%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

-------------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA:   PASS
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -100.0% PASS

-------------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
-------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 5:19 PM**
**Report Generation Date: 05/12/2021 5:19 PM**

Input File Name: I_Pond_Outwash_SUSTAIN_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Infiltration Pond in Outwash Soils
Comments: Puget East 40 in MAP

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

************************ WATERSHED DEFINITION *************************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 10.651 | 10.651 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 10.651 | 10.651 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Till Forest 10.651
----------------------------------------------
Subbasin Total 10.651

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 10.651
----------------------------------------------
Subbasin Total 10.651

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 103.52
Max Pond Elevation (ft) : 105.00
Storage Depth (ft) : 3.52
Pond Bottom Length (ft) : 172.0
Pond Bottom Width (ft) : 104.8
Pond Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 18031.
Area at Riser Crest El (sq-ft) : 18,031.
(acres) : 0.414
Volume at Riser Crest (cu-ft) : 63,468.
(ac-ft) : 1.457
Area at Max Elevation (sq-ft) : 18031.
(acres) : 0.414
Vol at Max Elevation (cu-ft) : 90,154.
(ac-ft) : 2.070

Constant Infiltration Option Used
Infiltration Rate (in/hr): 2.50

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 18.00
Common Length (ft) : 0.000
Riser Crest Elevation : 103.52 ft

Hydraulic Structure Geometry

Number of Devices:    0

************************FLOOD FREQUENCY AND DURATION STATISTICS**********************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins:  1
Number of Links:  0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins:  1
Number of Links:  1

**************Groundwater Recharge Summary ****************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1836.472 |
| Total: | 1836.472 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link:     New Structure Lnk1 | 4774.918 |
| Total: | 4774.918 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped:   11.623 ac-ft/year,  Post Developed:   30.221 ac-ft/year**

**************Water Quality Facility Data ****************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links:  0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links:  1

********** Link: New Structure Lnk1                              **********

Basic Wet Pond Volume (91% Exceedance):  47176. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume:  70764. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 12.64

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 4775.18
Inflow Volume Including PPT-Evap (ac-ft): 4775.18
Total Runoff Infiltrated (ac-ft): 4774.92, 100.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.26
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.99%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.227 | 2-Year | 0.000 |
| 5-Year | 0.370 | 5-Year | 0.000 |
| 10-Year | 0.498 | 10-Year | 0.000 |
| 25-Year | 0.632 | 25-Year | 0.000 |
| 50-Year | 0.806 | 50-Year | 0.000 |
| 100-Year | 0.874 | 100-Year | 0.000 |
| 200-Year | 1.360 | 200-Year | 1.623 |
| 500-Year | 2.014 | 500-Year | 3.811 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -100.0%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.9%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

-----------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS
-----------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -100.0% PASS

--------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
--------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 5:35 PM**
**Report Generation Date: 05/12/2021 5:35 PM**

| | |
|---|---|
| Input File Name: | I_Pond_Outwash_SUSTAIN_PugetEast60.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Infiltration Pond in Outwash Soils |
| Comments: | Puget East 60 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 20

Full Period of Record Available used for Routing
Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961060 Puget East 60 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 7.870 | 7.870 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 7.870 | 7.870 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Till Forest | 7.870 |
| Subbasin Total | 7.870 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 7.870 |
| Subbasin Total | 7.870 |

**************************** LINK DATA *********************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used

| | |
|---|---|
| Pond Floor Elevation (ft) | : 100.00 |
| Riser Crest Elevation (ft) | : 103.52 |
| Max Pond Elevation (ft) | : 105.00 |
| Storage Depth (ft) | : 3.52 |
| Pond Bottom Length (ft) | : 172.0 |
| Pond Bottom Width (ft) | : 104.8 |
| Pond Side Slopes (ft/ft) | : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : 18031. |
| Area at Riser Crest El (sq-ft) | : 18,031. |
| (acres) | : 0.414 |
| Volume at Riser Crest (cu-ft) | : 63,468. |
| (ac-ft) | : 1.457 |
| Area at Max Elevation (sq-ft) | : 18031. |
| (acres) | : 0.414 |
| Vol at Max Elevation (cu-ft) | : 90,154. |
| (ac-ft) | : 2.070 |

Constant Infiltration Option Used
Infiltration Rate (in/hr): 2.50

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 18.00 |
| Common Length (ft) | : 0.000 |
| Riser Crest Elevation | : 103.52 ft |

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary **************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1938.837 |
| Total: | 1938.837 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 5658.921 |
| Total: | 5658.921 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 12.271 ac-ft/year, Post Developed: 35.816 ac-ft/year**

**************Water Quality Facility Data **************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 47756. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 71634. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours):  12.79

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft):  5659.12
Inflow Volume Including PPT-Evap (ac-ft):  5659.12
Total Runoff Infiltrated (ac-ft):  5658.92,  100.00%
Total Runoff Filtered (ac-ft):  0.00,  0.00%
Primary Outflow To Downstream System (ac-ft):  0.20
Secondary Outflow To Downstream System (ac-ft):  0.00
Volume Lost to ET (ac-ft):  0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

**************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.334 | 2-Year | 0.000 |
| 5-Year | 0.518 | 5-Year | 0.000 |
| 10-Year | 0.686 | 10-Year | 0.000 |
| 25-Year | 1.006 | 25-Year | 0.000 |
| 50-Year | 1.383 | 50-Year | 0.000 |
| 100-Year | 1.510 | 100-Year | 0.000 |
| 200-Year | 2.226 | 200-Year | 1.316 |
| 500-Year | 3.191 | 500-Year | 3.089 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -100.0%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.9%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

------------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA:   PASS
------------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -100.0% PASS

-----------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
-----------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 11:37 AM**
**Report Generation Date: 05/12/2021 11:37 AM**

| | |
|---|---|
| Input File Name: | Infiltration_Vault_PugetEast32.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Infiltration Vault in Till Soils |
| Comments: | Puget East 32 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 13

Full Period of Record Available used for Routing
Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961032 Puget East 32 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 7.994 | 7.994 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 7.994 | 7.994 |

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Till Forest | 7.994 |
| Subbasin Total | 7.994 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 7.994 |
| Subbasin Total | 7.994 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 106.00
Max Pond Elevation (ft) : 107.00
Storage Depth (ft) : 6.00
Pond Bottom Length (ft) : 191.6
Pond Bottom Width (ft) : 95.8
Pond Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 18359.
Area at Riser Crest El (sq-ft) : 18,359.
(acres) : 0.421
Volume at Riser Crest (cu-ft) : 110,155.
(ac-ft) : 2.529
Area at Max Elevation (sq-ft) : 18359.
(acres) : 0.421
Vol at Max Elevation (cu-ft) : 128,514.
(ac-ft) : 2.950

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.30

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 18.00
Common Length (ft) : 0.000
Riser Crest Elevation : 106.00 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

************Groundwater Recharge Summary *************

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1033.227 |
| Total: | 1033.227 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 2719.112 |
| Total: | 2719.112 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 6.539 ac-ft/year, Post Developed: 17.210 ac-ft/year**

************Water Quality Facility Data *************

**----------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 29673. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 44509. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours):  66.43

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft):  2723.77
Inflow Volume Including PPT-Evap (ac-ft):  2723.77
Total Runoff Infiltrated (ac-ft):  2719.11,  99.83%
Total Runoff Filtered (ac-ft):  0.00,  0.00%
Primary Outflow To Downstream System (ac-ft):  0.28
Secondary Outflow To Downstream System (ac-ft):  0.00
Volume Lost to ET (ac-ft):  0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.83%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 9.469E-02 | 2-Year | 0.000 |
| 5-Year | 0.160 | 5-Year | 0.000 |
| 10-Year | 0.248 | 10-Year | 0.000 |
| 25-Year | 0.298 | 25-Year | 0.000 |
| 50-Year | 0.373 | 50-Year | 0.000 |
| 100-Year | 0.423 | 100-Year | 0.000 |
| 200-Year | 0.520 | 200-Year | 0.273 |
| 500-Year | 0.651 | 500-Year | 0.640 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.9%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.7%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

-----------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA:   PASS
-----------------------------------------------------------------------------------------------

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99.9% PASS

----------------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
----------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 11:24 AM**
**Report Generation Date: 05/12/2021 11:27 AM**

| | |
|---|---|
| Input File Name: | Infiltration_Vault_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Infiltration Vault in Till Soils |
| Comments: | Puget East 40 in MAP |

## PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 6.593 | 6.593 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 6.593 | 6.593 |

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Till Forest 6.593
----------------------------------------------
Subbasin Total 6.593

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 6.593 |
| Subbasin Total | 6.593 |

**************************** LINK DATA *********************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used

| | |
|---|---|
| Pond Floor Elevation (ft) | : 100.00 |
| Riser Crest Elevation (ft) | : 106.00 |
| Max Pond Elevation (ft) | : 107.00 |
| Storage Depth (ft) | : 6.00 |
| Pond Bottom Length (ft) | : 191.6 |
| Pond Bottom Width (ft) | : 95.8 |
| Pond Side Slopes (ft/ft) | : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : 18359. |
| Area at Riser Crest El (sq-ft) | : 18,359. |
| (acres) | : 0.421 |
| Volume at Riser Crest (cu-ft) | : 110,155. |
| (ac-ft) | : 2.529 |
| Area at Max Elevation (sq-ft) | : 18359. |
| (acres) | : 0.421 |
| Vol at Max Elevation (cu-ft) | : 128,514. |
| (ac-ft) | : 2.950 |

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.30

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 18.00 |
| Common Length (ft) | : 0.000 |
| Riser Crest Elevation | : 106.00 ft |

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary *************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1136.841 |
| Total: | 1136.841 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 2951.695 |
| Total: | 2951.695 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 7.195 ac-ft/year, Post Developed: 18.682 ac-ft/year**

**************Water Quality Facility Data *************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 29204. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 43805. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours):  65.43

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft):  2956.01
Inflow Volume Including PPT-Evap (ac-ft):  2956.01
Total Runoff Infiltrated (ac-ft):  2951.70,  99.85%
Total Runoff Filtered (ac-ft):  0.00,  0.00%
Primary Outflow To Downstream System (ac-ft):  0.39
Secondary Outflow To Downstream System (ac-ft):  0.00
Volume Lost to ET (ac-ft):  0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.85%

**************Compliance Point Results ****************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.140 | 2-Year | 0.000 |
| 5-Year | 0.229 | 5-Year | 0.000 |
| 10-Year | 0.309 | 10-Year | 0.000 |
| 25-Year | 0.391 | 25-Year | 0.000 |
| 50-Year | 0.499 | 50-Year | 0.000 |
| 100-Year | 0.541 | 100-Year | 0.173 |
| 200-Year | 0.842 | 200-Year | 0.442 |
| 500-Year | 1.246 | 500-Year | 0.797 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.9%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.6%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

---------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA:   PASS
---------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99.9% PASS

--------------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA:          PASS
--------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 11:46 AM**
**Report Generation Date: 05/12/2021 11:46 AM**

Input File Name: Infiltration_Vault_PugetEast60.fld
Project Name: WQBE Phase 2
Analysis Title: Infiltration Vault in Till Soils
Comments: Puget East 60 in MAP

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 20

Full Period of Record Available used for Routing
Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961060 Puget East 60 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 4.405 | 4.405 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 4.405 | 4.405 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------

| | |
|---|---|
| Till Forest | 4.405 |
| Subbasin Total | 4.405 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 4.405 |
| ---------------------------------------------- | |
| Subbasin Total | 4.405 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 106.00
Max Pond Elevation (ft) : 107.00
Storage Depth (ft) : 6.00
Pond Bottom Length (ft) : 191.6
Pond Bottom Width (ft) : 95.8
Pond Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 18359.
Area at Riser Crest El (sq-ft) : 18,359.
(acres) : 0.421
Volume at Riser Crest (cu-ft) : 110,155.
(ac-ft) : 2.529
Area at Max Elevation (sq-ft) : 18359.
(acres) : 0.421
Vol at Max Elevation (cu-ft) : 128,514.
(ac-ft) : 2.950

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.30

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 18.00
Common Length (ft) : 0.000
Riser Crest Elevation : 106.00 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

*************Groundwater Recharge Summary *************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1085.083 |
| Total: | 1085.083 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 3164.794 |
| Total: | 3164.794 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 6.868 ac-ft/year, Post Developed: 20.030 ac-ft/year**

*************Water Quality Facility Data *************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 26727. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 40090. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours):  60.15

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft):  3167.17
Inflow Volume Including PPT-Evap (ac-ft):  3167.17
Total Runoff Infiltrated (ac-ft):  3164.79,  99.93%
Total Runoff Filtered (ac-ft):  0.00,  0.00%
Primary Outflow To Downstream System (ac-ft):  0.75
Secondary Outflow To Downstream System (ac-ft):  0.00
Volume Lost to ET (ac-ft):  0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.93%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.187 | 2-Year | 0.000 |
| 5-Year | 0.290 | 5-Year | 0.000 |
| 10-Year | 0.384 | 10-Year | 0.000 |
| 25-Year | 0.563 | 25-Year | 0.000 |
| 50-Year | 0.774 | 50-Year | 0.000 |
| 100-Year | 0.845 | 100-Year | 0.634 |
| 200-Year | 1.246 | 200-Year | 0.653 |
| 500-Year | 1.786 | 500-Year | 0.654 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.9%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.0%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

---------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA:   PASS
---------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99.9% PASS

-----------------------------------------------------------------------------------------------

MEETS ALL LID DURATION DESIGN CRITERIA:     PASS

-----------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 12:02 PM**
**Report Generation Date: 05/12/2021 12:02 PM**

| | |
|---|---|
| Input File Name: | Infiltration_Vault_PugetEast32_Outwash.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Infiltration Vault in Outwash Soils |
| Comments: | Puget East 32 in MAP |

## PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 13

Full Period of Record Available used for Routing
Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961032 Puget East 32 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 9.902 | 9.902 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 9.902 | 9.902 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------

| | |
|---|---|
| Till Forest | 9.902 |
| Subbasin Total | 9.902 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 9.902 |
| ---------------------------------------------- | |
| Subbasin Total | 9.902 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used

| | |
|---|---|
| Pond Floor Elevation (ft) | : 100.00 |
| Riser Crest Elevation (ft) | : 106.00 |
| Max Pond Elevation (ft) | : 107.00 |
| Storage Depth (ft) | : 6.00 |
| Pond Bottom Length (ft) | : 152.0 |
| Pond Bottom Width (ft) | : 76.0 |
| Pond Side Slopes (ft/ft) | : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : 11556. |
| Area at Riser Crest El (sq-ft) | : 11,556. |
| (acres) | : 0.265 |
| Volume at Riser Crest (cu-ft) | : 69,335. |
| (ac-ft) | : 1.592 |
| Area at Max Elevation (sq-ft) | : 11556. |
| (acres) | : 0.265 |
| Vol at Max Elevation (cu-ft) | : 80,891. |
| (ac-ft) | : 1.857 |

Constant Infiltration Option Used
Infiltration Rate (in/hr): 2.50

Riser Geometry

| | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 18.00 |
| Common Length (ft) | : 0.000 |
| Riser Crest Elevation | : 106.00 ft |

Hydraulic Structure Geometry

Number of Devices:    0

************************FLOOD FREQUENCY AND DURATION STATISTICS*********************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins:  1
Number of Links:  0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins:  1
Number of Links:  1

**************Groundwater Recharge Summary ****************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1279.929 |
| Total: | 1279.929 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link:     New Structure Lnk1 | 3374.043 |
| Total: | 3374.043 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped:   8.101 ac-ft/year,  Post Developed:   21.355 ac-ft/year**

**************Water Quality Facility Data ****************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links:  0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links:  1

********** Link: New Structure Lnk1                    **********

Basic Wet Pond Volume (91% Exceedance):  36757. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume:  55136. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours):  15.37

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft):  3374.12
Inflow Volume Including PPT-Evap (ac-ft):  3374.12
Total Runoff Infiltrated (ac-ft):  3374.04,  100.00%
Total Runoff Filtered (ac-ft):  0.00,  0.00%
Primary Outflow To Downstream System (ac-ft):  0.07
Secondary Outflow To Downstream System (ac-ft):  0.00
Volume Lost to ET (ac-ft):  0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

**************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.117 | 2-Year | 0.000 |
| 5-Year | 0.198 | 5-Year | 0.000 |
| 10-Year | 0.307 | 10-Year | 0.000 |
| 25-Year | 0.369 | 25-Year | 0.000 |
| 50-Year | 0.462 | 50-Year | 0.000 |
| 100-Year | 0.524 | 100-Year | 0.000 |
| 200-Year | 0.645 | 200-Year | 0.534 |
| 500-Year | 0.806 | 500-Year | 1.254 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -100.0%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.9%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

-------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA:   PASS
-------------------------------------------------------------------------------------------

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -100.0% PASS

-----------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
-----------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 11:52 AM**
**Report Generation Date: 05/12/2021 11:52 AM**

| | |
|---|---|
| Input File Name: | Infiltration_Vault_PugetEast40_Outwash.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Infiltration Vault in Outwash Soils |
| Comments: | Puget East 40 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 9.037 | 9.037 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 9.037 | 9.037 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Till Forest | 9.037 |
| Subbasin Total | 9.037 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 9.037
----------------------------------------------
Subbasin Total 9.037

*************************** LINK DATA *********************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

*************************** LINK DATA *********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 106.00
Max Pond Elevation (ft) : 107.00
Storage Depth (ft) : 6.00
Pond Bottom Length (ft) : 152.0
Pond Bottom Width (ft) : 76.0
Pond Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 11556.
Area at Riser Crest El (sq-ft) : 11,556.
(acres) : 0.265
Volume at Riser Crest (cu-ft) : 69,335.
(ac-ft) : 1.592
Area at Max Elevation (sq-ft) : 11556.
(acres) : 0.265
Vol at Max Elevation (cu-ft) : 80,891.
(ac-ft) : 1.857

Constant Infiltration Option Used
Infiltration Rate (in/hr): 2.50

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 18.00
Common Length (ft) : 0.000
Riser Crest Elevation : 106.00 ft

Hydraulic Structure Geometry

Number of Devices: 0

************************FLOOD FREQUENCY AND DURATION STATISTICS**********************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ****************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1558.189 |
| Total: | 1558.189 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 4051.330 |
| Total: | 4051.330 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 9.862 ac-ft/year, Post Developed: 25.641 ac-ft/year**

**************Water Quality Facility Data ****************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 40027. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 60041. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours):  16.72

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft):  4051.59
Inflow Volume Including PPT-Evap (ac-ft):  4051.59
Total Runoff Infiltrated (ac-ft):  4051.33,  100.00%
Total Runoff Filtered (ac-ft):  0.00,  0.00%
Primary Outflow To Downstream System (ac-ft):  0.26
Secondary Outflow To Downstream System (ac-ft):  0.00
Volume Lost to ET (ac-ft):  0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.99%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.193 | 2-Year | 0.000 |
| 5-Year | 0.314 | 5-Year | 0.000 |
| 10-Year | 0.423 | 10-Year | 0.000 |
| 25-Year | 0.536 | 25-Year | 0.000 |
| 50-Year | 0.684 | 50-Year | 0.000 |
| 100-Year | 0.741 | 100-Year | 0.000 |
| 200-Year | 1.154 | 200-Year | 1.749 |
| 500-Year | 1.708 | 500-Year | 4.106 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -100.0%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.9%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

----------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA:   PASS
----------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -100.0% PASS

----------------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
----------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 12:09 PM**
**Report Generation Date: 05/12/2021 12:09 PM**

| | |
|---|---|
| Input File Name: | Infiltration_Vault_PugetEast60_Outwash.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Infiltration Vault in Outwash Soils |
| Comments: | Puget East 60 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 20

Full Period of Record Available used for Routing
Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961060 Puget East 60 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 6.611 | 6.611 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 6.611 | 6.611 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Till Forest 6.611
----------------------------------------------
Subbasin Total 6.611

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 6.611 |
| Subbasin Total | 6.611 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Structure Lnk1**
Link Type: Structure
Downstream Link: None

| Prismatic Pond Option Used | |
|---|---|
| Pond Floor Elevation (ft) | : 100.00 |
| Riser Crest Elevation (ft) | : 106.00 |
| Max Pond Elevation (ft) | : 107.00 |
| Storage Depth (ft) | : 6.00 |
| Pond Bottom Length (ft) | : 152.0 |
| Pond Bottom Width (ft) | : 76.0 |
| Pond Side Slopes (ft/ft) | : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : 11556. |
| Area at Riser Crest El (sq-ft) | : 11,556. |
| (acres) | : 0.265 |
| Volume at Riser Crest (cu-ft) | : 69,335. |
| (ac-ft) | : 1.592 |
| Area at Max Elevation (sq-ft) | : 11556. |
| (acres) | : 0.265 |
| Vol at Max Elevation (cu-ft) | : 80,891. |
| (ac-ft) | : 1.857 |

Constant Infiltration Option Used
Infiltration Rate (in/hr): 2.50

| Riser Geometry | |
|---|---|
| Riser Structure Type | : Circular |
| Riser Diameter (in) | : 18.00 |
| Common Length (ft) | : 0.000 |
| Riser Crest Elevation | : 106.00 ft |

Hydraulic Structure Geometry

Number of Devices: 0

***********************FLOOD FREQUENCY AND DURATION STATISTICS*********************

**--------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**--------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

*************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 1628.549 |
| Total: | 1628.549 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Structure Lnk1 | 4753.263 |
| Total: | 4753.263 |

**Total Predevelopment Recharge is Less than Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 10.307 ac-ft/year, Post Developed: 30.084 ac-ft/year**

*************Water Quality Facility Data ***************

**--------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**--------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 40113. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 60170. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 16.75

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 4753.45
Inflow Volume Including PPT-Evap (ac-ft): 4753.45
Total Runoff Infiltrated (ac-ft): 4753.26, 100.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.19
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.281 | 2-Year | 0.000 |
| 5-Year | 0.435 | 5-Year | 0.000 |
| 10-Year | 0.577 | 10-Year | 0.000 |
| 25-Year | 0.845 | 25-Year | 0.000 |
| 50-Year | 1.162 | 50-Year | 0.000 |
| 100-Year | 1.268 | 100-Year | 0.000 |
| 200-Year | 1.870 | 200-Year | 1.323 |
| 500-Year | 2.680 | 500-Year | 3.106 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -100.0%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.9%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%
PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%
PASS

----------------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS
----------------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -100.0% PASS

--------------------------------------------------------------------------------------------------
MEETS ALL LID DURATION DESIGN CRITERIA: PASS
--------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 12:18 PM**
**Report Generation Date: 05/12/2021 12:18 PM**

| | |
|---|---|
| Input File Name: | Planter_Drywell_PugetEast32.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Bioretention Planter pretreatment for drywell |
| Comments: | Puget East 32 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 13

Full Period of Record Available used for Routing
Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961032 Puget East 32 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.011 | 0.011 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 0.011 | 0.011 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 0.011 |
| Subbasin Total | 0.011 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.011
----------------------------------------------
Subbasin Total 0.011

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.50
Storage Depth (ft) : 0.50
Bottom Length (ft) : 3.6
Bottom Width (ft) : 1.2
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 4.
Area at Riser Crest El (sq-ft) : 4.
(acres) : 0.000
Volume at Riser Crest (cu-ft) : 4.
(ac-ft) : 0.000

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.00

Underdrain Present
Orifice NOT Present in Under Drain

Riser Geometry
Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ****************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge Equals Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year**

**************Water Quality Facility Data ****************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 3.71
Inflow Volume Including PPT-Evap (ac-ft): 3.74
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 3.41, 91.13%
Primary Outflow To Downstream System (ac-ft): 3.74
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.13%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 3.514E-03 | 2-Year | 3.504E-03 |
| 5-Year | 4.753E-03 | 5-Year | 4.811E-03 |
| 10-Year | 5.543E-03 | 10-Year | 5.571E-03 |
| 25-Year | 6.895E-03 | 25-Year | 6.964E-03 |
| 50-Year | 8.758E-03 | 50-Year | 8.872E-03 |
| 100-Year | 1.100E-02 | 100-Year | 1.112E-02 |
| 200-Year | 1.137E-02 | 200-Year | 1.156E-02 |
| 500-Year | 1.186E-02 | 500-Year | 1.214E-02 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -11.0%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): 2.8% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%
FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 48.9%
PASS

-------------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 7.6% FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 39.7% FAIL

-------------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 12:12 PM**
**Report Generation Date: 05/12/2021 12:13 PM**

| | |
|---|---|
| Input File Name: | Planter_Drywell_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Bioretention Planter pretreatment for drywell |
| Comments: | Puget East 40 in MAP |

## PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

*********************** WATERSHED DEFINITION ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.009 | 0.009 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 0.009 | 0.009 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 0.009 |
| Subbasin Total | 0.009 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 0.009
----------------------------------------------
Subbasin Total 0.009

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.50
Storage Depth (ft) : 0.50
Bottom Length (ft) : 3.6
Bottom Width (ft) : 1.2
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 4.
Area at Riser Crest El (sq-ft) : 4.
(acres) : 0.000
Volume at Riser Crest (cu-ft) : 4.
(ac-ft) : 0.000

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.00

Underdrain Present
Orifice NOT Present in Under Drain

Riser Geometry
Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge Equals Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year**

**************Water Quality Facility Data ***************

**----------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 4.08
Inflow Volume Including PPT-Evap (ac-ft): 4.12
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 3.76, 91.19%
Primary Outflow To Downstream System (ac-ft): 4.12
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.19%

**************Compliance Point Results ****************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 3.391E-03 | 2-Year | 3.376E-03 |
| 5-Year | 4.405E-03 | 5-Year | 4.469E-03 |
| 10-Year | 4.955E-03 | 10-Year | 5.005E-03 |
| 25-Year | 6.238E-03 | 25-Year | 6.318E-03 |
| 50-Year | 7.940E-03 | 50-Year | 8.046E-03 |
| 100-Year | 9.180E-03 | 100-Year | 9.358E-03 |
| 200-Year | 9.516E-03 | 200-Year | 9.729E-03 |
| 500-Year | 9.959E-03 | 500-Year | 1.022E-02 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -10.7%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): 1.7% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%
FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 62.1% FAIL

-------------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 7.9% FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 44.0% FAIL

-------------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 12:22 PM**
**Report Generation Date: 05/12/2021 12:22 PM**

| | |
|---|---|
| Input File Name: | Planter_Drywell_PugetEast60.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Bioretention Planter pretreatment for drywell |
| Comments: | Puget East 60 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 20

Full Period of Record Available used for Routing
Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961060 Puget East 60 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.007 | 0.007 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.000 |
| Total (acres) | 0.007 | 0.007 |

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 0.007 |
| Subbasin Total | 0.007 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 0.007 |
| Subbasin Total | 0.007 |

*************************** LINK DATA *********************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

*************************** LINK DATA *********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

| | |
|---|---|
| Base Elevation (ft) | : 100.00 |
| Riser Crest Elevation (ft) | : 100.50 |
| Storage Depth (ft) | : 0.50 |
| Bottom Length (ft) | : 3.6 |
| Bottom Width (ft) | : 1.2 |
| Side Slopes (ft/ft) | : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : 4. |
| Area at Riser Crest El (sq-ft) | : 4. |
| (acres) | : 0.000 |
| Volume at Riser Crest (cu-ft) | : 4. |
| (ac-ft) | : 0.000 |

Infiltration on Bottom and Sideslopes Selected

Soil Properties

| | |
|---|---|
| Biosoil Thickness (ft) | : 1.50 |
| Biosoil Saturated Hydraulic Conductivity (in/hr) | : 6.00 |
| Biosoil Porosity (Percent) | : 30.00 |
| Maximum Elevation of Bioretention Soil | : 101.00 |
| Native Soil Hydraulic Conductivity (in/hr) | : 0.00 |

Underdrain Present
Orifice NOT Present in Under Drain

Riser Geometry
Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary **************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge Equals Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year**

**************Water Quality Facility Data **************

**----------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**----------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft):  4.75
Inflow Volume Including PPT-Evap (ac-ft):  4.81
Total Runoff Infiltrated (ac-ft):  0.00,  0.00%
Total Runoff Filtered (ac-ft):  4.39,  91.14%
Primary Outflow To Downstream System (ac-ft):  4.81
Secondary Outflow To Downstream System (ac-ft):  0.00
Volume Lost to ET (ac-ft):  0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.14%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 2.894E-03 | 2-Year | 2.912E-03 |
| 5-Year | 3.698E-03 | 5-Year | 3.759E-03 |
| 10-Year | 4.348E-03 | 10-Year | 4.396E-03 |
| 25-Year | 5.494E-03 | 25-Year | 5.584E-03 |
| 50-Year | 6.572E-03 | 50-Year | 6.717E-03 |
| 100-Year | 7.710E-03 | 100-Year | 7.954E-03 |
| 200-Year | 7.831E-03 | 200-Year | 8.008E-03 |
| 500-Year | 7.987E-03 | 500-Year | 8.073E-03 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):   -15.5%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):   2.7%   FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%):   99999.0%
FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%):   73.7%   FAIL

-------------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA:   FAIL
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):   7.2%   FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):   51.9%   FAIL

-------------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA:   FAIL
-------------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 1:14 PM**
**Report Generation Date: 05/12/2021 1:15 PM**

| | |
|---|---|
| Input File Name: | Planter_UIC_PugetEast32.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Bioretention Planter pretreatment for drywell |
| Comments: | Puget East 32 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 13

Full Period of Record Available used for Routing
Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961032 Puget East 32 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 1.496 | 1.496 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.013 |
| Total (acres) | 1.496 | 1.509 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 1.496
----------------------------------------------
Subbasin Total 1.496

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins:  1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 1.496 |
| Subbasin Total | 1.496 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links:  0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links:  1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type:  Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.50
Storage Depth (ft) : 0.50
Bottom Length (ft) : 41.7
Bottom Width (ft) : 13.9
Side Slopes (ft/ft) : L1= 0.00   L2= 0.00  W1= 0.00  W2= 0.00
Bottom Area (sq-ft) : 579.
Area at Riser Crest El (sq-ft) : 579.
(acres) : 0.013
Volume at Riser Crest (cu-ft) : 550.
(ac-ft) : 0.013

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.00

Underdrain Present
Orifice NOT Present in Under Drain

Riser Geometry
Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge Equals Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year**

**************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance):  0.18 cfs
Off-line Design Discharge Rate (91% Exceedance):  0.10 cfs

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft):  509.66
Inflow Volume Including PPT-Evap (ac-ft):  513.79
Total Runoff Infiltrated (ac-ft):  0.00,  0.00%
Total Runoff Filtered (ac-ft):  467.53,  91.00%
Primary Outflow To Downstream System (ac-ft):  513.33
Secondary Outflow To Downstream System (ac-ft):  0.00
Volume Lost to ET (ac-ft):  0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

**************Compliance Point Results ****************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.482 | 2-Year | 0.468 |
| 5-Year | 0.652 | 5-Year | 0.651 |
| 10-Year | 0.761 | 10-Year | 0.746 |
| 25-Year | 0.946 | 25-Year | 0.907 |
| 50-Year | 1.202 | 50-Year | 1.144 |
| 100-Year | 1.509 | 100-Year | 1.435 |
| 200-Year | 1.560 | 200-Year | 1.458 |
| 500-Year | 1.627 | 500-Year | 1.486 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -13.7% PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -3.9% PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 37.5% FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 26.1% PASS

-------------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA:   FAIL
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 7.9% FAIL

| | | |
|---|---|---|
| Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): | 41.7% | FAIL |

-------------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------------

## MGS FLOOD
## PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 1:07 PM**
**Report Generation Date: 05/12/2021 1:07 PM**

| | |
|---|---|
| Input File Name: | Planter_UIC_PugetEast40.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Bioretention Planter pretreatment for drywell |
| Comments: | Puget East 40 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

**********************  WATERSHED DEFINITION  ***********************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 1.252 | 1.252 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.013 |
| Total (acres) | 1.252 | 1.265 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
Impervious 1.252
----------------------------------------------
Subbasin Total 1.252

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 1.252 |
| Subbasin Total | 1.252 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.50
Storage Depth (ft) : 0.50
Bottom Length (ft) : 41.7
Bottom Width (ft) : 13.9
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 579.
Area at Riser Crest El (sq-ft) : 579.
(acres) : 0.013
Volume at Riser Crest (cu-ft) : 550.
(ac-ft) : 0.013

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.00

Underdrain Present
Orifice NOT Present in Under Drain

Riser Geometry
Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge Equals Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year**

**************Water Quality Facility Data ***************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 561.42
Inflow Volume Including PPT-Evap (ac-ft): 566.94
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 515.89, 91.00%
Primary Outflow To Downstream System (ac-ft): 566.59
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.467 | 2-Year | 0.449 |
| 5-Year | 0.606 | 5-Year | 0.596 |
| 10-Year | 0.682 | 10-Year | 0.678 |
| 25-Year | 0.858 | 25-Year | 0.836 |
| 50-Year | 1.093 | 50-Year | 1.051 |
| 100-Year | 1.263 | 100-Year | 1.196 |
| 200-Year | 1.309 | 200-Year | 1.287 |
| 500-Year | 1.370 | 500-Year | 1.411 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -14.4%
PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -4.7%
PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 23.1% FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 18.9%
PASS

-------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 8.4% FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 46.7% FAIL

-------------------------------------------------------------------------------------------
LID DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------

# MGS FLOOD
# PROJECT REPORT

**Program Version: MGSFlood 4.54**
**Program License Number: 201810010**
**Project Simulation Performed on: 05/12/2021 1:22 PM**
**Report Generation Date: 05/12/2021 1:24 PM**

| | |
|---|---|
| Input File Name: | Planter_UIC_PugetEast60.fld |
| Project Name: | WQBE Phase 2 |
| Analysis Title: | Bioretention Planter pretreatment for UIC |
| Comments: | Puget East 60 in MAP |

**PRECIPITATION INPUT**

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 20

Full Period of Record Available used for Routing
Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961060 Puget East 60 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

*********************** WATERSHED DEFINITION ************************

**Predevelopment/Post Development Tributary Area Summary**

| | Predeveloped | Post Developed |
|---|---|---|
| Total Subbasin Area (acres) | 0.905 | 0.905 |
| Area of Links that Include Precip/Evap (acres) | 0.000 | 0.013 |
| Total (acres) | 0.905 | 0.918 |

**----------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| | -------Area (Acres) -------- |
|---|---|
| Impervious | 0.905 |
| Subbasin Total | 0.905 |

**----------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

| -------Area (Acres) -------- | |
|---|---|
| Impervious | 0.905 |
| Subbasin Total | 0.905 |

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

**------------------------------------------**
**Link Name: New Bio Lnk1**
Link Type: Bioretention Facility
Downstream Link: None

| | |
|---|---|
| Base Elevation (ft) | : 100.00 |
| Riser Crest Elevation (ft) | : 100.50 |
| Storage Depth (ft) | : 0.50 |
| Bottom Length (ft) | : 41.7 |
| Bottom Width (ft) | : 13.9 |
| Side Slopes (ft/ft) | : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00 |
| Bottom Area (sq-ft) | : 579. |
| Area at Riser Crest El (sq-ft) | : 579. |
| (acres) | : 0.013 |
| Volume at Riser Crest (cu-ft) | : 550. |
| (ac-ft) | : 0.013 |

Infiltration on Bottom and Sideslopes Selected

Soil Properties

| | |
|---|---|
| Biosoil Thickness (ft) | : 1.50 |
| Biosoil Saturated Hydraulic Conductivity (in/hr) | : 6.00 |
| Biosoil Porosity (Percent) | : 30.00 |
| Maximum Elevation of Bioretention Soil | : 101.00 |
| Native Soil Hydraulic Conductivity (in/hr) | : 0.00 |

Underdrain Present
Orifice NOT Present in Under Drain

Riser Geometry
Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

**---------------------SCENARIO: PREDEVELOPED**
Number of Subbasins: 1
Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**
Number of Subbasins: 1
Number of Links: 1

************Groundwater Recharge Summary *************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Total: | 0.000 |

Total Post Developed Recharge During Simulation

| Model Element | Recharge Amount (ac-ft) |
|---|---|
| Subbasin: Subbasin 1 | 0.000 |
| Link: New Bio Lnk1 | 0.000 |
| Total: | 0.000 |

**Total Predevelopment Recharge Equals Post Developed**
**Average Recharge Per Year, (Number of Years= 158)**
**Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year**

************Water Quality Facility Data *************

**---------------------SCENARIO: PREDEVELOPED**

Number of Links: 0

**---------------------SCENARIO: POSTDEVELOPED**

Number of Links: 1

********** Link: New Bio Lnk1 **********

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.18 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.10 cfs

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 650.48
Inflow Volume Including PPT-Evap (ac-ft): 659.52
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 600.14, 91.00%
Primary Outflow To Downstream System (ac-ft): 659.52
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

**************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

| Predevelopment Runoff | | Postdevelopment Runoff | |
|---|---|---|---|
| Tr (Years) | Discharge (cfs) | Tr (Years) | Discharge (cfs) |
| 2-Year | 0.397 | 2-Year | 0.386 |
| 5-Year | 0.507 | 5-Year | 0.507 |
| 10-Year | 0.596 | 10-Year | 0.590 |
| 25-Year | 0.753 | 25-Year | 0.727 |
| 50-Year | 0.901 | 50-Year | 0.859 |
| 100-Year | 1.057 | 100-Year | 0.982 |
| 200-Year | 1.073 | 200-Year | 1.035 |
| 500-Year | 1.095 | 500-Year | 1.106 |

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -19.1% PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -5.3% PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 23.1% FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 15.8% PASS

-------------------------------------------------------------------------------------------------
FLOW DURATION DESIGN CRITERIA: FAIL
-------------------------------------------------------------------------------------------------

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 7.5% FAIL

| | | |
|---|---|---|
| Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): | 43.7% | FAIL |

-----------------------------------------------------------------------------------------------

LID DURATION DESIGN CRITERIA: FAIL

-----------------------------------------------------------------------------------------------

# ATTACHMENT G

Summary of Transformed Configurations and Design Flow Rates for SUSTAIN Input

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**Table G-1: Transformed Configuration for Actions Sized Using Explicit Modeling in MGSFlood**

| | Design Configuration | | | | Transformed Configuration for SUSTAIN Modeling [d] | | | |
|---|---|---|---|---|---|---|---|---|
| Action [a] | Ponding Depth or Design Flow Depth (ft) [b, c] | Bottom Width (ft) | Bottom Length (ft) | Bottom Footprint (sf) | Ponding Depth or Design Flow Depth (ft) | Bottom Width (ft) | Bottom Length (ft) | Bottom Footprint (sf) |
| Rain Garden - Till Soils | 0.50 | 3.54 | 7.08 | 25.00 | 0.14 | 11.15 | 7.08 | 78.94 |
| Rain Garden - Outwash Soils | 0.50 | 3.54 | 7.08 | 25.00 | 0.14 | 9.20 | 7.08 | 65.14 |
| Bioretention - Till Soils | 0.50 | 5.33 | 16.00 | 85.00 | 0.35 | 8.55 | 16.00 | 136.80 |
| Bioretention - Outwash Soils | 0.50 | 5.33 | 16.00 | 85.00 | 0.06 | 12.90 | 16.00 | 206.40 |
| Bioswale | 0.12 | 2.00 | 100.00 | 200.00 | 0.12 | 2.00 | 117.98 | 235.96 |
| Stormwater Treatment Wetland | N/A | 21.50 | 32.75 | 502.98 | N/A | 8.00 | 269.01 | 2152.08 |
| Infiltration Pond - Till Soils | 4.00 | 118.00 | 236.00 | 27850.00 | 3.63 | 139.77 | 236.00 | 32985.72 |
| Infiltration Pond - Outwash Soils | 4.00 | 86.00 | 172.00 | 14790.00 | 3.52 | 104.83 | 172.00 | 18030.76 |
| Wetpond | N/A | 10.16 | 54.47 | 553.09 | N/A | 23.21 | 69.64 | 1616.51 |

**Notes:**

a Values reported for infiltration ponds (sized per King County Level 2 Flow Control) are based on a Unit Action Footprint multiplied by 10. See Technical Memo for more information on Level 2 Flow Control Sizing.
b Value reported for bioswales is the Design Flow Depth. All other values reported are Ponding Depths.
c Ponding Depth or Design Flow Depth is not a design value for Stormwater Treatment Wetlands and Wetponds. Instead, these Actions are based on a Design Basic Volume (Vb) of 6,456 cubic feet and 6,465 cubic feet, respectively. These values are consistent through the transformation process.
d Values reported for the transformed configurations apply to all climate regions (32-inch, 40-inch, 60-inch).

**Table G-2: Tranformed Configuration for Detention Pond, Varying Climate Regions [a]**

| | Design Configuration | | | | | | | | Transformed Configuration for SUSTAIN Modeling | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean Annual Precipitation (inches) | Ponding Depth (ft) | Bottom Width (ft) | Bottom Length (ft) | Bottom Footprint (sf) | Orifice Height (ft) | Orifice Diameter (in) | Top Notch Width (in) | Top Notch Length (in) | Ponding Depth (ft) | Bottom Width (ft) | Bottom Length (ft) | Bottom Footprint (sf) | Orifice Height (ft) | Orifice Diameter (in) | Top Notch Width (in) | Top Notch Length (in) |
| 32 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 4.00 | 165.70 | 300.00 | 49710.00 | 0.00 | 0.80 | 0.87 | 12.55 |
| 40 | 4.00 | 150.00 | 300.00 | 45000.00 | 0.00 | 1.41 | 0.87 | 17.31 | 4.00 | 165.70 | 300.00 | 49710.00 | 0.00 | 4.41 | 0.87 | 17.31 |
| 60 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 4.00 | 165.70 | 300.00 | 49710.00 | 0.00 | 2.09 | 0.82 | 24.41 |

**Notes:**

a Detention Pond Transformed Configurations are reported separate from Table J-1 since orifice and notch configurations vary between each modeled climate region (32-inch, 40-inch, and 60-inch Mean Annual Precipitation)

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# ATTACHMENT H

Phase 2 Calculations

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## Bioswale Sizing

KC SWDM Section 6.3.1

**Goal:** Maximize drainage area for a facility sized using 40-inch MAP while maintaining bottom area from Phase 1, then transform facility for SUSTAIN input (vertical side slopes) and adjust drainage area for three precipitation factors.

| Dimensions from Phase 1 | | |
|---|---|---|
| 2 | ft | bottom width |
| 100 | ft | bottom length |

| Legend | |
|---|---|
| Blue text | indicates inputs that were changed during Phase 2 |
| Green text | indicates values to maintain from Phase 1 |
| Orange text | indicates inputs that were changed for the SUSTAIN input transformation |

| Parameter | | | | Unit | Notes |
|---|---|---|---|---|---|
| Original Design | Transformed for SUSTAIN | | | | |
| 40 | 40 | 32 | 60 | | Precipitation Factor |
| 0.64 | 0.64 | 0.78 | 0.455 | ac | Drainage area, 100% impervious |
| 0.052 | 0.052 | 0.052 | 0.052 | cfs | Off-line WQ design flow rate |
| 0.2 | 0.2 | 0.2 | 0.2 | | Mannings |
| 0.119 | 0.119 | 0.119 | 0.119 | ft | Design flow depth (initial 0.33) |
| 0.015 | 0.015 | 0.015 | 0.015 | ft/ft | Longitudinal slope |
| 2.00 | 2.00 | 2.00 | 2.00 | ft | Bottom width of swale |
| 3 | 0 | 0 | 0 | H:V | Side slope |
| 0.28 | 0.24 | 0.24 | 0.24 | sf | Cross-sectional area at design depth |
| 0.19 | 0.22 | 0.22 | 0.22 | fps | Design flow velocity |
| 540 | 540 | 540 | 540 | s | Hydraulic residence time |
| 100.11 | 117.98 | 117.98 | 117.98 | ft | Swale length |
| 28.08 | 28.08 | 28.08 | 28.08 | cf | Volume |

**Note:** Calculations were performed in order from left to right.

**Basic Stormwater Wetland Sizing,**
KC SWDM Worksheet 8-C

**Goal:** Maximize drainage area for a facility sized using 40-inch MAP while maintaining bottom area from Phase 1, then transform facility for SUSTAIN input (vertical side slopes) and adjust drainage area for three precipitation factors.

| Dimensions from Phase 1 | | |
|---|---|---|
| 503 | sf | bottom area |

| Legend | |
|---|---|
| Blue text | indicates inputs that were changed during Phase 2 |
| Green text | indicates values to maintain from Phase 1 |
| Orange text | indicates inputs that were changed for the SUSTAIN input transformation |
| | Design Assumptions |
| | Toggle value to meet specified condition for blue cells |
| | Cells to match by toggling values |

| Parameter | | | | | | |
|---|---|---|---|---|---|---|
| Original Design | Transformed for SUSTAIN | | | Units | Step in KC Worksheet | Notes |
| 40 | 40 | 32 | 60 | in | | Mean Annual Precipitation |
| 1 | 1 | 1 | 1 | unitless | Step 1 | f=1 for Basic Size |
| 98 | 98 | 98 | 98 | unitless | Step 2 | CN from Table 6.4.1.1.A, assuming 100% impervious |
| 1.44 | 1.44 | 1.15 | 2.16 | in | Step 3 | Precipitation P, 72% of 2-year, 24-hour |
| 0.2 | 0.2 | 0.2 | 0.2 | in | | Potential detention of area S, calculated |
| 1.23 | 1.23 | 0.94 | 1.94 | in | | Runoff depth Qd, calculated |
| 1.446 | 1.446 | 1.892 | 0.917 | acre | Step 4 | Drainage area A, Assumed (adjusted to get the same bottom area as Phase 1) |
| 6456.2454 | 6456.245 | 6455.882 | 6457.697 | cf | | Basic volume Vb, calculated |
| 6456.2454 | 6456.245 | 6455.882 | 6457.697 | cf | | Required volume, calculated |
| 2152.0818 | 2152.082 | 2151.961 | 2152.566 | sf | Step 5 | Atop, Total ponding area |
| 3 | 0 | 0 | 0 | H:V | | Sideslope |
| 3 | 3 | 3 | 3 | L:W | | check length-to-width ratio at mid-depth |
| 2152.0818 | 2152.082 | 2151.961 | 2152.566 | cf | Step 6a | first cell volume (1/3 total volume) |
| 4 | 4 | 4 | 4 | ft | | first cell depth |
| 538.02045 | 538.0205 | 537.9902 | 538.1415 | sf | | first cell mid-depth surface area |
| 8 | 8 | 8 | 8 | ft | | assumed bottom width |
| 20 | 8 | 8 | 8 | ft | | first cell mid-depth width |
| 26.9010225 | 67.25256 | 67.24878 | 67.26768 | ft | | first cell mid-depth length |
| 1 | 8 | 8 | 8 | L:W | | check mid-depth length:width ratio |
| 32 | 8 | 8 | 8 | ft | | first cell ponding area width |
| 38.9010225 | 67.25256 | 67.24878 | 67.26768 | ft | | first cell ponding area length |
| 8 | 8 | 8 | 8 | ft | | first cell bottom width check |
| 14.9010225 | 67.25256 | 67.24878 | 67.26768 | ft | | first cell bottom length |
| 2 | 8 | 8 | 8 | L:W | | check bottom length:width ratio |
| 119.20818 | 538.0205 | 537.9902 | 538.1415 | sf | | first cell bottom area |
| 1244.83272 | 538.0205 | 537.9902 | 538.1415 | sf | | first cell ponding area |
| 907.24908 | 1614.061 | 1613.971 | 1614.424 | sf | Step 6b | second cell ponding area |
| 28.35 | 201.7577 | 201.7577 | 201.7577 | ft | | second cell ponding area length |
| 2152.03272 | 2152.082 | 2152.052 | 2152.203 | sf | | total ponding area check |
| 32 | 8 | 8 | 8 | ft | | second cell ponding area width |
| 1.75 | 1.75 | 1.75 | 1.75 | ft | | second cell average depth |
| 17.85 | 201.7577 | 201.7577 | 201.7577 | ft | | second cell bottom length |
| 21.5 | 8 | 8 | 8 | ft | | second cell bottom width |
| 383.775 | 1614.062 | 1614.062 | 1614.062 | sf | | second cell bottom area |
| 67.2510225 | 269.0103 | 269.0065 | 269.0254 | ft | | total ponding area length |
| 32 | 8 | 8 | 8 | ft | | total ponding area width |
| 2152.03272 | 2152.082 | 2152.052 | 2152.203 | | | ponding area |
| 1 | 1 | 1 | 1 | ft | | freeboard |
| 73.2510225 | 269.0103 | 269.0065 | 269.0254 | ft | | total top length |
| 38 | 8 | 8 | 8 | ft | | total top width |
| 32.7510225 | 269.0103 | 269.0065 | 269.0254 | ft | | total bottom length |
| 21.5 | 8 | 8 | 8 | ft | | total bottom width |
| 2783.538855 | 2152.082 | 2152.052 | 2152.203 | sf | | total top area |
| 502.98318 | 2152.082 | 2152.052 | 2152.203 | | | total bottom area |
| 1.927658487 | 33.62628 | 33.62581 | 33.62817 | L:W | | top length:width |
| 0.118 | 0.118 | 0.127 | 0.105 | cfs | | Off-line WQ design flow rate (modeled 100% impervious in MGSFlood) |

**Note:** Calculations were performed in order from left to right.

**Basic Wetpond Sizing**
KC SWDM Worksheet 8-C

**Goal:** Maximize drainage area for a facility sized using 40-inch MAP while maintaining bottom area from Phase 1, then transform facility for SUSTAIN input (vertical side slopes) and adjust drainage area for three precipitation factors.

| Dimensions from Phase 1 | | |
|---|---|---|
| 553 | sf | bottom area |

| Legend | |
|---|---|
| Blue text | indicates inputs that were changed during Phase 2 |
| Green text | indicates values to maintain from Phase 1 |
| Orange te | indicates inputs that were changed for the SUSTAIN input transformation |
| | Design Assumptions |
| | Toggle value to meet specified condition for blue cells |
| | Cells to match by toggling values |

| Parameter: Original Design | Parameter: Transformed for SUSTAIN | | | Units | Step in KC Worksheet | Notes |
|---|---|---|---|---|---|---|
| 40 | 40 | 32 | 60 | | | Mean Annual Precipitation |
| 1 | 1 | 1 | 1 | unitless | Step 1 | f=1 for Basic Size |
| 98 | 98 | 98 | 98 | unitless | Step 2 | CN from Table 6.4.1.1.A, assuming 100% impervious |
| 1.44 | 1.44 | 1.15 | 2.16 | in | Step 2 | Precipitation P, 72% of 2-year, 24-hour |
| 0.2 | 0.2 | 0.2 | 0.2 | in | | Potential detention of area S, calculated |
| 1.23 | 1.23 | 0.94 | 1.94 | in | | Runoff depth Qd, calculated |
| 1.448 | 1.448 | 1.895 | 0.9181 | acre | Step 4 | Drainage area A, Assumed |
| 6465.175 | 6465.175 | 6466.119 | 6465.444 | cf | | Basic volume Vb, calculated |
| 6465.175 | 6465.175 | 6466.119 | 6465.444 | cf | | Required volume, calculated |
| 4 | 4 | 4 | 4 | ft | | Max ponding depth |
| 2 | 2 | 2 | 2 | ft | | Mid depth |
| 3 | 0 | 0 | 0 | H:V | | Sideslope |
| 3 | 3 | 3 | 3 | L:W | | Length-to-width ratio at mid-depth |
| 22.155 | 23.21278 | 23.21278 | 23.21278 | | | W0, mid-depth |
| 66.465 | 69.63835 | 69.63835 | 69.63835 | | | L0, mid-depth |
| 10.155 | 23.21278 | 23.21278 | 23.21278 | ft | | W2, assumed at minimum wetpond depth, assuming one geometry for entire facility, not varying by cell |
| 54.465 | 69.63835 | 69.63835 | 69.63835 | ft | | L2, bottom length (calculated assuming sideslopes on all 4 sides) |
| 34.155 | 23.21278 | 23.21278 | 23.21278 | ft | | W1, ponding area width |
| 78.465 | 69.63835 | 69.63835 | 69.63835 | ft | | L1, ponding area length |
| 3233 | 3233 | 3233 | 3233 | sf | | [A1 (ponding area) + A2 (bottom area)] |
| 3233.064 | 3233 | 3233 | 3233 | sf | | A1 + A2 Backcheck |
| 553.0921 | 1616.5 | 1616.5 | 1616.5 | sf | | A2, Bottom area |
| 2679.972 | 1616.5 | 1616.5 | 1616.5 | sf | | A1, Ponding area |
| 1 | 1 | 1 | 1 | ft | | freeboard |
| 3211.692 | 1616.5 | 1616.5 | 1616.5 | sf | | Top Area |
| 6466.13 | 6466 | 6466 | 6466 | cf | | Volume Check |
| 84.465 | 69.63835 | 69.63835 | 69.63835 | ft | | Top Length |
| 38.02394 | 23.21278 | 23.21278 | 23.21278 | ft | | Top Width |
| 2.221364 | 3 | 3 | 3 | L:W | | Top Length:Top Width |
| 0.118 | 0.118 | 0.127 | 0.105 | cfs | | Off-line WQ design flow rate (modeled 100% impervious in MGSFlood) |

**Note:** Calculations were performed in order from left to right.

**Basic Wetvault**
KC SWDM Worksheet 8-C

**Goal:** Maximize drainage area for a facility sized using 40-inch MAP while maintaining bottom area and dimensions from Phase 1, then adjust drainage area for three precipitation factors.

| Dimensions from Phase 1 | | |
|---|---|---|
| 1615 | sf | bottom area |
| 69.6 | ft | bottom length |
| 23.2 | ft | bottom width |

| Legend | |
|---|---|
| Blue text | indicates inputs that were changed during Phase 2 |
| Green text | indicates values to maintain from Phase 1 |
| Orange tex | indicates inputs that were changed for the SUSTAIN input transformation |
| | Design Assumptions |
| | Toggle value to meet specified condition for blue cells |
| | Cells to match by toggling values |

| Parameter | | | Units | Step in KC Worksheet | Notes |
|---|---|---|---|---|---|
| 32 | 40 | 60 | in | | Mean Annual Precipitation |
| 1 | 1 | 1 | unitless | Step 1 | f=1 for Basic Size |
| 98 | 98 | 98 | unitless | Step 2 | CN from Table 6.4.1.1.A, assuming 100% impervious |
| 1.15 | 1.44 | 2.16 | in | Step 3 | Precipitation P, 72% of 2-year, 24-hour |
| 0.2 | 0.2 | 0.2 | in | | Potential detention of area S, calculated |
| 0.94 | 1.23 | 1.94 | in | | Runoff depth Qd, calculated |
| 1.8929 | 1.4465 | 0.9171 | acre | Step 4 | Drainage area A, Assumed |
| 6458.953 | 6458.478 | 6458.402 | cf | | Basic volume Vb, calculated |
| 6458.953 | 6458.478 | 6458.402 | cf | | Required volume, calculated |
| 4 | 4 | 4 | ft | | Max ponding depth |
| 2 | 2 | 2 | ft | | Mid depth |
| 3 | 3 | 3 | L:W | | Length-to-width ratio |
| 23.2 | 23.2 | 23.2 | ft | | W, Width |
| 69.6 | 69.6 | 69.6 | ft | | L, Length |
| 1614.72 | 1614.72 | 1614.72 | sf | | Footprint |
| 3 | 3 | 3 | ft | | freeboard, doesn't affect area |
| 6458.88 | 6458.88 | 6458.88 | cf | | Volume Check |
| 0.127 | 0.118 | 0.105 | cfs | | Off-line WQ design flow rate (modeled 100% impervious in MGSFlood) |

**High Rate Underground Filter System**

**Goal:** Using a ratio of drainage area to treatment capacity, determine unit Action Drainage area for three defined precipitation regions.

| Design Assumptions | | |
|---|---|---|
| Footprint | 16 | sf |
| Treatment capacity [a] | 0.065 | cfs |

| Mean Annual Precipitation (in) | Off-line WQ Design Flow from MGSFlood (cfs) [b] | Drainage Area for Unit Action Footprint (ac) | Drainage Area for Unit Action Footprint (sf) |
|---|---|---|---|
| 32 | 0.067 | 0.9701 | 42259.70 |
| 40 | 0.081 | 0.8025 | 34955.56 |
| 60 | 0.114 | 0.5702 | 24836.84 |

**Note:**

a Treatment capacity provided by Contech; see table below.

b Off-line WQ Design Flow Rate computed in MGSFlood with 1 acre of impervious drainage area and a 15-minute time step.

**Filterra Treatment Capacity, provided by Contech**

| Maximum Treatment Flow for Filterra (175"/ hr) | |
|---|---|
| Basic and Enhanced Treatment Only | |
| Unit Size (ft x ft) | Treatment Capacity (cfs) |
| 4x4 | 0.065 |
| 4x6 | 0.097 |
| 4x8 | 0.13 |
| 6x6 | 0.146 |
| 6x8 | 0.194 |
| 6x10 | 0.243 |
| 6x12 | 0.292 |
| 7x13 | 0.369 |
| 8x12 | 0.389 |
| 8x14 | 0.454 |
| 8x16 | 0.519 |
| 8x18 | 0.583 |
| 8x20 | 0.648 |

Offline flow rate

**High Rate Underground Filter System as Pretreatment [a]**

**Goal:** Using a ratio of drainage area to treatment capacity, determine Unit Action Drainage area for three precipitation regions.

| **Design Assumptions** | | |
|---|---|---|
| Footprint | 24 | sf |
| Treatment capacity [b] | 0.097 | cfs |

| Mean Annual Precipitation (in) | Off-line WQ Design Flow from MGS Flood (cfs) [c] | Drainage Area for Unit Action Footprint (ac) | Drainage Area for Unit Action Footprint (sf) |
|---|---|---|---|
| 32 | 0.067 | 1.4478 | 63064.48 |
| 40 | 0.081 | 1.1975 | 52164.44 |
| 60 | 0.114 | 0.8509 | 37064.21 |

**Notes:**

a The 24 sf high-rate underground filter system is used as pre-treatment for the deep UIC well, infiltration pond, and infiltration vault Actions. When used as pre-treatment, the contributing drainage area is determined by the pre-treatment capacity.

b Treatment capacity provided by Contech; see table below.

c Off-line WQ Design Flow Rate computed in MGSFlood with 1 acre of impervious drainage area and a 15-minute time step.

**Filterra Treatment Capacity, provided by Contech**

| Maximum Treatment Flow for Filterra (175"/ hr) | |
|---|---|
| Basic and Enhanced Treatment Only | |
| Unit Size (ft x ft) | Treatment Capacity (cfs) |
| 4x4 | 0.065 |
| 4x6 | 0.097 |
| 4x8 | 0.13 |
| 6x6 | 0.146 |
| 6x8 | 0.194 |
| 6x10 | 0.243 |
| 6x12 | 0.292 |
| 7x13 | 0.369 |
| 8x12 | 0.389 |
| 8x14 | 0.454 |
| 8x16 | 0.519 |
| 8x18 | 0.583 |
| 8x20 | 0.648 |

Offline flow rate

**Regional Vegetated Media Filtration Facility**

**Goal:** Using the following formula, determine Unit Action Drainage area for each of the three defined precipitation regions:

$$Unit\ Action\ Drainage\ Area = \frac{\frac{Manchester\ WQ\ Design\ Flow\ Rate}{WQBE\ WQ\ Design\ Flow\ Rate} * Drainage\ Area * \frac{Ecology\ GULD\ Infiltration\ Rate\ for\ Filterra}{Manchester\ Design\ Infiltration\ Rate\ for\ Filterra}}{Factor\ of\ Safety}$$

| **Design Assumptions** | | |
|---|---|---|
| Footprint [a] | 5940 | sf |
| Drainage Area [a] | 73 | ac |
| Ecology GULD infiltration rate for Filterra (in/hr) | 175 | in/hr |
| Manchester design infiltration rate for Filterra (in/hr) [a] | 24.8 | in/hr |
| Factor of safety | 1.3 | |
| Manchester Mean Annual Precipitation [b] | 40 | in |
| Off-line Water Quality Design Flow Rate, Manchester [b, c] | 2.643 | cfs |

| **Mean Annual Precipitation (in) [b, c]** | **Off-line WQ Design Flow Rate (cfs) [c]** | **Unit Action Drainage Area (ac)** |
|---|---|---|
| 32 | 2.173 | 482 |
| 40 | 2.643 | 396 |
| 60 | 3.839 | 273 |

**Notes:**

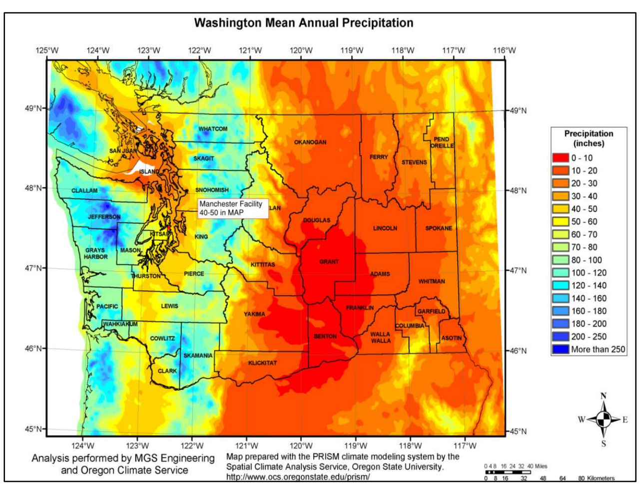
a From Kitsap County Manchester Stormwater Park Report (Parametrix 2014).

b Manchester, WA lies in the 40-inch MAP region. See Washington Mean Annual Precipitation isopluvial map below.

c Manchester used the following land use assumptions to determine off-line WQ design flow rate in WWHM:
- -2.01 ac Forest flat
- -2.01 ac Forest mod
- -18.04 ac Lawn flat
- -17.29 ac Lawn mod
- -9.39 ac roads mod
- -10.24 ac rooftops flat
- -13.66 ac driveways mod

However, for purposes of WQBE precipitation sizing, the above WWHM assumptions were represented in MGSFlood with equivalent assumptions below to calculate off-line WQ Design Flow Rate:
- -4.02 ac Till forest
- -35.33 ac Till Grass
- -33.29 ac Impervious

**Mean Annual Precipitation, Washington State (http://www.mgsengr.com/)**



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# ATTACHMENT I

Precipitation Analysis Summary

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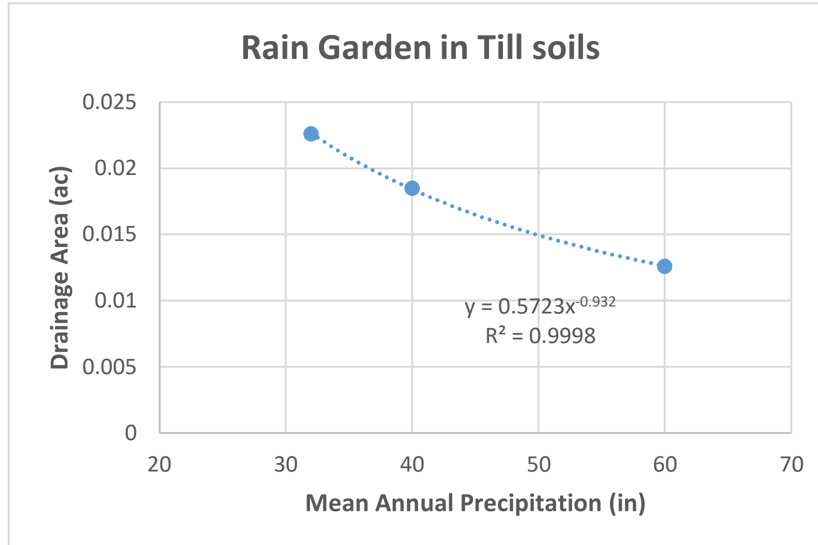
| Rain Garden on Till Soils | | |
|---|---|---|
| Unit Action Footprint Area = 25 SF [a] | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) | Unit Drainage Area (sf) |
| 32 | 0.0226 | 984 |
| 40 | 0.0185 | 806 |
| 60 | 0.0126 | 549 |

**Notes**

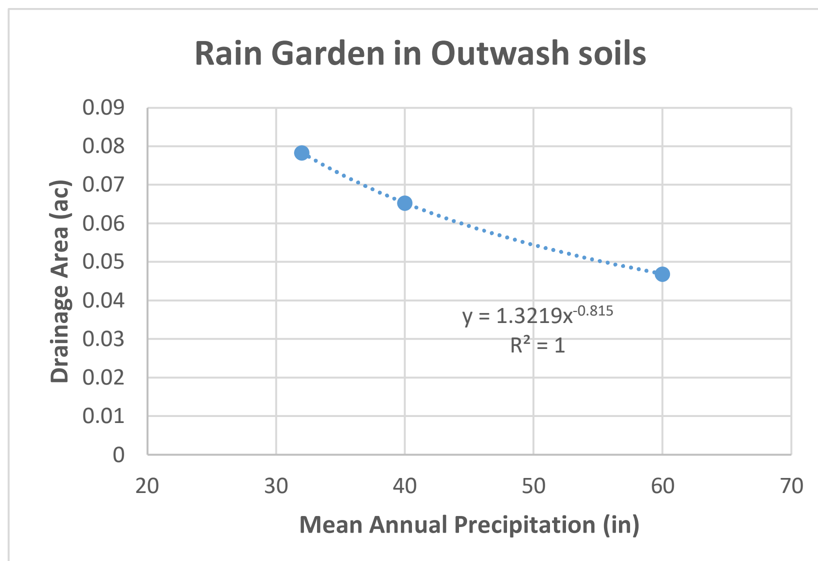
a Unit Action Footprint transformed to 33 SF for SUSTAIN input



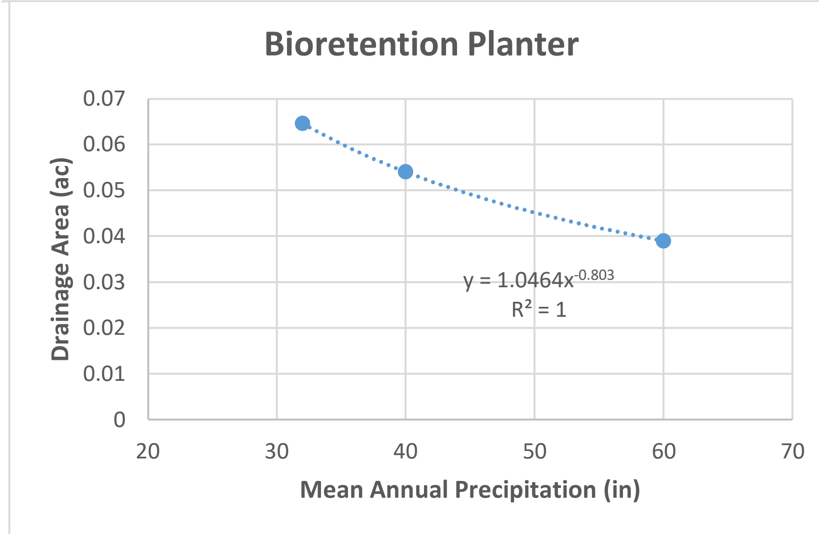

| Rain Garden on Outwash Soils | | |
|---|---|---|
| Unit Action Footprint Area = 25 SF [a] | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) | Unit Drainage Area (sf) |
| 32 | 0.0783 | 3411 |
| 40 | 0.0653 | 2844 |
| 60 | 0.0469 | 2043 |

**Notes**

a Unit Action Footprint transformed to 65 SF for SUSTAIN input



| Bioretention Planter | | |
|---|---|---|
| Unit Action Footprint Area = 25 SF | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) | Unit Drainage Area (sf) |
| 32 | 0.0646 | 2814 |
| 40 | 0.0541 | 2357 |
| 60 | 0.0390 | 1699 |

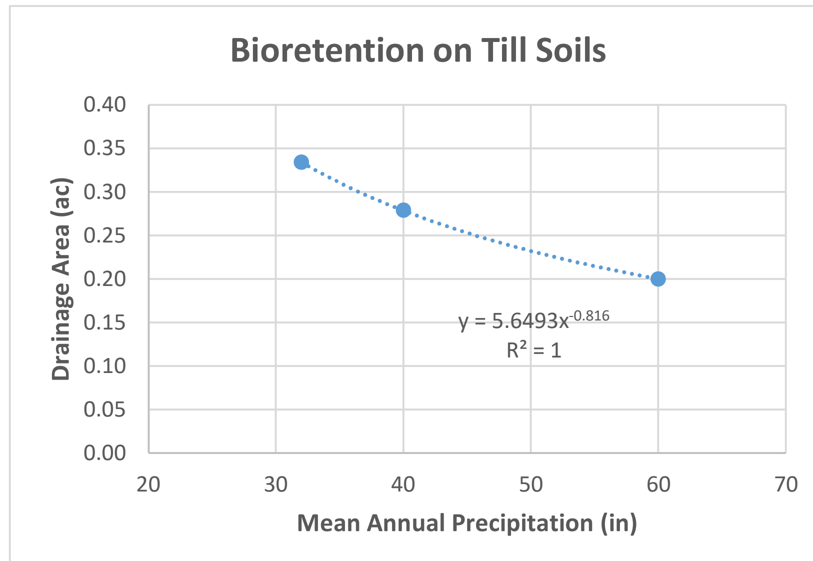



| Bioretention on Till Soils | | |
|---|---|---|
| Unit Action Footprint Area = 85 SF [a] | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) [b] | Unit Drainage Area (sf) [b] |
| 32 | 0.3339 | 14545 |
| 40 | 0.2789 | 12148 |
| 60 | 0.2000 | 8712 |

**Notes**

a Unit Action Footprint transformed to 137 SF for SUSTAIN input

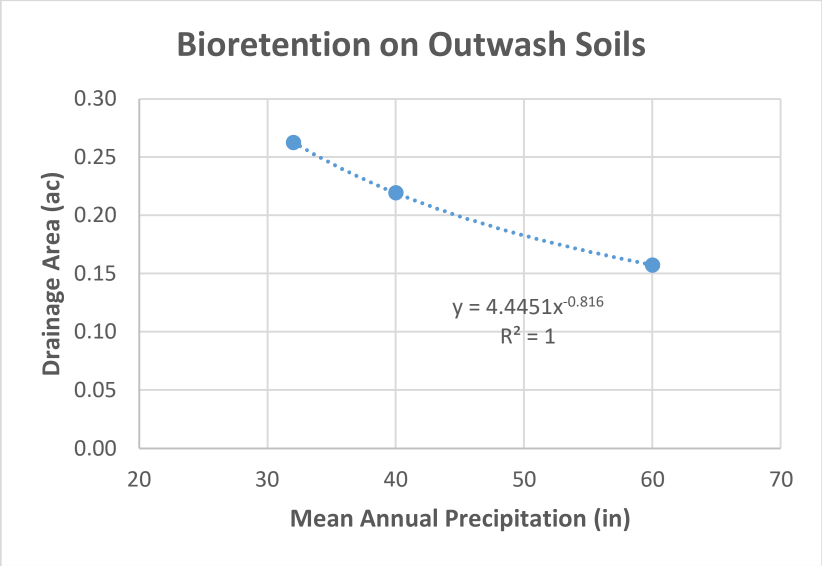
b Drainage Area includes 5% increase of drainage area modeled to account for storage and infiltration area under the elevated underdrain



| Bioretention on Outwash Soils | | |
|---|---|---|
| Unit Action Footprint Area = 85 SF [a] | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) | Unit Drainage Area (sf) |
| 32 | 0.2627 | 11443 |
| 40 | 0.2197 | 9570 |
| 60 | 0.1574 | 6856 |

**Notes**

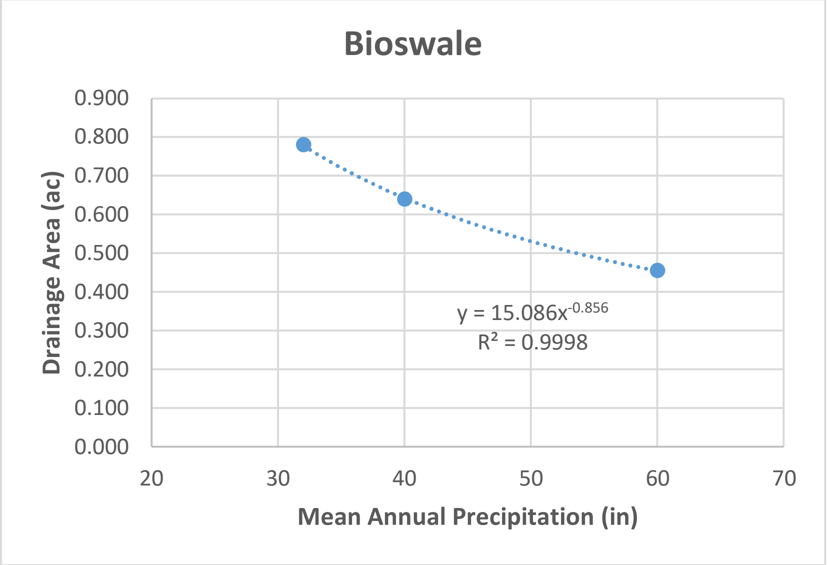
a Unit Action Footprint transformed to 206 SF for SUSTAIN input




| Bioswale | | |
|---|---|---|
| Unit Action Footprint Area = 200 SF [a] | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) | Unit Drainage Area (sf) |
| 32 | 0.780 | 33977 |
| 40 | 0.640 | 27878 |
| 60 | 0.455 | 19820 |

**Notes**

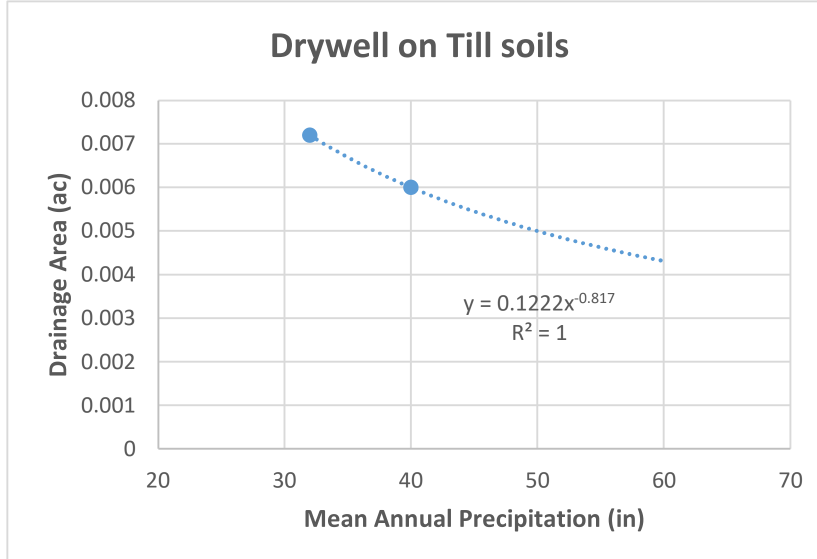
a Unit Action Footprint transformed to 236 SF for SUSTAIN input



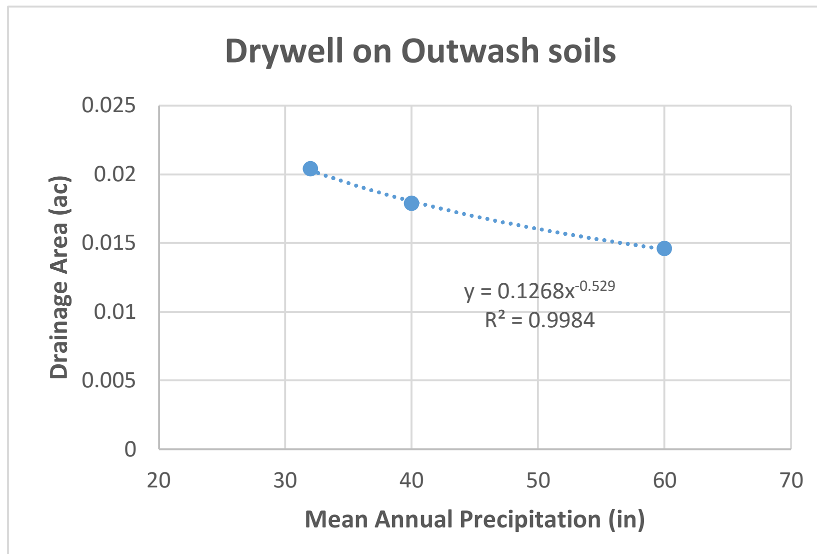
| Drywell on Till Soils | | |
|---|---|---|
| Unit Action Footprint Area = 13 SF | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) | Unit Drainage Area (sf) |
| 32 | 0.0072 | 314 |
| 40 | 0.0060 | 261 |
| 60 [a] | 0 | 0 |

**Notes**

a Cannot run model; MGSFlood limits minimum contributing area to 0.005 acres

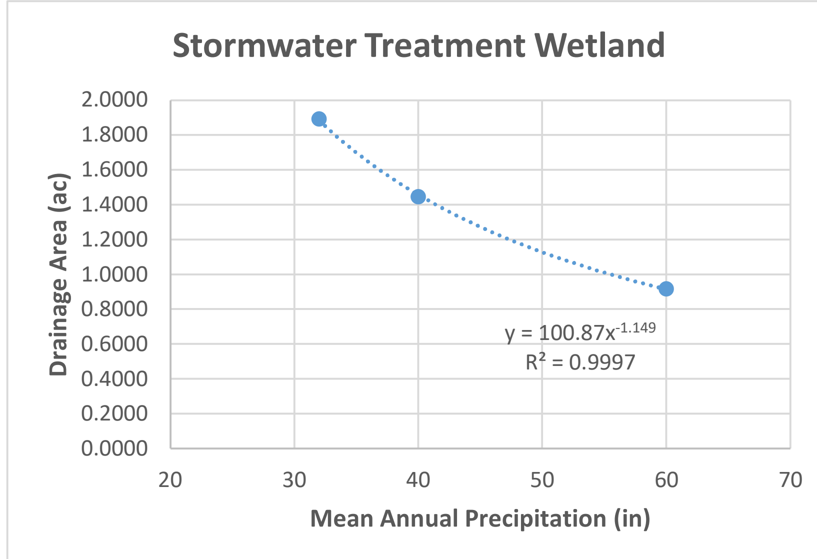



| Drywell on Outwash Soils | | |
|---|---|---|
| Unit Action Footprint Area = 13 SF | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) | Unit Drainage Area (sf) |
| 32 | 0.0204 | 889 |
| 40 | 0.0179 | 780 |
| 60 | 0.0146 | 636 |



| Stormwater Treatment Wetland | | |
|---|---|---|
| **Unit Action Footprint Area = 503 SF [a]** | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) | Unit Drainage Area (sf) |
| 32 | 1.8920 | 82416 |
| 40 | 1.4460 | 62988 |
| 60 | 0.9170 | 39945 |

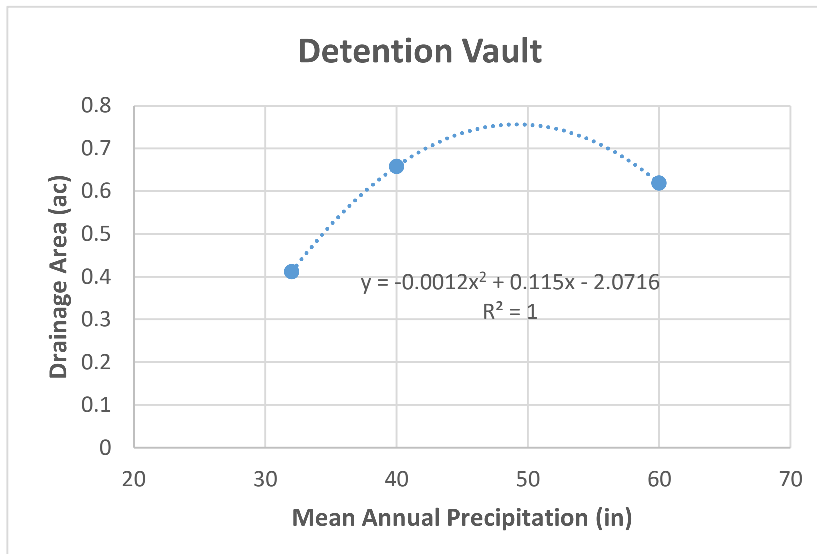
a Unit Action Footprint transformed to 2152 SF for SUSTAIN input




| Detention Vault | | |
|---|---|---|
| **Unit Action Footprint Area = 2592 SF** | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) [a] | Unit Drainage Area (sf) [a] |
| 32 | 0.4114 | 17921 |
| 40 | 0.6579 | 28658 |
| 60 | 0.6192 | 26972 |

**Note**

a Unit drainage area is the modeled drainage area scaled down by a factor of 10

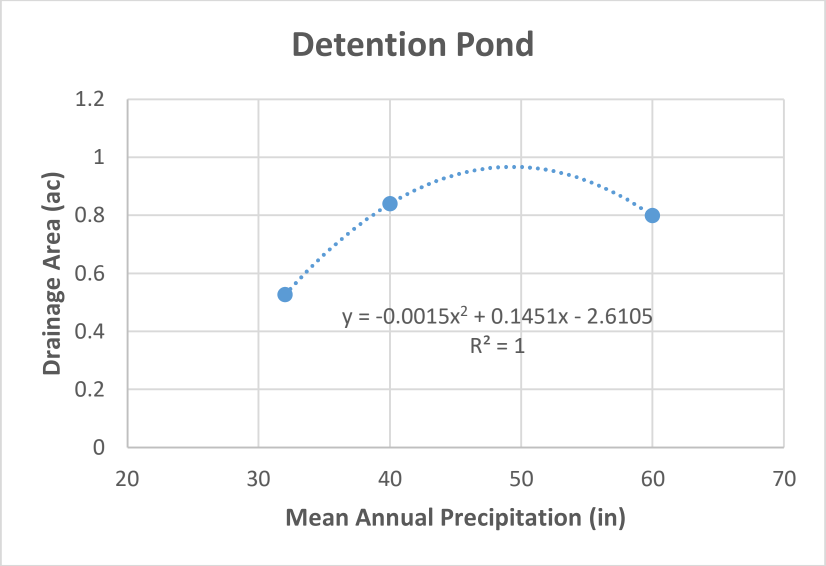


| Detention Pond | | |
|---|---|---|
| Unit Action Footprint Area = 4500 SF [a] | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) [b] | Unit Drainage Area (sf) [b] |
| 32 | 0.5262 | 22921 |
| 40 | 0.8395 | 36569 |
| 60 | 0.7987 | 34791 |

**Note**

a Unit Action Footprint transformed to 4971 SF for SUSTAIN input

b Unit drainage area is the modeled drainage area scaled down by a factor of 10

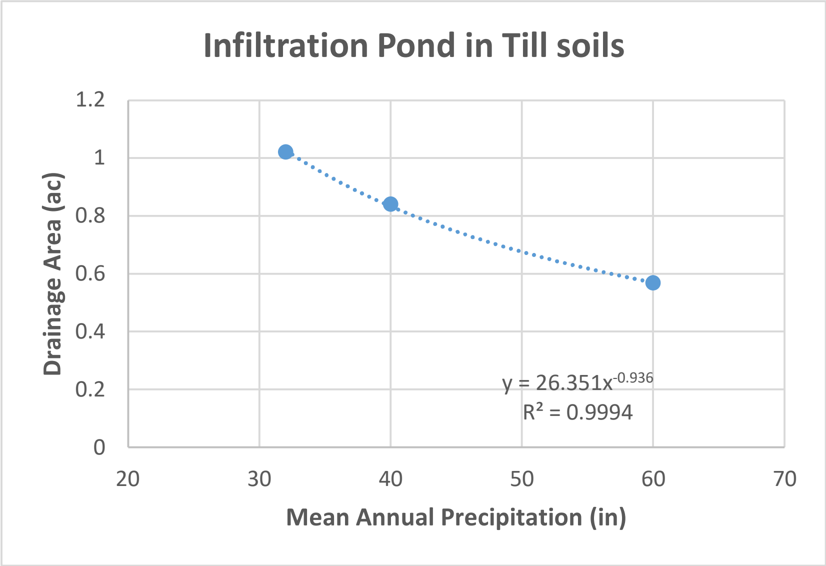



| Infiltration Pond in Till Soils | | |
|---|---|---|
| Unit Action Footprint Area = 2785 SF [a] | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) [b] | Unit Drainage Area (sf) [b] |
| 32 | 1.0213 | 44488 |
| 40 | 0.8401 | 36595 |
| 60 | 0.5683 | 24755 |

**Note**

a Unit Action Footprint transformed to 3299 SF for SUSTAIN input

b Unit drainage area is the modeled drainage area scaled down by a factor of 10

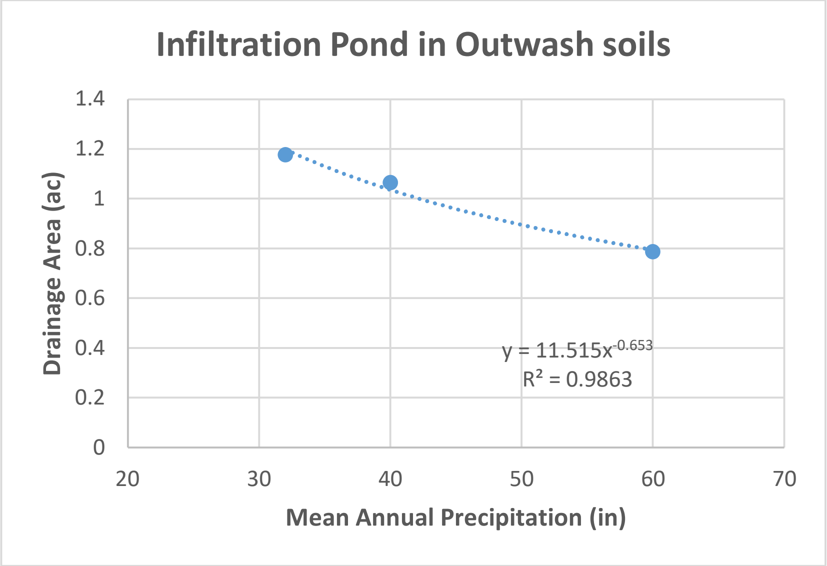


| Infiltration Pond in Outwash Soils | | |
|---|---|---|
| Unit Action Footprint Area = 1479 SF [a] | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) [b] | Unit Drainage Area (sf) [b] |
| 32 | 1.1768 | 51261 |
| 40 | 1.0651 | 46396 |
| 60 | 0.7870 | 34282 |

**Note**

a Unit Action Footprint transformed to 1803 SF for SUSTAIN input

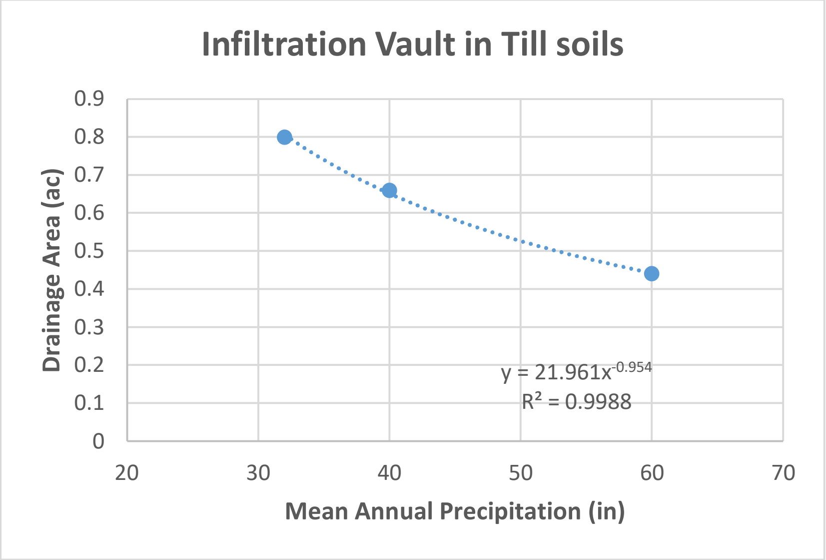
b Unit drainage area is the modeled drainage area scaled down by a factor of 10




| Infiltration Vault in Till Soils | | |
|---|---|---|
| Unit Action Footprint Area = 1836 SF | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) [a] | Unit Drainage Area (sf) [a] |
| 32 | 0.7994 | 34822 |
| 40 | 0.6593 | 28719 |
| 60 | 0.4405 | 19188 |

**Note**

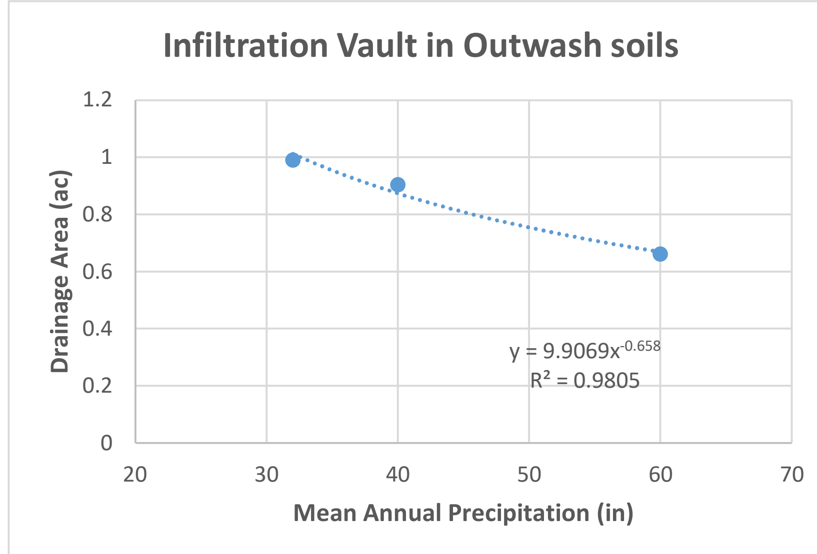
a Unit drainage area is the modeled drainage area scaled down by a factor of 10



| Infiltration Vault in Outwash Soils | | |
|---|---|---|
| Unit Action Footprint Area = 1156 SF | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) [a] | Unit Drainage Area (sf) [a] |
| 32 | 0.9902 | 43133 |
| 40 | 0.9037 | 39365 |
| 60 | 0.6611 | 28798 |

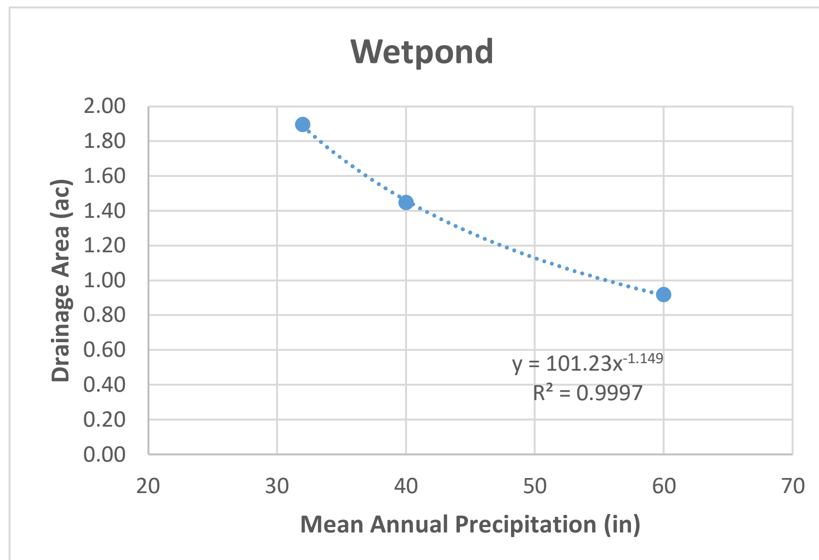
**Note**

a Unit drainage area is the modeled drainage area scaled down by a factor of 10

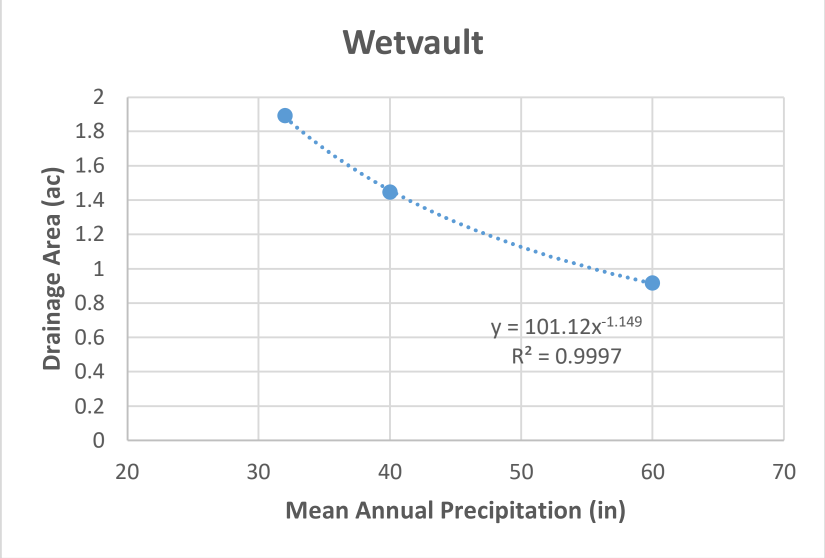



| Wetpond | | |
|---|---|---|
| Unit Action Footprint Area = 553 SF [a] | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) | Unit Drainage Area (sf) |
| 32 | 1.90 | 82546 |
| 40 | 1.45 | 63075 |
| 60 | 0.92 | 39992 |

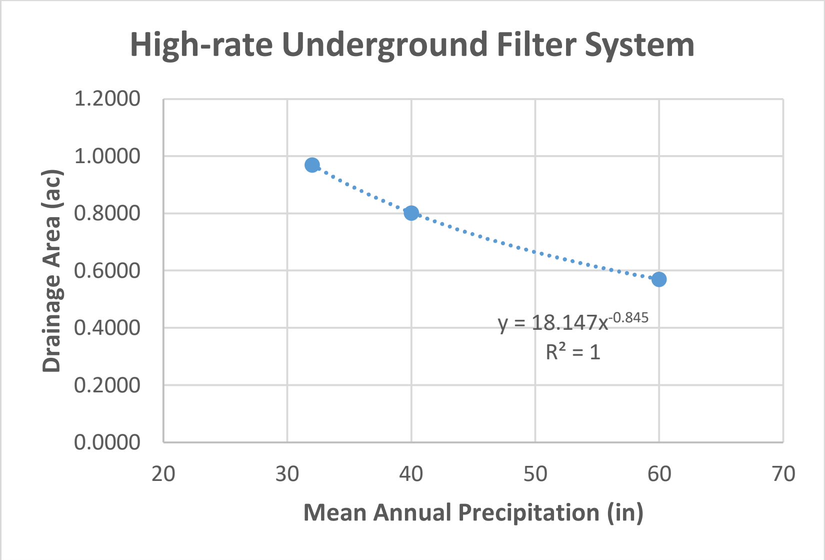
a Unit Action Footprint transformed to 1616 SF for SUSTAIN input



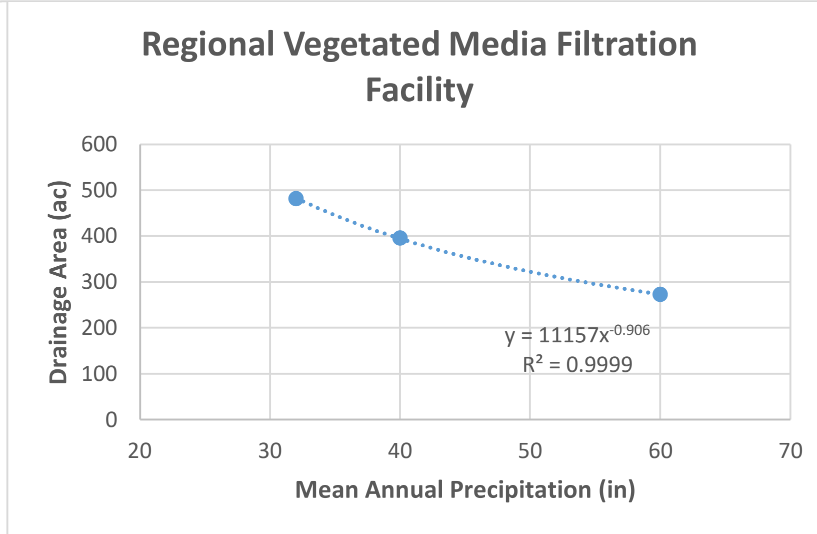
| Wetvault | | |
|---|---|---|
| Unit Action Footprint Area = 1615 SF | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) | Unit Drainage Area (sf) |
| 32 | 1.8929 | 82455 |
| 40 | 1.4465 | 63010 |
| 60 | 0.9171 | 39949 |



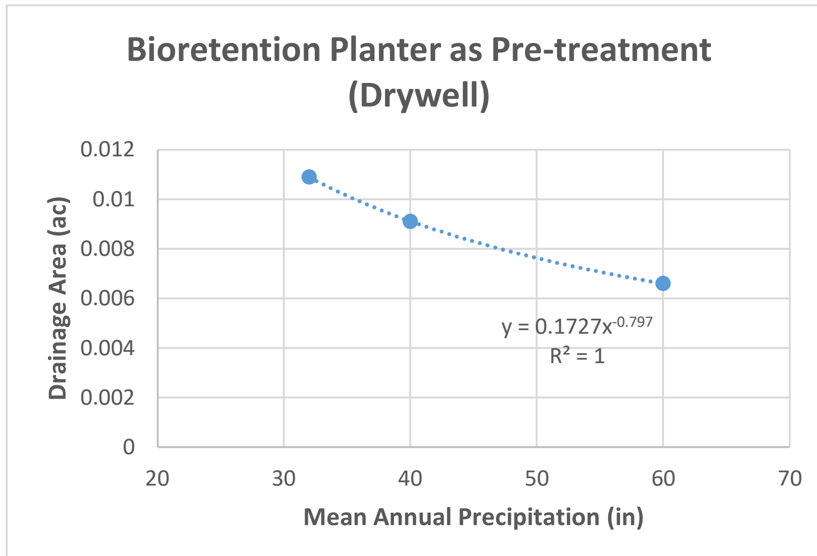

| High-rate Underground Filter System | | |
|---|---|---|
| Unit Action Footprint Area = 16 SF | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) | Unit Drainage Area (sf) |
| 32 | 0.9701 | 42260 |
| 40 | 0.8025 | 34956 |
| 60 | 0.5702 | 24837 |



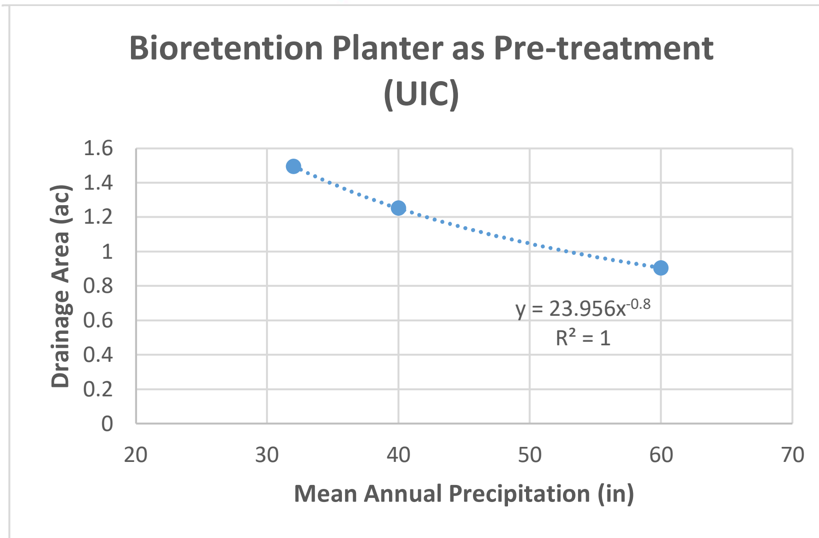
| Regional Vegetated Media Facility | | |
|---|---|---|
| Unit Action Footprint Area = 5940 SF | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) | Unit Drainage Area (sf) |
| 32 | 482 | 5940 |
| 40 | 396 | 5940 |
| 60 | 273 | 5940 |




| Bioretention Planter as Pre-treatment (Drywell) | | |
|---|---|---|
| Unit Action Footprint Area = 4.3 SF | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) | Unit Drainage Area (sf) |
| 32 | 0.0109 | 475 |
| 40 | 0.0091 | 396 |
| 60 | 0.0066 | 287 |



| Bioretention Planter as Pre-treatment (UIC) | | |
|---|---|---|
| Unit Action Footprint Area = 579 SF | | |
| Mean Annual Precipitation (in) | Unit Drainage Area (ac) | Unit Drainage Area (sf) |
| 32 | 1.4957 | 65153 |
| 40 | 1.2522 | 54546 |
| 60 | 0.9046 | 39404 |



# ATTACHMENT J

Annotated Fact Sheet

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Action name

Action icon

# BIORETENTION

## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022

General description of the Action including major assumptions and benefits provided

Photo depicting real-world application

City of Redmond Overlake Village LID Retrofit Project
Photo courtesy of RKI

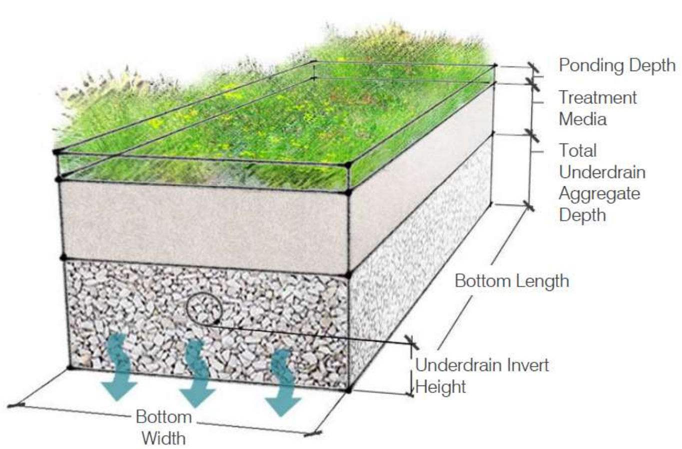
### ACTION DESCRIPTION

Shallow earthen depressions with a designed high-performance bioretention soil media (HPBSM) and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system. Provides volume and peak flow reduction and water quality treatment.

Summary of Action design parameters

Schematic illustration of major components included in SUSTAIN model

### UNIT ACTION SCHEMATIC




### DESIGN PARAMETERS

| Parameter | Soil Type: Till | Soil Type: Outwash |
|---|---|---|
| Unit Footprint Area | 85 SF | 85 SF |
| Unit Drainage Area | 12,148 SF | 9,570 SF |
| Ponding Depth | 6 in | 6 in |
| Bottom Length | 16 ft | 16 ft |
| Bottom Width | 5.33 ft | 5.33 ft |
| Side Slope | 3H : 1V | 3H : 1V |
| Treatment Media Depth | 18 in | 18 in |
| Treatment Media Porosity | 30% | 30% |
| Treatment Media Infiltration Rate | 6 in/hr | 6 in/hr |
| Total Underdrain Aggregate Depth | 26 in | N/A |
| Underdrain Invert Height | 12 in | N/A |
| Underdrain Diameter | 8 in | N/A |
| Underdrain Aggregate Porosity | 40% | N/A |
| Native Soil Design Infiltration Rate | 0.3 in/hr | 2.5 in/hr |

N/A: Not Applicable

### TREATMENT AREAS

Summary of where the Action can be applied, informing cost estimates and SUSTAIN model assumptions on implementation

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Driveways
- Parking Lots
- Sidewalk
- Plazas
- Local Roads
- Arterial Roads
- Highways

### DESIGN ASSUMPTIONS

Basis of design summary

- Design is based on *2016 King County Surface Water Design Manual (KCSWDM)* Section C.2.6.1.
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Although not listed in the Basic or Enhanced Water Quality Treatment Menu in the KCSWDM, this project assumes the Action, including the HPBSM, provides Enhanced Water Quality Treatment.
- The HPBSM is a low phosphorus media composed of 70% sand, 20% coir and 10% high carbon wood ash (biochar). No polishing layer is included.
- For bioretention installed in till soils, an elevated underdrain promotes infiltration. Design includes 6” cover, 8” underdrain pipe, and 12” bedding.
- For bioretention installed on outwash soils, no underdrain is included.



Visit kingcounty.gov/WQBE for more information.

A project for Clean Water Healthy Habitat HERRERA RKI planning engineering FDR King County

# BIORETENTION
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 2

01/14/2022

Summary of SUSTAIN modeling processes

### SUSTAIN MODEL REPRESENTATION

Hydrologic:
- Model explicitly represents ponding, infiltration, underdrain flow, and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:
- Water that infiltrates is lost to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).

Median percent removal and median effluent concentrations for target pollutants analyzed in SUSTAIN

### PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal [a] | Median Effluent Concentration [a] |
|---|---|---|
| Total Copper | 62.3% | 10.5 µg/L |
| Dissolved Copper | 57.6% | 6.4 µg/L |
| Total Zinc | 91.0% | 10.0 µg/L |
| Dissolved Zinc | 86.2% | <4.0 µg/L [b] |
| Total Phosphorus | 54.9% | 0.113 mg-P/L |
| Total Nitrogen | 51.3% | 1.33 mg/L |
| Total Suspended Solids | 78.0% | 21.5 mg/L |
| Total PCBs | 78.0%[c] | 572 pg/L[c] |
| Total PBDEs | 67.1%[c] | 0.054 ng/L[c] |
| Total PAHs | 95.0% | <0.01 µg/L [b] |
| Bis(2-ethylhexyl)phthalate | 63.2%[c] | 0.070 µg/L[c] |
| Fecal Coliform | 61.5 % | 240 CFU |

a. Performance based on the low phosphorus alternative bioretention soil media with 70% sand/20% coconut coir/10% high carbon wood ash
b. Method detection limit
c. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

### UNIT ACTION COSTS

| Costs/Unit Action [a, b] | With Underdrain | | | No Underdrain | | |
|---|---|---|---|---|---|---|
| | On Property with Acquisition | On Property without Acquisition | In Right of Way/ Highway | On Property with Acquisition | On Property without Acquisition | In Right of Way/ Highway |
| Total Project | $100,000 | $85,000 | $139,000 | $98,000 | $83,000 | $135,000 |
| Total Direct Construction | $59,000 | $59,000 | $97,000 | $57,000 | $57,000 | $94,000 |
| Total Indirect Non-Construction | $42,000 | $26,000 | $42,000 | $41,000 | $25,000 | $41,000 |
| Operation and Maintenance | $2,800/year | $2,800/year | $2,800/year | $2,800/year | $2,800/year | $2,800/year |
| Property Acquisition [c] | $14,000 | $0 | $0 | $14,000 | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.

Total project, operation and maintenance, and property acquisition cost estimates for various model configurations

### PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Site must have sufficient space (e.g., right-of-way applications typically require minimum planter width of 12 feet)
- Locate away from traveled areas on individual lots to prevent soil compaction and damage to vegetation
- No discharge towards existing basements, erosion hazard areas, or landslide hazard areas
- Meet infiltration siting restrictions, including setbacks:
  - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
  - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
  - 100 feet away from proposed or existing septic system drainfields
- See comprehensive list of infeasibility criteria in Section C.2.6 of *the 2016 King County Surface Water Design Manual*

Considerations for program implementation and siting of individual Actions in SUSTAIN



Visit kingcounty.gov/WQBE for more information.

# Appendix C

## Phase 3 Action Design Assumptions and Modeling Parameters

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Science + Planning + Design

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# TECHNICAL MEMORANDUM


Date: October 4, 2024

To: Carly Greyell, King County Water and Land Resources Division
Jim Simmonds, King County Wastewater Treatment Division

From: Alice Lancaster, Herrera Environmental Consultants, Inc.
Olivia Wright, Herrera Environmental Consultants, Inc
John Lenth, Herrera Environmental Consultants, Inc.


Subject: WQBE Phase 3 Action Development (Appendix C to 439-TM1)

# Contents



# Attachments

# Tables



# Figures

# Introduction

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes for selecting cost-effective water quality investments, reducing pollutant load and improving ecological and human health outcomes. The WQBE Toolkit will include a set of computational models:

- Integrated pollutant loading models, which estimate pollutant loads for major King County waterbodies taking into account major pollutant pathways and sources.
- System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) models, which identify cost-effective combinations of potential water quality improvement investments for reduction of pollutant loads or stormwater volumes.
- Qualitative causal models, which define relationships between potential water quality projects and programs and five ecological/human health endpoints (southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches).

The WQBE Toolkit provides information that will be used in planning and prioritization of water quality investments. However, it is not the only information that informs these decisions. These efforts will also consider information not provided by the WQBE Toolkit, including how well different actions would advance equity and social justice, meet regulatory requirements, impact the cost of wastewater rates, and reflect other regional priorities (e.g., sustainability, community well-being, and more).

Part of this effort has involved the development of model inputs for "Actions" composed of structural or nonstructural stormwater controls that improve water quality and/or provide flow control. These Actions provide the unit building blocks (or "unit Actions") that are aggregated and combined to develop "Programs," or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. SUSTAIN models are then developed for each Program to evaluate cost effectiveness combinations of Actions, or "Packages", for improving water quality or providing flow control.

The WQBE Toolkit is being developed in three phases over a period extending from 2020 through 2024.

- **Phase 1 (2020)**: Assumptions for a preliminary set of nineteen Actions and three Programs focused on improving water quality were developed to be modeled with the WQBE Toolkit.
- **Phase 2 (2021–2022):** Preliminary Actions and Programs from Phase 1 were refined to improve their representation in SUSTAIN (Herrera 2022). The three water quality Programs from Phase 1 were subsequently modeled with SUSTAIN (Paradigm and Herrera 2022).
- **Phase 3 (2023–2024):** An additional five Actions and four Programs focused on providing flow control were developed and the Phase 2 Action costs were refined using a simplified approach that allows for more direct comparison to similar planning level cost estimates in the region.

This memorandum documents the Actions developed in Phase 3 for the WQBE Toolkit. The following information is provided: the Action development process, an overview of the WQBE Actions and Action Fact Sheets, the design assumptions and technical basis for the new Action Fact Sheet content, and key limitations/future considerations.

# Action Development Process

The Core Team (Consultant and County staff directly overseeing WQBE toolkit development) held a workshop with King County staff on April 18, 2023, to select and define the Actions to be developed under Phase 3. The results of this workshop are summarized in a companion memorandum (Herrera 2023). The following Actions were recommended for development.

- Sports Fields and Parks Detention
- Blue Roofs
- Compost Amendment
- Reforestation
- Tree Planting in the Right of Way
- Continuous Monitoring and Active Control (CMAC system)
- Floodplain Storage
- High-flow Bypass (tightline of stormwater to bottom of watershed)
- Retrofit Existing Flow Control Facilities

Subsequent to the workshop, the Core Team decided to eliminate the following Actions from further consideration: tree planting in the right of way, floodplain storage, high-flow bypass, and CMAC system. Tree planting in the right of way was not advanced because this Action would provide minimal flow control. Floodplain storage and high-flow bypass were not advanced due to modeling complexities and budget limitations. CMAC system was not advanced because SUSTAIN currently does not have the functionality to represent the flow control benefits of this Action.

Upon further investigation, the retrofitting existing facilities Action was also eliminated from further consideration due to the difficulty representing this Action in SUSTAIN. An exploratory analysis was completed to size a "mini-pond" and outlet structure that represents the difference between a pond meeting 1990 King County flow control standards and the same 1990 pond with an optimized flow control structure, ideally achieving a pasture or forested flow control standard. The following steps were completed during this analysis:

1. Using Western Washington Hydrology Model (WWHM2012), size a pond for a 10-acre tributary area (60% impervious, 40% pervious) to 1990 King County standards.

2. Optimize the 1990 pond outlet structure (assuming no change in pond volume or depth) to achieve a pasture standard to the greatest extent feasible.
3. Identify if there is a relationship between the discharge of the 1990 and the optimized-1990 ponds. This would inform the feasibility of developing a small pond representing the difference in the two ponds for inclusion in the SUSTAIN optimization.

A meaningful relationship between the discharge of the two ponds could not be identified to facilitate the creation of a modified discharge curve or mini-pond for input into SUSTAIN. Therefore, a SUSTAIN representation for this Action could not be developed.

While the retrofitting existing facilities, CMAC, floodplain storage, and high-flow bypass Actions are not being advanced in connection with Phase 3, the County may choose to use other means to evaluate the cost-effectiveness of these likely beneficial Actions.

# Action Overview

This section provides a high-level description of the WQBE Actions, Action Fact Sheets, and WQBE Programs.

## Actions

"Actions" are structural or nonstructural stormwater controls that improve water quality and/or provide flow control. The nineteen Actions developed under Phase 2 are listed below. These Actions are documented under a separate memorandum in Appendix B of Herrera (2024).

- **Green Stormwater Infrastructure (GSI) practices** include rain gardens, HPBSM[1] bioretention, bioretention HPBSM planters, bioswales, media filter drains, drywells, deep underground injection (UIC) wells, permeable pavement, depaving, and stormwater treatment wetlands.
- **Stormwater retention/detention/infiltration practices** include detention vaults, detention ponds, infiltration ponds, infiltration vaults, and cisterns.
- **Gray practices** include wetponds, wetvaults, high-rate underground filter systems, and regional vegetated media filtration facilities.

Five new flow control-focused Actions were developed under Phase 3. A high-level description of each Program is provided below.

- **Sports Fields and Parks Detention** is subsurface storage at an existing sport field or park to provide flow control while preserving recreational site use. An underground chamber array will detain the

[1] HPBSM is high-performance bioretention soil media.

water draining from the overlying area and offsite contributing drainage area. The stored stormwater runoff is released through a control structure at an attenuated rate.

- **Blue Roof** is rooftop detention designed to provide temporary storage and slow release of stormwater runoff. This technique is most commonly used in dense urban areas where other methods of stormwater detention are impractical.
- **Compost Amendment** includes amending soil under existing lawn surfaces with compost to increase water holding capacity and infiltration. Amended area is revegetated with turf.
- **Reforest High Density Development** converts existing impervious surface and buildings to forest by uncompacting/ amending soil and planting trees and understory vegetation. The costs for this Action assume demolition and disposal of buildings, pavement and utilities. While the benefits of this Action would increase over time as the trees and vegetation become established, the performance of this Action is represented as a mature forest.
- **Reforest Pervious** converts existing pervious surface to forest by uncompacting/ amending soil and planting trees and understory vegetation. While the benefits of this Action would increase over time as the trees and vegetation become established, its performance is represented as a mature forest.

This memorandum is focused on documenting these Actions developed in Phase 3.

## Action Fact Sheets

Action Fact Sheets were prepared to compile Action descriptions and the information used to develop modeling inputs for the SUSTAIN model, including design, performance, and cost assumptions. Fact Sheets include the following:

- Description and photo of Action
- Potential areas managed, including land uses, property types, and surface types
- Design parameters for unit Action, including footprint area, drainage area, and design section
- Schematic for unit Action, illustrating section and dimensions
- Design assumptions, including basis for sizing
- Representation of hydrologic and treatment performance in the SUSTAIN model
- Action treatment performance parameters, including median percent removal and median effluent concentration
- Planning-level cost estimates for unit Action
- Programmatic feasibility and siting considerations

Phase 3 Action Fact Sheets are included in Appendix G of Herrera (2024). In Phase 3, updates were made to the original Fact Sheets from Phase 2 (Herrera 2022) to refine Action costs and improve their accuracy and clarity.

## Aggregating Actions into Programs

Actions provide the unit building blocks (or "unit Actions") that are aggregated and combined to develop "Programs," or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. The Programs developed in Phase 3 focus on flow control and include a mix of Actions developed under Phase 2 and Phase 3. Phase 3 Program Fact Sheets can be found in Appendix H of Herrera (2024).

# Action Assumptions and Technical Basis

The key assumptions and technical basis for information included in the Action Fact Sheets are provided below.

## Action Benefits and Areas Managed

Table 1 provides a description for each Action and lists the flow control and water quality treatment benefits provided. The table also summarizes the potential areas managed by the Action, including land uses (e.g., residential, commercial), surface types (e.g., roof, pervious), and property ownership (e.g., public, private) to inform Program development and SUSTAIN modeling.

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| Table 1. Action Description, Benefits, and Area Managed | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Potential Area Managed | | |
| Action | Description | WQBE Phase | Benefits Provided | Land Use | Surface Type | Property Ownership |
| Rain garden | A shallow, landscaped depression with adapted plants, visually similar to bioretention but with compost-amended native soils and no underdrain. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas and to allow stormwater to pass through the amended soil profile. Provides volume and peak flow reduction and water quality treatment. | Developed in Phase 2; costs updated in Phase 3 | • Volume Reduction<br>• Peak Flow Reduction<br>• Water Quality Treatment | • Residential<br>• Commercial | • Roofs<br>• Lawns<br>• Driveways<br>• Sidewalks<br>• Parking Lots | • Private Parcel<br>• Public Parcel |
| Bioretention HPBSM | A shallow earthen depressions with a designed high-performance bioretention soil media (HPBSM) and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system. Provides volume and peak flow reduction and water quality treatment. | Developed in Phase 2; costs updated in Phase 3; Previously named "bioretention" in Phase 2 | • Volume Reduction<br>• Peak Flow Reduction<br>• Water Quality Treatment | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural | • Roofs<br>• Lawn<br>• Driveways<br>• Parking Lots<br>• Sidewalks<br>• Plazas<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way |
| Bioretention HPBSM planter | Similar to bioretention, this Action includes a designed high-performance bioretention soil media (HPBSM) and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants. This Action varies from bioretention in that the sides are vertically contained by walls constructed from formed concrete. These designs are often used in highly-urbanized settings. Provides water quality treatment and peak flow reduction. For this analysis, the Action is assumed to have an underdrain and closed bottom. | Developed in Phase 2; costs updated in Phase 3; Previously named "bioretention planter" in Phase 2 | • Peak Flow Reduction<br>• Water Quality Treatment | • Residential<br>• Commercial<br>• Industrial | • Roofs<br>• Driveways<br>• Parking Lots<br>• Sidewalks<br>• Plazas<br>• Local Roads<br>• Arterial Roads | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way |
| Bioswale | An open, gently sloped, vegetated channel designed for treatment of stormwater. Grass is most common vegetation, but wetland vegetation can be used if soil is saturated. Provides water quality treatment, peak flow reduction, and conveyance. These are designed to "filter" water as it is conveyed through a vegetated swale. While this Action may provide incidental infiltration, that is not the primary treatment mechanism. | Developed in Phase 2; costs updated in Phase 3 | • Peak Flow Reduction<br>• Water Quality Treatment | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural | • Parking Lots<br>• Arterial Roads<br>• Local Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way |
| Media Filter Drain (MFD) | A linear flow-through stormwater treatment device that can be sited along roadway side slopes (conventional design) and medians, borrow ditches, or other linear depressions. Cut-slope applications may also be considered. MFDs have four basic components: a gravel no-vegetation zone, a vegetated filter strip, the MFD mix bed, and an optional gravel-filled underdrain trench or layer of crushed surfacing base course. Treated water is either infiltrated into the underlying soil or collected by an underdrain and discharged to the drainage system. | Developed in Phase 2; costs updated in Phase 3 | • Volume Reduction<br>• Peak Flow Reduction<br>• Water Quality Treatment | • Highway<br>• Agricultural | • Arterial Roads<br>• Local Roads<br>• Highways | • Public Right-of-Way |
| Drywell | A gravel filled hole that conveys stormwater runoff into the soil matrix. Provides volume and peak flow reduction. Pretreatment is required for this Action. | Developed in Phase 2; costs updated in Phase 3 | • Volume Reduction<br>• Peak Flow Reduction | • Residential<br>• Commercial<br>• Industrial<br>• Agricultural | • Roofs<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Lawns | • Private Parcel<br>• Public Parcel |

**Table 1 (continued). Action Description, Benefits, and Area Managed**

| Action | Description | WQBE Phase | Benefits Provided | Potential Area Managed: Land Use | Surface Type | Property Ownership |
|---|---|---|---|---|---|---|
| Deep Underground Injection Control (UIC) Well | A well that extends below an upper confining layer and discharges into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below. This analysis assumes a water-well style UIC downstream of a pre-treatment Action. Provides volume and peak flow reduction. Pretreatment is required for this Action. | Developed in Phase 2; costs updated in Phase 3 | • Volume Reduction<br>• Peak Flow Reduction | • Residential<br>• Commercial | • Roofs<br>• Sidewalks<br>• Lawns<br>• Local Roads<br>• Arterial Roads | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way |
| Permeable pavement | Includes pervious concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material. Intended to allow passage of water through pavement. Provides volume and peak flow reduction. Provides water quality treatment when sand treatment layer is provided. | Developed in Phase 2; costs updated in Phase 3 | • Volume Reduction<br>• Peak Flow Reduction<br>• Water Quality Treatment | • Residential<br>• Commercial | • Low Volume Residential Driveways<br>• Sidewalks<br>• Plazas<br>• Trails<br>• Pedestrian and Bike Paths<br>• Parking Lots | • Private Parcel<br>• Public Parcel<br>• |
| Depaving | Depaving, or removal of impervious surfaces down to bare soil. The area is amended with soil and planted with low lying ground cover. To allow continued site use, the area is retrofit with an alternative treatment (e.g., wheel strip driveways) per King County Surface Water Design Manual, "Reduced Impervious Surface Credit". Provides volume and peak flow reduction. | Developed in Phase 2; costs updated in Phase 3 | • Volume Reduction<br>• Peak Flow Reduction | • Residential<br>• Commercial<br>• Industrial | • Driveways<br>• Sidewalks<br>• Parking Lots | • Private Parcel<br>• Public Parcel<br>• |
| Stormwater treatment wetland | Similar to a wet pond but also provides a shallow marsh area to allow the establishment of emergent wetland aquatic plants, which improves pollutant removal. Provides water quality treatment and peak flow reduction. | Developed in Phase 2; costs updated in Phase 3 | • Peak Flow Reduction<br>• Water Quality Treatment | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural<br>• Forest | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way |
| Detention vault | A box-shaped underground facility that provides temporary storage of stormwater runoff. The stored stormwater runoff is then released through a control structure at an attenuated rate. Provides peak flow reduction. | Developed in Phase 2; costs updated in Phase 3 | • Peak Flow Reduction | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural<br>• Forest | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Plazas<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way |
| Detention pond | A surface basin that provides temporary storage of stormwater runoff. The stored stormwater runoff is then released through a control structure at an attenuated rate, allowing the basin to dry out between storm events. Provides peak flow reduction. | Developed in Phase 2; costs updated in Phase 3 | • Volume Reduction<br>• Peak Flow Reduction | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural<br>• Forest | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way |

**Table 1 (continued). Action Description, Benefits, and Area Managed**

| Action | Description | WQBE Phase | Benefits Provided | Potential Area Managed: Land Use | Surface Type | Property Ownership |
|---|---|---|---|---|---|---|
| Infiltration pond | A surface basin that temporarily stores stormwater runoff similar to a detention pond, but also provides infiltration. Provides volume and peak flow reduction. Pretreatment is required for this Action. | Developed in Phase 2; costs updated in Phase 3 | • Volume Reduction<br>• Peak Flow Reduction | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural<br>• Forest | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way |
| Infiltration vault | An open bottomed, box-shaped underground facility that stores stormwater runoff similar to detention vaults, but also provides infiltration via an open bottom. Provides volume reduction and peak flow reduction. Pretreatment is required for this Action. | Developed in Phase 2; costs updated in Phase 3 | • Volume Reduction<br>• Peak Flow Reduction | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural<br>• Forest | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Plazas<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way |
| Cistern | A tank designed to provide temporary storage and slow release of rooftop stormwater runoff. Provides peak flow reduction. | Developed in Phase 2; costs updated in Phase 3 | • Peak Flow Reduction | • Residential<br>• Commercial<br>• Industrial | • Roofs | • Private Parcel<br>• Public Parcel |
| Wetpond | A constructed stormwater pond that retains a permanent pool of water ("wetpool"), at least during the wet season, for settling of particulate pollutants. Provides water quality treatment and peak flow reduction. | Developed in Phase 2; costs updated in Phase 3 | • Peak Flow Reduction<br>• Water Quality Treatment | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural<br>• Forest | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way |
| Wetvault | An underground structure similar to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants. Provides water quality treatment and peak flow reduction. | Developed in Phase 2; costs updated in Phase 3 | • Peak Flow Reduction<br>• Water Quality Treatment | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural<br>• Forest | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Plazas<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way |

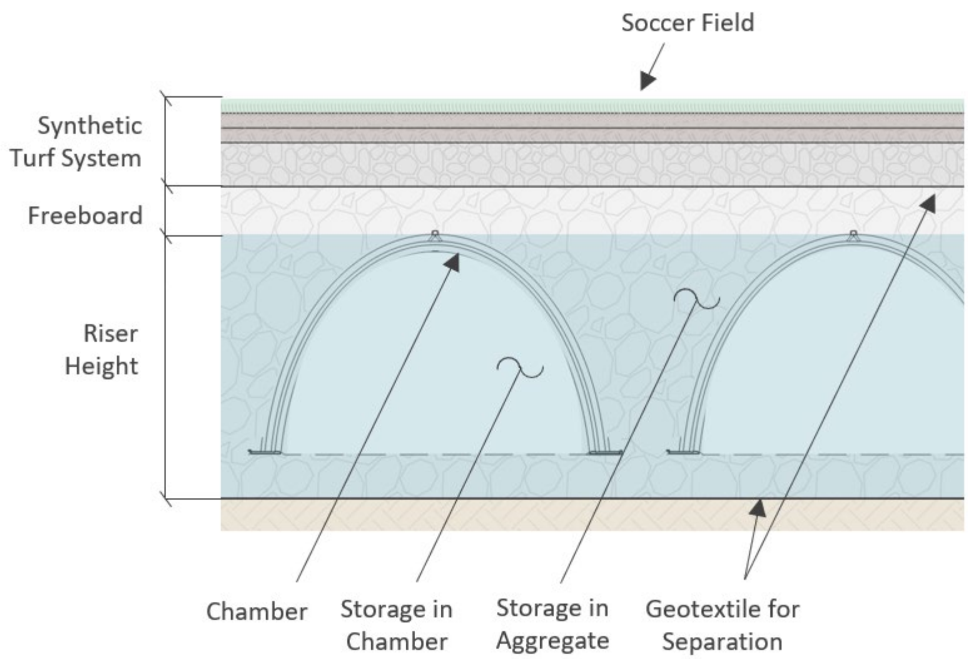
**Table 1 (continued). Action Description, Benefits, and Area Managed**

| Action | Description | WQBE Phase | Benefits Provided | Potential Area Managed: Land Use | Potential Area Managed: Surface Type | Potential Area Managed: Property Ownership |
|---|---|---|---|---|---|---|
| High-rate underground filter system | An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in highly urbanized settings and may be proprietary. Provides water quality treatment. | Developed in Phase 2; costs updated in Phase 3 | • Water Quality Treatment | • Commercial<br>• Industrial<br>• Highway | • Roofs<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Plazas<br>• Local Roads<br>• Arterial Roads | • Private Parcel<br>• Public Parcel<br>• Public Right-of-Way |
| Stormwater park (water quality treatment) | A large-scale vegetated media filtration facility designed to treat stormwater runoff from a large drainage area. Provides water quality treatment through a Filterra® treatment media. | Developed in Phase 2; costs updated in Phase 3; Previously named "Regional stormwater treatment facility" in Phase 2 | • Water Quality Treatment | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural<br>• Forest | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Plazas<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel |
| Sports field and park detention | Subsurface storage at existing sport field or park to provide flow control while preserving recreational site use. An underground chamber array will detain the water draining from the overlying area and offsite contributing drainage area. The stored stormwater runoff is released through a control structure at an attenuated rate. | Developed in Phase 3 | • Peak Flow Reduction | • Residential<br>• Commercial<br>• Industrial<br>• Highway<br>• Agricultural<br>• Forest | • Roofs<br>• Lawns<br>• Sidewalks<br>• Driveways<br>• Parking Lots<br>• Plazas<br>• Local Roads<br>• Arterial Roads<br>• Highways | • Private Parcel<br>• Public Parcel |
| Blue roof | Rooftop detention designed to provide temporary storage and slow release of stormwater runoff. This technique is most commonly used in dense urban areas where other methods of stormwater detention are impractical. | Developed in Phase 3 | • Peak Flow Reduction | • Commercial<br>• Industrial | • Roofs | • Private Parcel<br>• Public Parcel |
| Compost amendment | Amending existing pervious surfaces with compost to increase water holding capacity. | Developed in Phase 3 | • Volume Reduction<br>• Peak Flow Reduction | • Residential<br>• Commercial<br>• Industrial | • Lawns | • Private Parcel<br>• Public Parcel |
| Reforest High Density Development | Converting existing impervious surfaces and buildings to forest. | Developed in Phase 3 | • Volume Reduction<br>• Peak Flow Reduction | • Commercial<br>• Industrial | • Parking lots<br>• Walkways<br>• Driveways<br>• Buildings<br>• Lawn | • Private Parcel<br>• Public Parcel |
| Reforest Pervious Area | Converting pervious surfaces to forest. | Developed in Phae 3 | • Volume Reduction<br>• Peak Flow Reduction | • Residential | • Lawn | • Private Parcel |

## Action Design

Table 2 provides the design basis and major assumptions for the new Flow Control Actions developed in Phase 3. These assumptions impact Action performance, cost, and feasibility. For some Actions, schematics are provided to illustrate the section and dimensions (see Figure 1 for example).

**Figure 1. Unit Action Schematic for Sports Field and Park Detention.**




The design basis for Actions originally developed under Phase 2 are provided in Appendix B of Herrera (2024).

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**Table 2. Representative Design and Assumptions for New Phase 3 Flow Control Actions.**

| Action | Design Basis/Assumptions | Notes |
|---|---|---|
| Sports field and park detention | • Representative Action assumes an array of subsurface storage chambers under one half of a standard soccer field to detain water draining from the overlying area and offsite contributing drainage area. Implementation also includes:<br>o ADS StormTech Chamber (SC-740) array<br>o Field restoration with artificial turf and paint<br>o Conveyance from upstream drainage area and to downstream drainage system<br>• No infiltration to underlying soil<br>• No additional site improvements (e.g., lighting, seating) are included<br>• No property acquisition | • Artificial turf was used to increase the potential for participation/partnering. Costs for natural turf would be lower.<br>• Storage chamber model (SC-740) is relatively shallow and selected to increase feasibility and allow for downstream tie in.<br>• Facility assumed to be non-infiltrating to increase feasibility (i.e., can be sited where infiltration is not feasible). However, an open bottom configuration sited in infiltrating soil would allow for a larger offsite drainage area and be more cost effective.<br>• See Attachment A for concept plan and section.<br>• See Attachment B for ADS StormTech Chamber (SC-740) array specifications. |
| Blue roof | • Representative Action assumes retrofitting an existing flat roof (with parapet) to provide up to 4 inches of storage. Implementation includes:<br>o Waterproof lining installed<br>o Roof drainage reconfigured to direct runoff from 1,000 sf to control structure at roof drain<br>o HVAC/utilities on roof raised 6 inches<br>o Control structure has 0.25-inch orifice and redundant overflow with protective screening (e.g., sand filter to protect orifice from clogging)<br>• Building does not require structural upgrades<br>• No property acquisition | • Assumes simple blue roof design with roof sub areas draining to multiple orifice-controlled discharge points. Other blue roof configurations can include check dams across the roofs deck, modular tray systems, hybrid green/blue roofs, and water harvesting for reuse. |
| Compost amendment | • Representative Action assumes amending soil under existing lawn surfaces and revegetating with turf. Implementation includes:<br>o Remove lawn vegetation and scarify (loosen) subgrade to 8 inches depth<br>o Place 1.75 inches of compost and rototill into 6.25 inches of soil (a total amended depth of about 9.5 inches, for a settled depth of 8 inches)<br>o Scarify (loosen) subsoil 4 inches below the amended layer to produce a 12-inch depth of uncompacted soil<br>o Water or roll to compact to 85% of maximum dry density<br>o Rake to level and remove surface woody debris and rocks larger than 1 inch diameter<br>o Revegetate with turf lawn (not seeded) | • Design is based on Washington State Department of Ecology's "Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13" Option 2 (amending existing site soil or subsoil). |
| Reforest High Density Development | • Representative Action assumes replacing a typical strip mall building and parking lot with forest. Implementation includes:<br>o Property acquisition, if on private property<br>o Demolish/remove structure and parking lot surface<br>o Scarify subsoil to 6" depth and place 18 inches of topsoil type A<br>o Plant multi-layer native plant communities and trees<br>o Build simple trail through forested area and install signage<br>o Maintain plants during 3-year plant establishment period<br>• Assumes one acre parcel coverage is 60% parking and 40% structure | • The existing land condition is assumed to be a typical strip mall. If a less impervious parcel type was selected, the costs would be lower and the hydrologic and treatment performance would be reduced. |
| Reforest Pervious Area | • Representative Action assumes replacing a pervious area with forest. Implementation includes:<br>o Scarify subsoil to 6" depth and place 18 inches of topsoil type A<br>o Plant multi-layer native plant communities and trees<br>o Maintain plants during 3-year plant establishment period | • The existing land condition is assumed to be pervious areas on residential property. |

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## Action Sizing and Performance

Table 3 summarizes the sizing and performance of the Phase 3 Flow Control Actions, including the basis of Action sizing, the size of the unit Action (i.e., footprint area), the size of the contributing drainage area, and how hydrologic (flow control) and treatment performance is represented in the SUSTAIN model.

### Sports Field and Park Detention Sizing and Performance

The unit area for the sports field and park detention Action was assumed to be half of a standard soccer field (29,600 square feet). The Action includes an array of model SC-740 ADS StormTech Chambers to provide subsurface storage and detention under the field. The space between and around the chambers is filled with aggregate. Detention storage is provided in both the open chamber areas and within the interstices of the aggregate (see Figure 1). Therefore, the storage capacity varies by stage and was modeled using a stage-storage-discharge table (FTABLE).

The maximum off-site contributing impervious area that could be routed to the unit was evaluated using MGSFlood Version 4.58 using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step. The drainage area was maximized while meeting the King County Surface Water Design Manual (KCSWDM) (King County 2021) Level 2 Flow Control standard for both the field and offsite areas. This standard requires matching:

- developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50 percent of the 2-year peak flow up to the full 50-year peak flow, and
- developed peak discharge rates to predeveloped peak discharge rates for the 2- and 10-year return periods.

A till forested historic site condition was assumed. While some areas in the WQBE target basins have different predeveloped conditions, this sizing basis was used for all areas. Therefore, the facility sizes will overperform in some locations (i.e., areas with outwash soil or a predeveloped pasture condition).

Based on this modeling, it was determined that the maximum offsite impervious area that can be managed using this unit Action is 76,230 square feet, for a total of 103,800 square feet (29,600 SF overlying field + 74,200 SF offsite drainage area).

A table of design and modeling parameters (including orifice sizing) is provided in the Action Fact Sheet (see Appendix G of Herrera 2024).

### Blue Roof

Simple blue roof configurations were modeled using MGSFlood to assess potential performance. It was assumed that the most likely design configuration would involve roof sub areas draining to multiple discharge points on a roof, each controlled by a 0.25-inch diameter orifice (the minimum allowed per the KCSWDM). It was determined that the King County flow control performance standards could not be achieved for these smaller contributing areas due to orifice sizing limitations. So, the Core Team evaluated a range of contributing areas to crudely optimize performance for a 0.25-inch orifice and a unit Action area of 1,000 square feet of roof was selected.

### Compost Amendment

The compost amendment Action assumes amendment of soil under existing lawn and revegetating with turf settled depth of 8 inches. The Action is represented as a 500 square foot unit with a depth of 8 inches. A table of design and modeling parameters and assumptions is provided in the Action Fact Sheet (see Appendix G of Herrera 2024).

### Reforest High Density Development and Reforest Pervious Area

Reforest high density development and reforest pervious area Actions are represented in the SUSTAIN model by converting the existing surface type to forest over the underlying soil type (till or outwash). The flow control and treatment performance will be based on the different hydrologic and pollutant loading characteristics of the new surface type.

**Table 3 Sizing and Performance Basis for New Phase 3 Flow Control Actions.**

| Action | Sizing Method and Flow Control Performance Standard | Unit Action Size (Footprint) | Contributing Drainage Area | SUSTAIN Model Representation | |
|---|---|---|---|---|---|
| | | | | Flow Control | Treatment |
| Sports field and park detention | Sized for KCSWDM Level 2 Flow Control standard assuming pre-developed till forest condition | 29,600 SF | 103,800 SF<br>(29,600 SF overlying field +<br>74,200 SF offsite drainage area) | Stage-storage-discharge routing (FTABLE). Not feasible to model explicitly in SUSTAIN because storage capacity varies by stage. See Attachment C for modeling assumptions and Ftable. | Water that flows through the orifice will be assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. While not designed for treatment, there will be some pollutant removal via sedimentation. See Treatment Performance Parameter table in Action Fact Sheet for median percent removal and median effluent concentration for several target pollutants. Parameters are based on detention pond and vault treatment performance which provide similar unit processes for pollutant removal. |
| Blue roof | Cannot achieve flow control performance standards; unit area crudely optimized for 0.25-inch orifice control | 1,000 SF | N/A | Model explicitly represents ponding, orifice flow, and overflow. | Action provides negligible treatment. |
| Compost amendment | Not sized | 500 SF | N/A | Model explicitly represents the amended soil depth and porosity, native soil infiltration rate, and overflow. | All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. |
| Reforest High Intensity Development | Not sized | 1 acre | N/A | Model converts the surface type from existing impervious surface to forest over underlying soil type (i.e., till or outwash). Action is modeled as a mature forest. However, hydrologic benefits of reforestation would increase over time as the trees and understory become mature. | Pollutant loads will be reduced due to the differences in pollutant concentrations and runoff volumes from the change in surface type (i.e., existing surface to forest). |
| Reforest Pervious Area | Not sized | 1 acre | N/A | Model converts the surface type from existing pervious surface to forest over underlying soil type (i.e., till or outwash). Action is modeled as a mature forest. However, hydrologic benefits of reforestation would increase over time as the trees and understory become mature. | Pollutant loads will be reduced due to the differences in pollutant concentrations and runoff volumes from the change in surface type (i.e., existing surface to forest). |

N/A – not applicable

SF – square feet

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## Action Feasibility and Siting

The feasibility and siting considerations for each Action are provided in the Action Fact Sheets (see Appendix G of Herrera 2024). These include both technical feasibility considerations for applying the Actions across the drainage areas (e.g., available space, slope conditions) and participation considerations (e.g., ability to engage willing partners and private property owners).

The Action feasibility and siting considerations informed the Action implementation factors developed for Programs (Herrera 2024).

## Action Costs

The Action Fact Sheets provide the Unit Action cost components. In Phase 3, the Action costs were refined to reflect a simplified costing approach and better meet the County's needs; hence, the basis of estimate documentation was updated in HDR and Herrera (2024).

The Unit Action costs include the total project cost which are equal to the sum of total direct construction costs and total indirect non-construction costs, annual operation and maintenance costs, and property acquisition costs. The property acquisition costs are itemized separately but included in the total indirect non-construction costs. The property acquisition costs are included for the Actions that likely require property acquisition if implemented on private property. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The Action Fact Sheets display the medium acquisition costs (Appendix G of Herrera 2024). The basis of estimate documentation provides details on the different cost categories for property acquisition costs (HDR and Herrera 2024).

# Key Limitations and Future Considerations

This document provides an overview of the assumptions and technical basis for the Phase 3 Action Fact Sheet content; these assumptions generally apply to the Phase 2 Actions as well. Below is a summary of key limitations of this work and considerations for future work.

- To simplify modeling, a representative design was developed for each Action and assumed to be appliable county-wide. In fact, Action design would vary based on site conditions and stakeholder interests. The representative design selected impacts Action performance, costs, and feasibility. Design modifications could be explored to evaluate tradeoffs. For example, adjustments could be made to make an Action more cost effective, but that could reduce overall feasibility.
- Consider adjusting Action to account for climate change (e.g., sizing Actions using a precipitation series that is perturbed for a future climate year).
- Consider developing additional Actions identified under previous WQBE brainstorming workshops (tree planting in the right of way, floodplain storage, high-flow bypass (tightline of stormwater to bottom of watershed), sand filters, creosote wood piling removal, and enhanced street sweeping).

# References


HDR and Herrera. 2024. Phase 3 Unit Cost Basis for Water Quality Benefits Evaluation (Appendix G to 439-TM1). Technical Memorandum prepared for King County Wastewater Treatment Division by HDR Engineering, Inc. March.

Herrera. 2022. Water Quality Benefits Evaluation – Phase 2 Action and Program Factsheet Development (431-TM1). Prepared for King County Water and Land Resources Division by Herrera Environmental Consultants. May.

Herrera. 2023. Proposed Flow Control Actions and Programs Assessment (TM #438-TM1). Prepared for King County Wastewater Treatment Division by Herrera Environmental Consultants, Inc., Seattle, Washington.

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King County. 2021. Surface Water Design Manual. Department of Natural Resources and Parks.

Paradigm and Herrera. 2022. Water Quality Benefits Evaluation – Phase 2 SUSTAIN Model Development (821-TM1). Prepared for King County Water and Land Resources Division by Paradigm Environmental and Herrera Environmental Consultants. December.

# Attachment A

## Stormwater Field and Park Detention Concept Plan and Section

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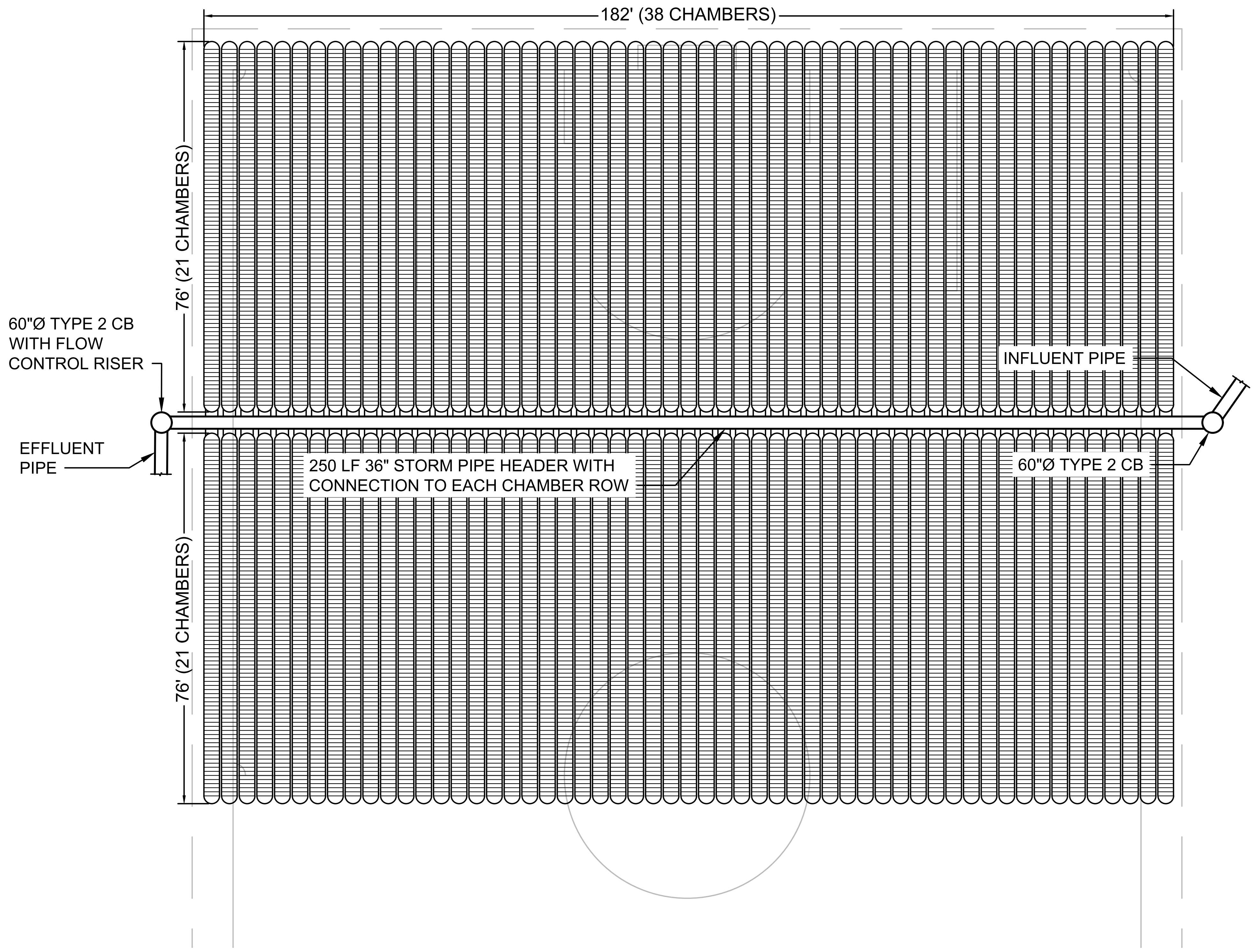
# Figure A1
# Sports Field Detention Action




## PLAN

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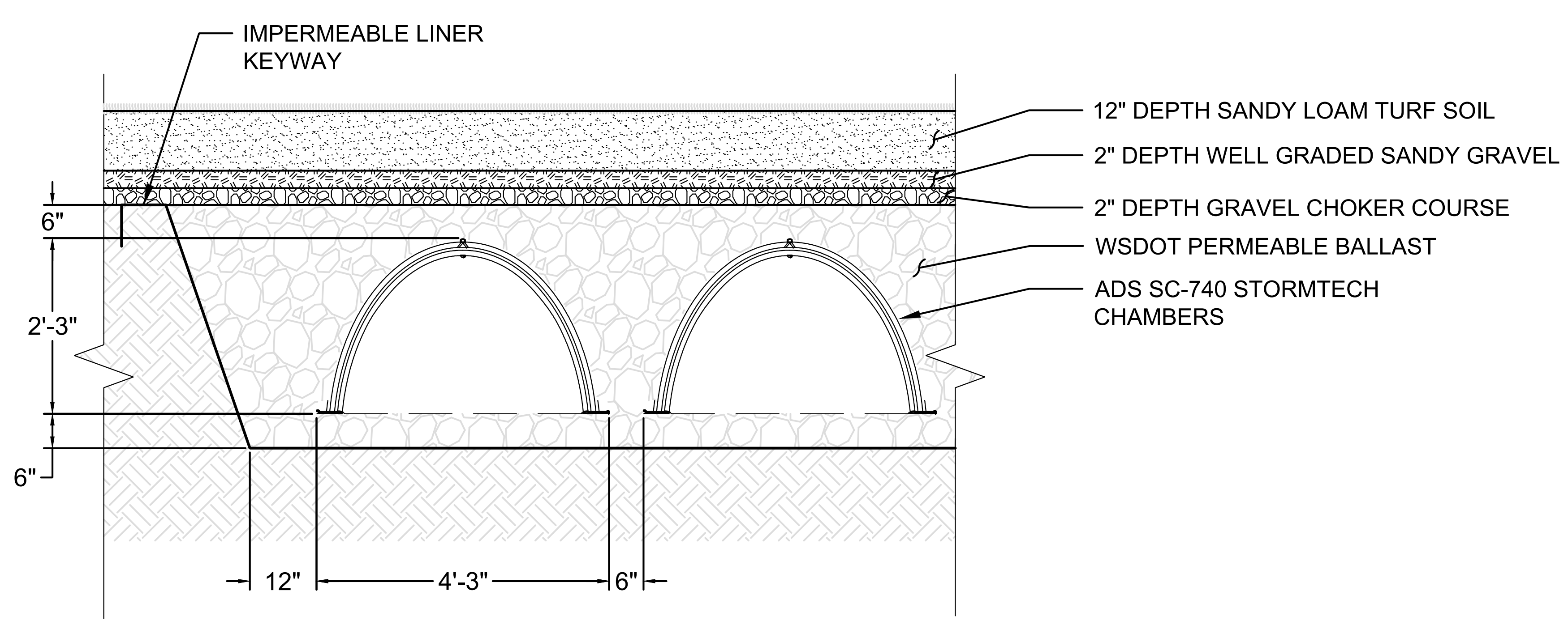


## SECTION

SCALE: NONE

# Attachment B

## ADS StormTech Chamber (SC-740) Array Specifications

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Advanced Drainage Systems, Inc.

ADS SiteAssist
FOR STORMTECH INSTALLATION INSTRUCTIONS VISIT OUR APP

## SC-740 STORMTECH CHAMBER SPECIFICATIONS

1. CHAMBERS SHALL BE STORMTECH SC-740.
2. CHAMBERS SHALL BE ARCH-SHAPED AND SHALL BE MANUFACTURED FROM VIRGIN, IMPACT-MODIFIED POLYPROPYLENE COPOLYMERS.
3. CHAMBERS SHALL MEET THE REQUIREMENTS OF ASTM F2418, "STANDARD SPECIFICATION FOR POLYPROPYLENE (PP) CORRUGATED WALL STORMWATER COLLECTION CHAMBERS".
4. CHAMBER ROWS SHALL PROVIDE CONTINUOUS, UNOBSTRUCTED INTERNAL SPACE WITH NO INTERNAL SUPPORTS THAT WOULD IMPEDE FLOW OR LIMIT ACCESS FOR INSPECTION.
5. THE STRUCTURAL DESIGN OF THE CHAMBERS, THE STRUCTURAL BACKFILL, AND THE INSTALLATION REQUIREMENTS SHALL ENSURE THAT THE LOAD FACTORS SPECIFIED IN THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS, SECTION 12.12, ARE MET FOR: 1) LONG-DURATION DEAD LOADS AND 2) SHORT-DURATION LIVE LOADS, BASED ON THE AASHTO DESIGN TRUCK WITH CONSIDERATION FOR IMPACT AND MULTIPLE VEHICLE PRESENCES.
6. CHAMBERS SHALL BE DESIGNED, TESTED AND ALLOWABLE LOAD CONFIGURATIONS DETERMINED IN ACCORDANCE WITH ASTM F2787, "STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS". LOAD CONFIGURATIONS SHALL INCLUDE: 1) INSTANTANEOUS (<1 MIN) AASHTO DESIGN TRUCK LIVE LOAD ON MINIMUM COVER 2) MAXIMUM PERMANENT (75-YR) COVER LOAD AND 3) ALLOWABLE COVER WITH PARKED (1-WEEK) AASHTO DESIGN TRUCK.
7. REQUIREMENTS FOR HANDLING AND INSTALLATION:
   - TO MAINTAIN THE WIDTH OF CHAMBERS DURING SHIPPING AND HANDLING, CHAMBERS SHALL HAVE INTEGRAL, INTERLOCKING STACKING LUGS.
   - TO ENSURE A SECURE JOINT DURING INSTALLATION AND BACKFILL, THE HEIGHT OF THE CHAMBER JOINT SHALL NOT BE LESS THAN 2".
   - TO ENSURE THE INTEGRITY OF THE ARCH SHAPE DURING INSTALLATION, a) THE ARCH STIFFNESS CONSTANT SHALL BE GREATER THAN OR EQUAL TO 550 LBS/FT/%. THE ASC IS DEFINED IN SECTION 6.2.8 OF ASTM F2418. AND b) TO RESIST CHAMBER DEFORMATION DURING INSTALLATION AT ELEVATED TEMPERATURES (ABOVE 73° F / 23° C), CHAMBERS SHALL BE PRODUCED FROM REFLECTIVE GOLD OR YELLOW COLORS.
8. ONLY CHAMBERS THAT ARE APPROVED BY THE SITE DESIGN ENGINEER WILL BE ALLOWED. UPON REQUEST BY THE SITE DESIGN ENGINEER OR OWNER, THE CHAMBER MANUFACTURER SHALL SUBMIT A STRUCTURAL EVALUATION FOR APPROVAL BEFORE DELIVERING CHAMBERS TO THE PROJECT SITE AS FOLLOWS:
   - THE STRUCTURAL EVALUATION SHALL BE SEALED BY A REGISTERED PROFESSIONAL ENGINEER.
   - THE STRUCTURAL EVALUATION SHALL DEMONSTRATE THAT THE SAFETY FACTORS ARE GREATER THAN OR EQUAL TO 1.95 FOR DEAD LOAD AND 1.75 FOR LIVE LOAD, THE MINIMUM REQUIRED BY ASTM F2787 AND BY SECTIONS 3 AND 12.12 OF THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS FOR THERMOPLASTIC PIPE.
   - THE TEST DERIVED CREEP MODULUS AS SPECIFIED IN ASTM F2418 SHALL BE USED FOR PERMANENT DEAD LOAD DESIGN EXCEPT THAT IT SHALL BE THE 75-YEAR MODULUS USED FOR DESIGN.
9. CHAMBERS AND END CAPS SHALL BE PRODUCED AT AN ISO 9001 CERTIFIED MANUFACTURING FACILITY.

## IMPORTANT - NOTES FOR THE BIDDING AND INSTALLATION OF THE SC-740 SYSTEM

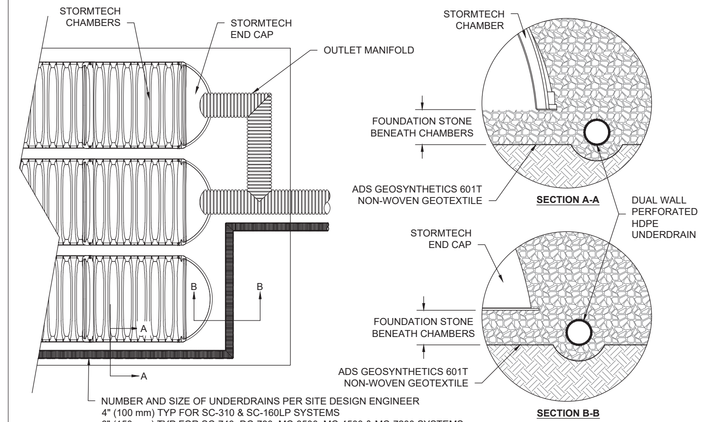
1. STORMTECH SC-740 CHAMBERS SHALL NOT BE INSTALLED UNTIL THE MANUFACTURER'S REPRESENTATIVE HAS COMPLETED A PRE-CONSTRUCTION MEETING WITH THE INSTALLERS.
2. STORMTECH SC-740 CHAMBERS SHALL BE INSTALLED IN ACCORDANCE WITH THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE".
3. CHAMBERS ARE NOT TO BE BACKFILLED WITH A DOZER OR AN EXCAVATOR SITUATED OVER THE CHAMBERS. STORMTECH RECOMMENDS 3 BACKFILL METHODS:
   - STONESHOOTER LOCATED OFF THE CHAMBER BED.
   - BACKFILL AS ROWS ARE BUILT USING AN EXCAVATOR ON THE FOUNDATION STONE OR SUBGRADE.
   - BACKFILL FROM OUTSIDE THE EXCAVATION USING A LONG BOOM HOE OR EXCAVATOR.
4. THE FOUNDATION STONE SHALL BE LEVELED AND COMPACTED PRIOR TO PLACING CHAMBERS.
5. JOINTS BETWEEN CHAMBERS SHALL BE PROPERLY SEATED PRIOR TO PLACING STONE.
6. MAINTAIN MINIMUM - 6" (150 mm) SPACING BETWEEN THE CHAMBER ROWS.
7. EMBEDMENT STONE SURROUNDING CHAMBERS MUST BE A CLEAN, CRUSHED, ANGULAR STONE 3/4-2" (20-50 mm).
8. THE CONTRACTOR MUST REPORT ANY DISCREPANCIES WITH CHAMBER FOUNDATION MATERIALS BEARING CAPACITIES TO THE SITE DESIGN ENGINEER.
9. ADS RECOMMENDS THE USE OF "FLEXSTORM CATCH IT" INSERTS DURING CONSTRUCTION FOR ALL INLETS TO PROTECT THE SUBSURFACE STORMWATER MANAGEMENT SYSTEM FROM CONSTRUCTION SITE RUNOFF.

## NOTES FOR CONSTRUCTION EQUIPMENT

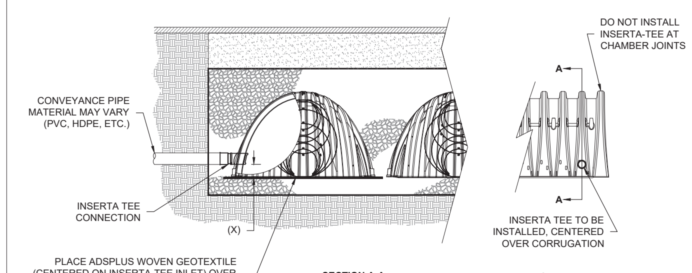
1. STORMTECH SC-740 CHAMBERS SHALL BE INSTALLED IN ACCORDANCE WITH THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE".
2. THE USE OF CONSTRUCTION EQUIPMENT OVER SC-740 CHAMBERS IS LIMITED:
   - NO EQUIPMENT IS ALLOWED ON BARE CHAMBERS.
   - NO RUBBER TIRED LOADERS, DUMP TRUCKS, OR EXCAVATORS ARE ALLOWED UNTIL PROPER FILL DEPTHS ARE REACHED IN ACCORDANCE WITH THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE".
   - WEIGHT LIMITS FOR CONSTRUCTION EQUIPMENT CAN BE FOUND IN THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE".
3. FULL 36" (900 mm) OF STABILIZED COVER MATERIALS OVER THE CHAMBERS IS REQUIRED FOR DUMP TRUCK TRAVEL OR DUMPING.

**USE OF A DOZER TO PUSH EMBEDMENT STONE BETWEEN THE ROWS OF CHAMBERS MAY CAUSE DAMAGE TO THE CHAMBERS AND IS NOT AN ACCEPTABLE BACKFILL METHOD. ANY CHAMBERS DAMAGED BY THE "DUMP AND PUSH" METHOD ARE NOT COVERED UNDER THE STORMTECH STANDARD WARRANTY.**

CONTACT STORMTECH AT 1-888-892-2694 WITH ANY QUESTIONS ON INSTALLATION REQUIREMENTS OR WEIGHT LIMITS FOR CONSTRUCTION EQUIPMENT.



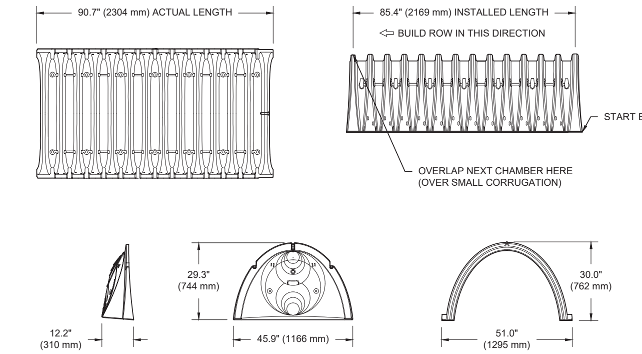

5 UNDERDRAIN DETAIL




NOTES:
- PART NUMBERS WILL VARY BASED ON INLET PIPE MATERIALS. CONTACT STORMTECH FOR MORE INFORMATION.
- CONTACT ADS ENGINEERING SERVICES IF INSERTA TEE INLET MUST BE RAISED AS NOT ALL INVERTS ARE POSSIBLE.

| CHAMBER | MAX DIAMETER OF INSERTA TEE | HEIGHT FROM BASE OF CHAMBER (X) |
|---|---|---|
| SC-310 | 6" (150 mm) | 4" (100 mm) |
| SC-740 | 10" (250 mm) | 4" (100 mm) |
| DC-780 | 10" (250 mm) | 4" (100 mm) |
| MC-3500 | 12" (300 mm) | 6" (150 mm) |
| MC-4500 | 12" (300 mm) | 8" (200 mm) |
| MC-7200 | 12" (300 mm) | 8" (200 mm) |
| INSERTA TEE FITTINGS AVAILABLE FOR SDR 26, SDR 35, SCH 40 IPS GASKETED & SOLVENT WELD, N-12, HP STORM, C-900 OR DUCTILE IRON | | |

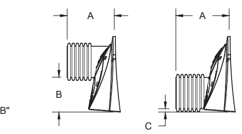
6 INSERTA-TEE SIDE INLET DETAIL




**NOMINAL CHAMBER SPECIFICATIONS**

| | | |
|---|---|---|
| SIZE (W X H X INSTALLED LENGTH) | 51.0" X 30.0" X 85.4" | (1295 mm X 762 mm X 2169 mm) |
| CHAMBER STORAGE | 45.9 CUBIC FEET | (1.30 m³) |
| MINIMUM INSTALLED STORAGE* | 74.9 CUBIC FEET | (2.12 m³) |
| WEIGHT | 75.0 lbs. | (33.6 kg) |

*ASSUMES 6" (152 mm) STONE ABOVE, BELOW, AND BETWEEN CHAMBERS




PRE-FAB STUB AT BOTTOM OF END CAP WITH FLAMP END WITH "BR"
PRE-FAB STUBS AT BOTTOM OF END CAP FOR PART NUMBERS ENDING WITH "B"
PRE-FAB STUBS AT TOP OF END CAP FOR PART NUMBERS ENDING WITH "T"
PRE-CORED END CAPS END WITH "PC"

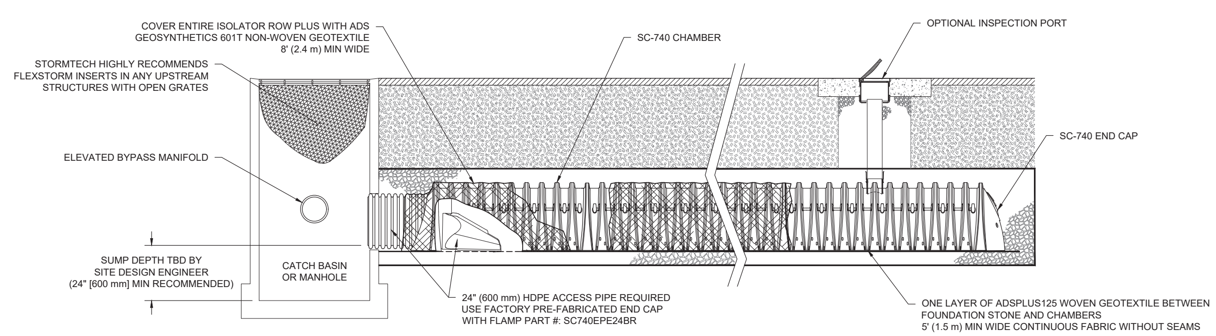
| PART # | STUB | A | B | C |
|---|---|---|---|---|
| SC740EPE06T / SC740EPE06TPC | 6" (150 mm) | 10.9" (277 mm) | 18.5" (470 mm) | --- |
| SC740EPE06B / SC740EPE06BPC | | | --- | 0.5" (13 mm) |
| SC740EPE08T /SC740EPE08TPC | 8" (200 mm) | 12.2" (310 mm) | 16.5" (419 mm) | --- |
| SC740EPE08B / SC740EPE08BPC | | | --- | 0.6" (15 mm) |
| SC740EPE10T / SC740EPE10TPC | 10" (250 mm) | 13.4" (340 mm) | 14.5" (368 mm) | --- |
| SC740EPE10B / SC740EPE10BPC | | | --- | 0.7" (18 mm) |
| SC740EPE12T / SC740EPE12TPC | 12" (300 mm) | 14.7" (373 mm) | 12.5" (318 mm) | --- |
| SC740EPE12B / SC740EPE12BPC | | | --- | 1.2" (30 mm) |
| SC740EPE15T / SC740EPE15TPC | 15" (375 mm) | 18.4" (467 mm) | 9.0" (229 mm) | --- |
| SC740EPE15B / SC740EPE15BPC | | | --- | 1.3" (33 mm) |
| SC740EPE18T / SC740EPE18TPC | 18" (450 mm) | 19.7" (500 mm) | 5.0" (127 mm) | --- |
| SC740EPE18B / SC740EPE18BPC | | | --- | 1.6" (41 mm) |
| SC740EPE24B* | 24" (600 mm) | 18.5" (470 mm) | --- | 0.1" (3 mm) |
| SC740EPE24BR* | 24" (600 mm) | 18.5" (470 mm) | --- | 0.1" (3 mm) |

ALL STUBS, EXCEPT FOR THE SC740EPE24B/SC740EPE24BR ARE PLACED AT BOTTOM OF END CAP SUCH THAT THE OUTSIDE DIAMETER OF THE STUB IS FLUSH WITH THE BOTTOM OF THE END CAP. FOR ADDITIONAL INFORMATION CONTACT STORMTECH AT 1-888-892-2694.

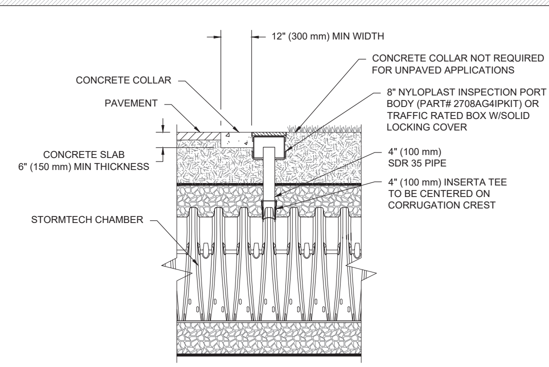
* FOR THE SC740EPE24B/SC740EPE24BR THE 24" (600 mm) STUB LIES BELOW THE BOTTOM OF THE END CAP APPROXIMATELY 1.75" (44 mm). BACKFILL MATERIAL SHOULD BE REMOVED FROM BELOW THE N-12 STUB SO THAT THE FITTING SITS LEVEL.

NOTE: ALL DIMENSIONS ARE NOMINAL

2 SC-740 TECHNICAL SPECIFICATIONS




3 SC-740 ISOLATOR ROW PLUS DETAIL




NOTE:
INSPECTION PORTS MAY BE CONNECTED THROUGH ANY CHAMBER CORRUGATION CREST.

4 4" PVC INSPECTION PORT DETAIL (SC SERIES CHAMBER)

## INSPECTION & MAINTENANCE

STEP 1) INSPECT ISOLATOR ROW PLUS FOR SEDIMENT
- A. INSPECTION PORTS (IF PRESENT)
  - A.1. REMOVE/OPEN LID ON NYLOPLAST INLINE DRAIN
  - A.2. REMOVE AND CLEAN FLEXSTORM FILTER IF INSTALLED
  - A.3. USING A FLASHLIGHT AND STADIA ROD, MEASURE DEPTH OF SEDIMENT AND RECORD ON MAINTENANCE LOG
  - A.4. LOWER A CAMERA INTO ISOLATOR ROW PLUS FOR VISUAL INSPECTION OF SEDIMENT LEVELS (OPTIONAL)
  - A.5. IF SEDIMENT IS AT, OR ABOVE, 3" (80 mm) PROCEED TO STEP 2. IF NOT, PROCEED TO STEP 3.
- B. ALL ISOLATOR PLUS ROWS
  - B.1. REMOVE COVER FROM STRUCTURE AT UPSTREAM END OF ISOLATOR ROW PLUS
  - B.2. USING A FLASHLIGHT, INSPECT DOWN THE ISOLATOR ROW PLUS THROUGH OUTLET PIPE
    - i) MIRRORS ON POLES OR CAMERAS MAY BE USED TO AVOID A CONFINED SPACE ENTRY
    - ii) FOLLOW OSHA REGULATIONS FOR CONFINED SPACE ENTRY IF ENTERING MANHOLE
  - B.3. IF SEDIMENT IS AT, OR ABOVE, 3" (80 mm) PROCEED TO STEP 2. IF NOT, PROCEED TO STEP 3.

STEP 2) CLEAN OUT ISOLATOR ROW PLUS USING THE JETVAC PROCESS
- A. A FIXED CULVERT CLEANING NOZZLE WITH REAR FACING SPREAD OF 45" (1.1 m) OR MORE IS PREFERRED
- B. APPLY MULTIPLE PASSES OF JETVAC UNTIL BACKFLUSH WATER IS CLEAN
- C. VACUUM STRUCTURE SUMP AS REQUIRED

STEP 3) REPLACE ALL COVERS, GRATES, FILTERS, AND LIDS; RECORD OBSERVATIONS AND ACTIONS.

STEP 4) INSPECT AND CLEAN BASINS AND MANHOLES UPSTREAM OF THE STORMTECH SYSTEM.

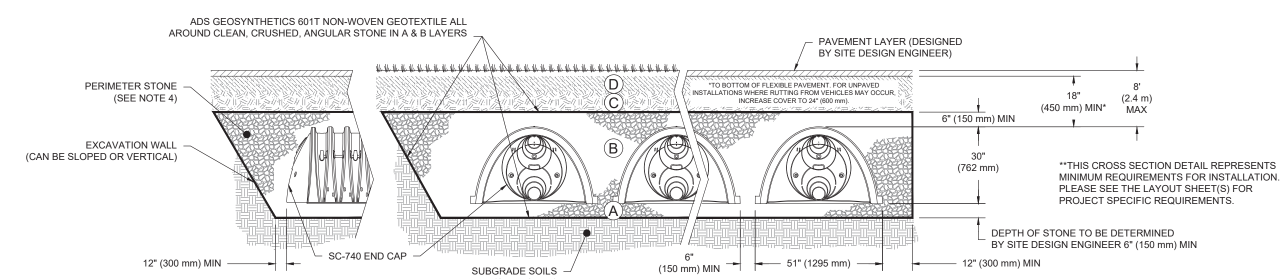
## NOTES

1. INSPECT EVERY 6 MONTHS DURING THE FIRST YEAR OF OPERATION. ADJUST THE INSPECTION INTERVAL BASED ON PREVIOUS OBSERVATIONS OF SEDIMENT ACCUMULATION AND HIGH WATER ELEVATIONS.
2. CONDUCT JETTING AND VACTORING ANNUALLY OR WHEN INSPECTION SHOWS THAT MAINTENANCE IS NECESSARY.

## ACCEPTABLE FILL MATERIALS: STORMTECH SC-740 CHAMBER SYSTEMS

| MATERIAL LOCATION | | DESCRIPTION | AASHTO MATERIAL CLASSIFICATIONS | COMPACTION / DENSITY REQUIREMENT |
|---|---|---|---|---|
| D | **FINAL FILL:** FILL MATERIAL FOR LAYER 'D' STARTS FROM THE TOP OF THE 'C' LAYER TO THE BOTTOM OF FLEXIBLE PAVEMENT OR UNPAVED FINISHED GRADE ABOVE. NOTE THAT PAVEMENT SUBBASE MAY BE PART OF THE 'D' LAYER. | ANY SOIL/ROCK MATERIALS, NATIVE SOILS, OR PER ENGINEER'S PLANS. CHECK PLANS FOR PAVEMENT SUBGRADE REQUIREMENTS. | N/A | PREPARE PER SITE DESIGN ENGINEER'S PLANS. PAVED INSTALLATIONS MAY HAVE STRINGENT MATERIAL AND PREPARATION REQUIREMENTS. |
| C | **INITIAL FILL:** FILL MATERIAL FOR LAYER 'C' STARTS FROM THE TOP OF THE EMBEDMENT STONE ('B' LAYER) TO 18" (450 mm) ABOVE THE TOP OF THE CHAMBER. NOTE THAT PAVEMENT SUBBASE MAY BE A PART OF THE 'C' LAYER. | GRANULAR WELL-GRADED SOIL/AGGREGATE MIXTURES, <35% FINES OR PROCESSED AGGREGATE. MOST PAVEMENT SUBBASE MATERIALS CAN BE USED IN LIEU OF THIS LAYER. | AASHTO M145[1] A-1, A-2-4, A-3 OR AASHTO M43[1] 3, 357, 4, 467, 5, 56, 57, 6, 67, 68, 7, 78, 8, 89, 9, 10 | BEGIN COMPACTIONS AFTER 12" (300 mm) OF MATERIAL OVER THE CHAMBERS IS REACHED. COMPACT ADDITIONAL LAYERS IN 6" (150 mm) MAX LIFTS TO A MIN. 95% PROCTOR DENSITY FOR WELL GRADED MATERIAL AND 95% RELATIVE DENSITY FOR PROCESSED AGGREGATE MATERIALS. ROLLER GROSS VEHICLE WEIGHT NOT TO EXCEED 12,000 lbs (53 kN). DYNAMIC FORCE NOT TO EXCEED 20,000 lbs (89 kN). |
| B | **EMBEDMENT STONE:** FILL SURROUNDING THE CHAMBERS FROM THE FOUNDATION STONE ('A' LAYER) TO THE 'C' LAYER ABOVE. | CLEAN, CRUSHED, ANGULAR STONE | AASHTO M43[1] 3, 357, 4, 467, 5, 56, 57 | NO COMPACTION REQUIRED. |
| A | **FOUNDATION STONE:** FILL BELOW CHAMBERS FROM THE SUBGRADE UP TO THE FOOT (BOTTOM) OF THE CHAMBER. | CLEAN, CRUSHED, ANGULAR STONE | AASHTO M43[1] 3, 357, 4, 467, 5, 56, 57 | PLATE COMPACT OR ROLL TO ACHIEVE A FLAT SURFACE.[2,3] |

PLEASE NOTE:
1. THE LISTED AASHTO DESIGNATIONS ARE FOR GRADATIONS ONLY. THE STONE MUST ALSO BE CLEAN, CRUSHED, ANGULAR. FOR EXAMPLE, A SPECIFICATION FOR #4 STONE WOULD STATE: "CLEAN, CRUSHED, ANGULAR NO. 4 (AASHTO M43) STONE".
2. STORMTECH COMPACTION REQUIREMENTS ARE MET FOR 'A' LOCATION MATERIALS WHEN PLACED AND COMPACTED IN 6" (150 mm) (MAX) LIFTS USING TWO FULL COVERAGES WITH A VIBRATORY COMPACTOR.
3. WHERE INFILTRATION SURFACES MAY BE COMPROMISED BY COMPACTION, FOR STANDARD DESIGN LOAD CONDITIONS, A FLAT SURFACE MAY BE ACHIEVED BY RAKING OR DRAGGING WITHOUT COMPACTION EQUIPMENT. FOR SPECIAL LOAD DESIGNS, CONTACT STORMTECH FOR COMPACTION REQUIREMENTS.
4. ONCE LAYER 'C' IS PLACED, ANY SOIL/MATERIAL CAN BE PLACED IN LAYER 'D' UP TO THE FINISHED GRADE. MOST PAVEMENT SUBBASE SOILS CAN BE USED TO REPLACE THE MATERIAL REQUIREMENTS OF LAYER 'C' OR 'D' AT THE SITE DESIGN ENGINEER'S DISCRETION.




## NOTES:

1. CHAMBERS SHALL MEET THE REQUIREMENTS OF ASTM F2418, "STANDARD SPECIFICATION FOR POLYPROPYLENE (PP) CORRUGATED WALL STORMWATER COLLECTION CHAMBERS".
2. SC-740 CHAMBERS SHALL BE DESIGNED IN ACCORDANCE WITH ASTM F2787 "STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS".
3. THE SITE DESIGN ENGINEER IS RESPONSIBLE FOR ASSESSING THE BEARING RESISTANCE (ALLOWABLE BEARING CAPACITY) OF THE SUBGRADE SOILS AND THE DEPTH OF FOUNDATION STONE WITH CONSIDERATION FOR THE RANGE OF EXPECTED SOIL MOISTURE CONDITIONS.
4. PERIMETER STONE MUST BE EXTENDED HORIZONTALLY TO THE EXCAVATION WALL FOR BOTH VERTICAL AND SLOPED EXCAVATION WALLS.
5. REQUIREMENTS FOR HANDLING AND INSTALLATION:
   - TO MAINTAIN THE WIDTH OF CHAMBERS DURING SHIPPING AND HANDLING, CHAMBERS SHALL HAVE INTEGRAL, INTERLOCKING STACKING LUGS.
   - TO ENSURE A SECURE JOINT DURING INSTALLATION AND BACKFILL, THE HEIGHT OF THE CHAMBER JOINT SHALL NOT BE LESS THAN 2".
   - TO ENSURE THE INTEGRITY OF THE ARCH SHAPE DURING INSTALLATION, a) THE ARCH STIFFNESS CONSTANT AS DEFINED IN SECTION 6.2.8 OF ASTM F2418 SHALL BE GREATER THAN OR EQUAL TO 550 LBS/FT/%. AND b) TO RESIST CHAMBER DEFORMATION DURING INSTALLATION AT ELEVATED TEMPERATURES (ABOVE 73° F / 23° C), CHAMBERS SHALL BE PRODUCED FROM REFLECTIVE GOLD OR YELLOW COLORS.

1 SC-740 CROSS SECTION DETAIL

DRAWN: | DATE:
REVIEWED: | PROJECT NO:
REV: | NOT TO SCALE

SC-740 STANDARD DETAILS

StormTech® Chamber System
888-892-2694 | WWW.STORMTECH.COM


ADS Advanced Drainage Systems, Inc.
4640 TRUEMAN BLVD
HILLIARD, OH 43026


SHEET

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# Attachment C

## Sports Field and Park Detention Modeling Assumptions and Stage-Storage-Discharge Routing Table

HERRERA
Science + Planning + Design

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19-07102-012

**WQBE Sports Field Detention Action**

**Performance Modeling**

12/12/2023 Neil Schaner

**Goal**

Size chamber detention for an area equal to half a soccer field. Determine contributing area that can be mitigated to KCSWDM Level 2 Flow Control (forested) std (50% 2yr to 50yr and match 2yr and 10yr peaks).

**Assumptions/Methodology**

| | | |
|---|---|---|
| Area/field sizing and slope per National Federation of State High School Associations (NFHS) | | |
| Soccer Field Area | Width (ft) | 185 |
| | Length (ft) | 320 |
| | Half Area (sf) | 29600 |
| Detention Chamber | Use ADS StormTech SC-740 | |
| | Chamber Width (ft) | 4.25 |
| | Perimeter Width (ft) | 1 |
| | Spacing (ft) | 0.5 |
| | Chamber Installed Length (ft) | 7.117 |
| | Number of Chamber rows | 38 |
| | **across width* | |
| | Facility Width (ft) | 182.0 |
| | Chambers in Each Row | 21 |
| | **along length, leave 6ft for header/piping* | |
| | Facility Length (ft) | 151.5 |
| | Facility Area (ft) | 27563.9 |
| | Aggregate Depth Below Chambers (ft) | 0.5 |
| | Chamber Height (ft) | 2.5 |
| | Aggregate Depth Above Chambers (ft) | 0.5 |
| | Total Facility Height (ft) | 3.5 |
| Chamber Model Representation | Use WWHM to create SSD table | |
| | Model Width (ft) | 4.75 |
| | **ignore 12" agg on perimeter, assume 6" between rows* | |
| | Model Length (ft) | 5679.10 |
| | **number of chambers times chamber length (ignores end caps and perimeter agg)* | |
| | Number of Chambers | 798 |
| | Number of End Caps | 4 |
| | Aggregate Porosity | 0.4 |
| Control Structure | Orifices as needed | |
| | Riser Height (ft) | 3 |
| | **freeboard within top 6" of aggregate* | |
| | Riser Diameter (in) | 12 |
| | Max Ponding El (ft) | 3.5 |
| MGSFlood Version 4.58 | | |
| 158-year, Puget East 40in MAP precip (no climate change perturbation) | | |
| 15 min time step | | |
| Predeveloped Scenario: till forest | | |
| Post-Developed Scenario: impervious area of equal size | | |
| HSPF Parameters (MGSFlood Defaults) | Till Forest | |
| | NSUR | 0.35 |
| | SLSUR | 0.01 |
| | LSUR | 400 |
| | Impervious | |
| | NSUR | 0.10 |
| | SLSUR | 0.01 |
| | LSUR | 400 |

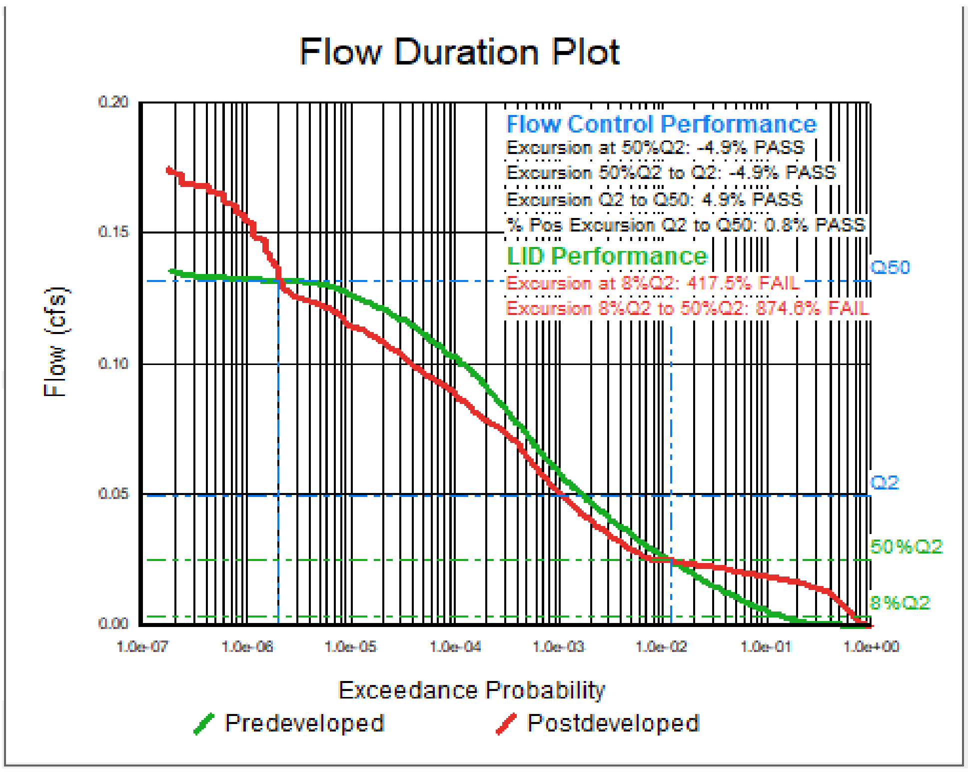
**Model Input**

| | |
|---|---|
| Tributary Area (ac) | 1.75 |
| Facility Area (ac) | 0.633 |
| Contributing Area (ac) | 2.383 |
| Orifice 1 El | 0.00 |
| Orifice 1 Diam (in) | 0.840 |
| Orifice 2 El | NA |
| Orifice 2 Diam (in) | NA |
| Notch El | 1.80 |
| Notch Width (in) | 0.33 |
| Notch Height (in) | 14.40 |
| Riser Common L (ft) | 0.03 |

**Model Results**

| | |
|---|---|
| 100yr WSEL (ft) | 2.964 |
| Flow Control Std | PASS |

| Recurrence Interval Flow Rat | 2-year (cfs) | 10-year (cfs) |
|---|---|---|
| Predeveloped Scenario | 0.0494 | 0.0997 |
| Post-developed Scenario | 0.02362 | 0.07352 |
| 2yr/10yr Flow Control Std. | PASS | PASS |



**Stage-Storage-Discharge Tables for Chamber Facility**

**From WWHM** *assumes agg porosity of 0.4

| stage | area | storage | area (sf) | storage (cf) |
|---|---|---|---|---|
| 0 | 0.619278 | 0 | 26975.75 | 0.00 |
| 0.083333 | 0.619278 | 0.020668 | 26975.75 | 900.30 |
| 0.166667 | 0.619278 | 0.041336 | 26975.75 | 1800.60 |
| 0.25 | 0.619278 | 0.062084 | 26975.75 | 2704.38 |
| 0.333333 | 0.619278 | 0.082746 | 26975.75 | 3604.42 |
| 0.416667 | 0.619278 | 0.103447 | 26975.75 | 4506.15 |
| 0.5 | 0.619278 | 0.124148 | 26975.75 | 5407.89 |
| 0.583333 | 0.619278 | 0.169075 | 26975.75 | 7364.91 |
| 0.666667 | 0.619278 | 0.213859 | 26975.75 | 9315.70 |
| 0.75 | 0.619278 | 0.258432 | 26975.75 | 11257.30 |
| 0.833333 | 0.619278 | 0.302748 | 26975.75 | 13187.70 |
| 0.916667 | 0.619278 | 0.346824 | 26975.75 | 15107.65 |
| 1 | 0.619278 | 0.390603 | 26975.75 | 17014.67 |
| 1.083333 | 0.619278 | 0.434053 | 26975.75 | 18907.35 |
| 1.166667 | 0.619278 | 0.477174 | 26975.75 | 20785.70 |
| 1.25 | 0.619278 | 0.519908 | 26975.75 | 22647.19 |
| 1.333333 | 0.619278 | 0.56226 | 26975.75 | 24492.05 |
| 1.416667 | 0.619278 | 0.60416 | 26975.75 | 26317.21 |
| 1.5 | 0.619278 | 0.645612 | 26975.75 | 28122.86 |
| 1.583333 | 0.619278 | 0.686643 | 26975.75 | 29910.17 |
| 1.666667 | 0.619278 | 0.727102 | 26975.75 | 31672.56 |
| 1.75 | 0.619278 | 0.767012 | 26975.75 | 33411.04 |
| 1.833333 | 0.619278 | 0.806336 | 26975.75 | 35124.00 |
| 1.916667 | 0.619278 | 0.845029 | 26975.75 | 36809.46 |
| 2 | 0.619278 | 0.883064 | 26975.75 | 38466.27 |
| 2.083333 | 0.619278 | 0.920467 | 26975.75 | 40095.54 |
| 2.166667 | 0.619278 | 0.957092 | 26975.75 | 41690.93 |
| 2.25 | 0.619278 | 0.992629 | 26975.75 | 43238.92 |
| 2.333333 | 0.619278 | 1.027183 | 26975.75 | 44744.09 |
| 2.416667 | 0.619278 | 1.060801 | 26975.75 | 46208.49 |
| 2.5 | 0.619278 | 1.093255 | 26975.75 | 47622.19 |
| 2.583333 | 0.619278 | 1.124347 | 26975.75 | 48976.56 |
| 2.666667 | 0.619278 | 1.153802 | 26975.75 | 50259.62 |
| 2.75 | 0.619278 | 1.181083 | 26975.75 | 51447.98 |
| 2.833333 | 0.619278 | 1.204824 | 26975.75 | 52482.13 |
| 2.916667 | 0.619278 | 1.227258 | 26975.75 | 53459.36 |
| 3 | 0.619278 | 1.248505 | 26975.75 | 54384.88 |
| 3.083333 | 0.619278 | 1.269174 | 26975.75 | 55285.22 |
| 3.166667 | 0.619278 | 1.289842 | 26975.75 | 56185.52 |
| 3.25 | 0.619278 | 1.31059 | 26975.75 | 57089.30 |
| 3.333333 | 0.619278 | 1.331252 | 26975.75 | 57989.34 |
| 3.416667 | 0.619278 | 1.351952 | 26975.75 | 58891.03 |
| 3.5 | 0.619278 | 1.372653 | 26975.75 | 59792.76 |

**MGSFlood SSD Table based on WWHM Table**

***Pond surface area increases by 0.1 sf per row to meet software need***

| Row | Elev (ft) | Surf Area (sf) | Volume (cf) |
|---|---|---|---|
| 1 | 0 | 26975.75 | 0.00 |
| 2 | 0.083333 | 26975.85 | 900.30 |
| 3 | 0.166667 | 26975.95 | 1800.60 |
| 4 | 0.25 | 26976.05 | 2704.38 |
| 5 | 0.333333 | 26976.15 | 3604.42 |
| 6 | 0.416667 | 26976.25 | 4506.15 |
| 7 | 0.5 | 26976.35 | 5407.89 |
| 8 | 0.583333 | 26976.45 | 7364.91 |
| 9 | 0.666667 | 26976.55 | 9315.70 |
| 10 | 0.75 | 26976.65 | 11257.30 |
| 11 | 0.833333 | 26976.75 | 13187.70 |
| 12 | 0.916667 | 26976.85 | 15107.65 |
| 13 | 1 | 26976.95 | 17014.67 |
| 14 | 1.083333 | 26977.05 | 18907.35 |
| 15 | 1.166667 | 26977.15 | 20785.70 |
| 16 | 1.25 | 26977.25 | 22647.19 |
| 17 | 1.333333 | 26977.35 | 24492.05 |
| 18 | 1.416667 | 26977.45 | 26317.21 |
| 19 | 1.5 | 26977.55 | 28122.86 |
| 20 | 1.583333 | 26977.65 | 29910.17 |
| 21 | 1.666667 | 26977.75 | 31672.56 |
| 22 | 1.75 | 26977.85 | 33411.04 |
| 23 | 1.833333 | 26977.95 | 35124.00 |
| 24 | 1.916667 | 26978.05 | 36809.46 |
| 25 | 2 | 26978.15 | 38466.27 |
| 26 | 2.083333 | 26978.25 | 40095.54 |
| 27 | 2.166667 | 26978.35 | 41690.93 |
| 28 | 2.25 | 26978.45 | 43238.92 |
| 29 | 2.333333 | 26978.55 | 44744.09 |
| 30 | 2.416667 | 26978.65 | 46208.49 |
| 31 | 2.5 | 26978.75 | 47622.19 |
| 32 | 2.583333 | 26978.85 | 48976.56 |
| 33 | 2.666667 | 26978.95 | 50259.62 |
| 34 | 2.75 | 26979.05 | 51447.98 |
| 35 | 2.833333 | 26979.15 | 52482.13 |
| 36 | 2.916667 | 26979.25 | 53459.36 |
| 37 | 3 | 26979.35 | 54384.88 |
| 38 | 3.083333 | 26979.45 | 55285.22 |
| 39 | 3.166667 | 26979.55 | 56185.52 |
| 40 | 3.25 | 26979.65 | 57089.30 |
| 41 | 3.333333 | 26979.75 | 57989.34 |
| 42 | 3.416667 | 26979.85 | 58891.03 |
| 43 | 3.5 | 26979.95 | 59792.76 |

# Appendix D

## Phase 3 Action Performance Parameters

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# TECHNICAL MEMORANDUM

**Date:** October 4, 2024

**To:** Carly Greyell, King County Water and Land Resources Division
Jim Simmonds, King County Wastewater Treatment Division

**From:** Olivia Wright, Herrera Environmental Consultants, Inc
John Lenth, Herrera Environmental Consultants, Inc.

**Subject:** WQBE Phase 3 Water Quality Performance Parameter Data Compilation (Appendix D to 439-TM1)

# Contents



# Attachment



# Tables

# Introduction

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes for selecting cost-effective water quality investments, reducing pollutant load and improving ecological and human health outcomes. The WQBE Toolkit will include a set of computational models:

- Integrated pollutant loading models, which estimate pollutant loads for major King County waterbodies taking into account major pollutant pathways and sources. Included in the suite of integrated pollutant loading models is a watershed model for estimating runoff volumes and pollutant loads that are delivered via stormwater and baseflow.
- System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) models, which identify cost-effective combinations of potential water quality improvement investments for reduction of pollutant loads or stormwater volumes.
- Qualitative causal models, which define relationships between potential water quality projects and programs and five ecological/human health endpoints (southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches).

The WQBE Toolkit provides information that will be used in planning and prioritization of water quality investments. However, it is not the only information that informs these decisions. These efforts will also consider information not provided by the WQBE Toolkit, including how well different actions would advance equity and social justice, meet regulatory requirements, impact the cost of wastewater rates, and reflect other regional priorities (e.g., sustainability, community well-being, and more).

Part of this effort has involved the development of model inputs for “Actions” composed of structural or nonstructural stormwater controls that improve water quality and/or provide flow control. These Actions provide the unit building blocks (or “unit Actions”) that are aggregated and combined to develop "Programs,” or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. SUSTAIN models are then developed for each Program to evaluate cost effectiveness combinations of Actions, or “Packages,” for improving water quality or providing flow control.

The WQBE Toolkit is being developed in three phases over a period extending from 2020 through 2024.

- Phase 1 (2020): Assumptions for a preliminary set of nineteen Actions and three Programs focused on improving water quality were developed to be modeled with the WQBE Toolkit.
- Phase 2 (2021-2022): Preliminary Actions and Programs from Phase 1 were refined to improve their representation in SUSTAIN (Herrera 2022a). The three water quality Programs from Phase 1 were subsequently modeled with SUSTAIN (Paradigm and Herrera 2022).

- **Phase 3 (2023-2024)**: An additional five Actions and four Programs focused on providing flow control were developed and the Phase 2 Action costs were refined using a simplified approach that allows for more direct comparison to similar planning level cost estimates in the region.

This memorandum documents the technical basis for pollutant removal performance parameter (performance parameter) data for the Actions developed in Phase 2 and Phase 3. It begins with a description of the methods that were used to compile and review these data. It then documents the approach used to fill gaps where existing data were not available for specific combinations of Actions and pollutants. Finally, the performance parameter data that are recommended as input for SUSTAIN models and included in the Action Fact Sheets are summarized.

# Methodology

The Actions in the WQBE toolkit were developed in two Phases. The following Actions were developed in Phase 2.

- Bioretention
- Raingarden
- Bioretention planter
- Bioswale
- Media Filter Drain
- Drywell
- Deep underground injection control (UIC) well
- Permeable pavement
- Depaving
- Detention vault
- Detention pond
- Infiltration vault
- Infiltration pond
- Cistern
- Stormwater treatment wetland
- Wetpond
- Wetvault
- High rate underground filter system (underground filter system)

- Regional vegetated media filtration stormwater facility [Stormwater park (water quality treatment)]
- The following Actions were developed in Phase 3:
- Sports field and park detention
- Compost amendment
- Blue roof
- Reforest High Density Development
- Reforest Pervious Area

See Appendix B and Appendix C of Herrera (2024) for the design details of the Actions developed in Phase 2 and Phase 3, respectively.

The SUSTAIN model simulates Action performance through the following three treatment pathways:

- Untreated bypass. Any water that overflows an Action or exceeds the capacity of an Action results in bypass. This water receives no treatment and retains the influent concentration.
- Retention, detention and filtration. Water that receives treatment through retention, detention and filtration that also discharges through a pipe to receiving waters is assigned a percent removal down to a minimum effluent concentration, or irreducible concentration. This reduction is applied to the water discharging through an orifice or an underdrain.
- Infiltration to groundwater. Runoff that infiltrates to groundwater is lost from SUSTAIN, the surface water model. SUSTAIN model results can be put back into the watershed model where the increased volume from infiltration to subsurface flow and groundwater can be assigned a pollutant concentration.

This section presents the methods used to compile and review the performance parameter data for each Action needed to model their performance using the SUSTAIN model. Also discussed are methods used to fill gaps when no data could be found for an Action and pollutant combination.

## Data Compilation

The Actions were screened and categorized into one of four groups to determine if performance parameter data would be needed to support SUSTAIN model development:

1. Actions that are expected to provide negligible water quality benefit. Actions in this category include:
   - Cistern
   - Blue roof

2. Actions that will not require compilation of performance parameter data for representation in SUSTAIN models. Actions in this category include:
   - Depaving
   - Reforest high density development
   - Reforest pervious area
3. Actions that provide pollutant removal through infiltration. All water that infiltrates is lost from the SUSTAIN model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Actions in this category include:
   - Raingarden
   - Drywell
   - Deep UIC well
   - Permeable pavement
   - Infiltration vault
   - Infiltration pond
   - Compost amendment
4. Actions that provide treatment via a combination of unit processes (e.g., filtration, sedimentation, sorption, etc.) and have the potential for a direct discharge to a receiving water via an outlet or underdrain pipe; hence, the associated influent and effluent pollutants will be included in the surface water model. Actions in this category include:
   - Bioretention
   - Bioretention planter
   - Bioswale
   - Media filter drain
   - Stormwater treatment wetland
   - Detention vault
   - Detention pond
   - Wetpond
   - Wetvault
   - Underground filter system
   - Stormwater park (water quality treatment)
   - Sports field and park detention

Attachment A presents a matrix that documents the results from this screening process with explanations for why Actions were categorized in specific groups.

No performance parameter data are required for Actions categorized in the first, second, and third groups based on their representation in the SUSTAIN models. Performance parameter data are required for Actions categorized in the fourth group to allow their representation in these models in one of two ways depending on their physical configuration:

- For Actions with an underdrain, the influent flow concentration is assigned a percent removal and an irreducible concentration for each pollutant.
- Water that flows through a pond or vault outlet is assigned a percent removal to the influent flow concentration and an irreducible concentration for each pollutant.

For Actions falling in category 4, Herrera (2022b) performed a literature review for the following suite of pollutants for the WQBE Toolkit:

- Total copper
- Dissolved copper
- Total zinc
- Dissolved zinc
- Total phosphorus
- Total nitrogen
- Total suspended solids (TSS)
- Total polychlorinated biphenyls (total PCB)
- Total polybrominated diphenyl ethers (total PBDE)
- Total polycyclic aromatic hydrocarbons (total PAH)
- Bis(2-ethylhexyl) phthalate (BEHP)
- Fecal Coliform

This literature review specifically focused on obtaining measured percent removal and effluent concentration (used as a surrogate for irreducible concentration) data for each Action using the following stepwise process:

- The International Stormwater Best Management Practices Database (ISBMPD) was queried on May 13, 2020 (ISBMPD 2019) to obtain all available influent and effluent data for each Action and pollutant combination. Because the ISBMPD is considered a highly consistent and complete source for these data, results from this query were prioritized in the compilation of performance parameter data for each Action. If no data were identified for a specific Action and pollutant combination through this query, the following additional step was performed.

- Additional sources for performance parameter data were identified using online literature search engines (Web of Science, UW library, internet searches) and knowledge of local/regional studies. These sources included peer reviewed papers, consultant reports, white papers, and agency reports. The additional data sources identified through this process are documented in Attachment A for specific Action and pollutant combinations where relevant.

In all cases, the following criteria were used to guide the compilation of performance parameter data during the literature review:

- Data must represent the performance of each Action individually (i.e., not in a treatment train).
- Data from both laboratory and field studies were included in the review.
- Data ideally consisted of influent and effluent concentrations from individual sampling events.

The data obtained from this literature review were subsequently compiled in a database for additional processing. Influent and effluent concentration data from individual sampling events were specifically processed as follows:

1. Influent and effluent concentration data from individual sampling events were excluded from subsequent analysis if the influent concentration was below the applicable reporting limit for the pollutant. These data were excluded because they cannot provide a meaningful assessment of treatment performance.
2. For each Action and pollutant combination, the influent and effluent concentration data from individual sampling events were analyzed to compute the median percent removal to represent the typical performance of an Action. The 25th percentile effluent concentration was calculated to represent the irreducible concentration for each Action and pollutant combination. In these computations, the reporting limit was used when the effluent concentration was below the applicable reporting limit for the pollutant. This resulted in a conservative estimate of performance in relation to using other substitution methods (e.g., 1/2 the reporting limit) in these computations.

The number of sampling events with influent and effluent concentration data for these computations is documented in Table 1 for each Action and pollutant combination; this table also identifies where significant data gaps exist for these combinations. The following section describes the process that was used to fill these data gaps where feasible.

**Table 1. Number of Sampling Events with Influent and Effluent Concentration Data for each Action and Pollutant Combination.**

| Parameter | Bioretention/ Bioretention Planter[a] | Bioswale | Media Filter Drain[b] | Stormwater Treatment Wetland | Detention Pond | Detention Vault | Wetpond | Wetvault | Under Ground Filter Systems/Stormwater Park[c] | Sports Field and Park Detention |
|---|---|---|---|---|---|---|---|---|---|---|
| Copper, Dissolved | 30 | 139 | 27 | 51 | 179 | NF | 287 | NF | 39 | NF |
| Copper, Total | 28 | 243 | 27 | 270 | 249 | NF | 712 | NF | 49 | NF |
| BEHP | NF | NF | NF | NF | NF | NF | NF | NF | NF | NF |
| Fecal Coliform | 15 | 84 | NF | 82 | 145 | NF | 163 | NF | 3 | NF |
| Nitrogen, Total | 10 | 204 | NF | 539 | 153 | NF | 533 | NF | 38 | NF |
| PBDE | NF | NF | NF | NF | NF | 1 | NF | NF | NF | NF |
| Total PAHs | 15 | NF | NF | 18 | NF | 6 | NF | NF | NF | NF |
| Total PCBs | NF | NF | NF | 15 | NF | NF | NF | NF | 4 | NF |
| Total Phosphorus | 44 | 364 | 39 | 714 | 414 | NF | 911 | NF | 109 | NF |
| Total Suspended Solids | 14 | 377 | 39 | 632 | 432 | NF | 967 | NF | 107 | NF |
| Zinc, Dissolved | 29 | 132 | 39 | 81 | 128 | NF | 238 | NF | 39 | NF |
| Zinc, Total | 29 | 281 | 39 | 327 | 269 | NF | 778 | NF | 54 | NF |

[a] Bioretention and bioretention planters are assumed to have equivalent performance (see assumptions in Attachment A).

[b] Media filter drain data Includes samples with unpaired influent and effluent concentrations from WSDOT (2013). Median percent removal was calculated for paired data only. 13 paired influent and effluent concentration data were available for total copper and dissolved copper, and 25 paired influent and effluent concentration data were available for total phosphorus, total suspended solids, total zinc, and dissolved zinc.

[c] Underground filter systems and stormwater parks (water quality treatment) are assumed to have equivalent performance (see assumptions in Attachment A).

NF = No data found

# Data Gaps

This section describes the processes used to fill data gaps when performance parameter data were not identified through the literature review described in the previous section for a given Action and pollutant combination. These processes involved filling data gaps based on data obtained from surrogate Actions or surrogate pollutants.

## Surrogate Actions

Where feasible, data gaps for specific Action and pollutant combinations were filled based on data obtained from surrogate Actions that are expected to provide equivalent treatment based on their unit processes (i.e., pollutant removal mechanisms). The surrogate Actions that were used to fill data gaps were discussed with King County and are presented below.

Detention Pond, Detention Vault, and Sports Field and Park Detention: Sedimentation is the primary unit process for pollutant removal in a detention pond. The ISBMPD contains a substantial amount of data for this Action, but data were unavailable for detention vaults and sports field and park detention, which also use sedimentation as their primary unit process for pollutant removal and have as similar structural geometry to detention ponds. Therefore, detention pond performance parameter data obtained from the ISBMPD for the following pollutants were also used for detention vaults and stormwater field and park detention:

- Total copper
- Dissolved copper
- Total zinc
- Dissolved zinc
- Total phosphorus
- Total nitrogen
- TSS

It is likely that the performance of detention vaults and sports field and park detention may be overestimated based on this approach due to these Actions lacking all of the unit processes present in a detention pond.

Similarly, performance parameter data for total PBDEs and total PAHs were summarized in Sebastian et al. (2014) for detention vaults but not detention ponds or sport fields and parks detention. Hence, these data were also used for detention ponds and sports fields and parks detention.

Wetpond and Wetvault: The primary unit processes for pollutant removal in a wetpond are sedimentation and biological uptake. Biological uptake is only an important unit process for those wetponds with abundant vegetation in the littoral zone. Many ponds lack this biologically active area and rely primarily on sedimentation for treatment; this makes them similar to wetvaults. Wetpond performance parameter data obtained from the ISBMPD for the following pollutants were also used for wetvaults:

- Total copper
- Dissolved copper
- Total zinc
- Dissolved zinc
- Total phosphorus
- Total nitrogen
- TSS
- Fecal coliform bacteria

It is likely that the performance of wetvaults may be overestimated based on this approach due to wetvaults lacking all of the unit processes present in a wetpond.

## Surrogate Parameters

As Table 1 demonstrates, performance parameter data were identified for most of the Actions through the literature review described above for TSS, most nutrients, and metals. However, data were not identified through this effort for most of the following organic pollutants:

- Total PCBs
- Total PAHs
- Total PBDE
- BEHP

In addition, performance parameter data were also not identified for some of the following additional pollutants:

- Total nitrogen
- Fecal coliform bacteria.

The sections below describe the methods used to fill these data gaps where possible.

### Organic Chemicals

Because the organic pollutants identified above are all strongly associated with suspended solids in stormwater due to their hydrophobic properties (Schueler and Youngk 2015), TSS was considered as a suitable surrogate for estimating their removal via treatment with the various Actions. Table 2 summarizes results from research on the affinity of the organic pollutants identified above for sediments. As is apparent, the fraction of organic pollutants associated with suspended sediments ranges from 78 to 86 percent. This implies that the removal of a large percentage of suspended sediment from stormwater by an Action will also result in the effective removal of these organic chemicals.

Given this consideration, the results in Table 2 were used to develop equations for estimating effluent organic pollutant concentrations (total PCBs, total PAHs, total PBDEs and BEHP) based on the effluent TSS concentrations obtained from the literature review described above. Specifically, the 25th percentile effluent TSS concentration (in mg/L) for each Action was multiplied by the estimated concentration of the organic pollutant in the associated sediment from Table 2. This resulted in an estimate of the organic chemical associated with the TSS. However, not all the organic pollutant will be associated with the sediment, a smaller fraction will also be in solution. Using data from Table 2 that quantifies the partitioning of the organic pollutant between the solid and aqueous phase in stormwater, the following correction factor was therefore applied to derive a final estimate of the effluent organic pollutant concentration from the Action:

RatioTD = 1 + (1- % in Sed/100). The % in Sed values are derived from Table 2.

The resultant equations are as follows:

Action effluent total PCB concentration (pg/L) =

$$\mathrm{TSS}\left(\frac{\mathrm{mg}}{\mathrm{L}}\right) \times \mathrm{Sed_C} \times \mathrm{Ratio_{TD}}$$

Where:

$\mathrm{Sed_C}$ = 21.8 ug/kg. The estimated total PCB concentration in the suspended solids (Table 2)

$\mathrm{Ratio_{TD}} = 1.22$. The ratio of total PCB associated with the liquid versus the solid phase.

Action effluent total PAH concentration (µg/L) =

$$\mathrm{TSS}\left(\frac{\mathrm{mg}}{\mathrm{L}}\right) \times \mathrm{Sed_C} \times \mathrm{Ratio_{TD}}$$

Where:

$\mathrm{Sed_C}$ = 108 ug/kg. The estimated total PAH concentration in the suspended solids (Table 2)

$\mathrm{Ratio_{TD}} = 1.15 \times 10^{-6}$. The ratio of total PAH associated with the liquid versus the solid phase, with unit adjustment.

Action effluent PBDE concentration (ng/L) =

$$\mathrm{TSS}\left(\frac{\mathrm{mg}}{\mathrm{L}}\right) \times \mathrm{Sed_C} \times \mathrm{Ratio_{TD}}$$

Where:

$\mathrm{Sed_C}$ = 2.2 ug/kg. The estimated PBDE concentration in the suspended solids (Table 2)

$\mathrm{Ratio_{TD}} = 1.14 \times 10^{-3}$. The ratio of PBDE associated with the liquid versus the solid phase, with unit adjustment.

Action effluent BEHP concentration (µg/L) =

$$\mathrm{TSS}\left(\frac{\mathrm{mg}}{\mathrm{L}}\right) \times \mathrm{Sed_C} \times \mathrm{Ratio_{TD}}$$

Where:

$\mathrm{Sed_C}$ = 2,743 ug/kg. The estimated BEHP concentration in the suspended solids (Table 2)

$\mathrm{Ratio_{TD}} = 1.19 \times 10^{-6}$. The ratio of BEHP associated with the liquid versus the solid phase, with unit adjustment.

**Table 2. Organic Chemical Associations with Suspended Solids.**

| Study | Source | Total PCBs (ug/kg)[a] | Total PCBs % in Sed[b] | Total PAHs (ug/kg) | Total PAHs % in Sed | PBDE (ug/kg) | PBDE % in Sed | BEHP (ug/kg) | BEHP % in Sed |
|---|---|---|---|---|---|---|---|---|---|
| Ecology (2009) | Lower Duwamish stormwater | 14.5 | – | 143.5 | – | – | – | – | – |
| CSN (2015) | Norway sediment traps (PCB), Wisconsin stormwater suspended sediment (PAH), France urban and river sediment (PBDE and BEHP) | 29 | – | 72.85 | – | 2.2 | – | 1,230 | – |
| Ko and Baker (2004) | Major tributaries to Chesapeake Bay | – | 75 | – | 80 | – | – | – | – |
| Bressy et al. (2012) | Paris storm drains | – | 85 | | 90 | – | – | – | – |
| ZWW (2017) | Seattle catch basins | – | – | – | – | – | – | 2,000 | – |
| Zgheib et al. (2011) | Paris storm drains | – | – | – | – | – | – | 5,000 | 81 |
| King County (2013) | Storm and stream discharging to Lake Washington | – | 73.7 | – | – | – | 85.5 | – | – |
| **Average** | | **21.8** | **78** | **108** | **85** | **2.2** | **86** | **2,743** | **81** |

[a] ug/kg columns indicate the concentration of the organic chemical in collected sediment (typically from sediment traps or catch basin sumps).

[b] % in Sed = the portion of the organic chemical associated with suspended solids in collected water samples.

Percent removal of the organic pollutants via treatment with the Actions was estimated based on research by Schueler and Youngk (2015) that established simple, relative relationships between TSS removal using stormwater treatment best management practices and the removal of various pollutants. This research established these specific relationships for TSS and the organic pollutants:

- Total PCB removal = TSS removal
- Total PAH removal > TSS removal
- PBDE removal < TSS removal
- BEHP removal < TSS removal

Based on these relationships, total PCB and total PAH percent removal was assumed to be equivalent to the TSS percent removal identified for each Action through the literature review. Percent removal for PBDE and BEHP was reduced relative to the TSS percent removal based on the partitioning values from Table 3 as follows:

- PBDE removal = TSS removal * 0.86
- BEHP removal = TSS removal * 0.81

These equations assume that PBDE and BEHP in the aqueous phase act conservatively as the Action treats the stormwater. While this is an oversimplification, the resultant values from these equations are considered acceptable given the lack of data directly related to these pollutants.

### Total Nitrogen and Fecal Coliform

TSS is not strongly related to total nitrogen and fecal coliform bacteria in stormwater; therefore, TSS was not considered a suitable surrogate for estimating effluent concentrations and percent removal of these pollutants via treatment with the Actions. Other pollutants were also not considered suitable for this purpose. Therefore, data gap still exists in the performance parameter data for the following combinations of Actions and pollutants:

- Total nitrogen treatment with the media filter drain.
- Fecal coliform bacteria treatment with the media filter drain, underground filter system, and stormwater park (water quality treatment).

# Summary of Compiled Performance Parameter Data

Tables 3 through 12 in this section document the performance parameter data compiled for each Action and pollutant combination through the methods described above. These data will be used as SUSTAIN model input to estimate percent reductions and effluent concentrations for Actions that will be evaluated in specific Programs with the WQBE toolkit. During future phases, the performance parameter data for this set of Actions may be updated and refined and data for new Actions may be added.

**Table 3. Bioretention/Bioretention Planter Performance Parameter Data.**

| Target Pollutants | Median Percent Removal[a,b] | 25th Percentile Effluent Concentration[a,b] |
|---|---|---|
| Total Copper | 62.3% | 7.1 µg/L |
| Dissolved Copper | 57.6% | 4.6 µg/L |
| Total Zinc | 91.0% | 5.0 µg/L |
| Dissolved Zinc | 86.2% | <4.0 µg/L[c] |
| Total Phosphorus | 54.9% | 0.024 mg/L |
| Total Nitrogen | 51.3% | 1.2 mg/L |
| Total Suspended Solids | 78.0% | 13.5 mg/L |
| Total PCBs | 78.0% | 358 pg/L |
| Total PBDEs | 67.1% | 0.034 ng/L |
| Total PAHs | 95.1% | <0.01 µg/L[c] |
| BEHP | 63.2% | 0.044 µg/L |
| Fecal Coliform | 61.5% | 31.5 CFU/100 mL |

[a] Bioretention and bioretention planters are assumed to have equivalent performance (see assumptions in Attachment A).

[b] Performance based on the low phosphorus alternative bioretention soil media with 70% sand/20% coconut coir/10% high carbon wood ash.

[c] Method detection limit.

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

**Table 4. Bioswale Performance Parameter Data.**

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | 33.9% | 4.8 µg/L |
| Dissolved Copper | 8.99% | 3.6 µg/L |
| Total Zinc | 33.3% | 20.0 µg/L |
| Dissolved Zinc | 29.0% | 15.0 µg/L |
| Total Phosphorus | -37.2% | 0.100 mg/L |
| Total Nitrogen | -7.63% | 0.562 mg/L |
| Total Suspended Solids | 27.9% | 10.0 mg/L |
| Total PCBs | 27.9% | 265 pg/L |
| Total PBDEs | 24.0% | 0.025 ng/L |
| Total PAHs | 27.9% | 0.0012 µg/L |
| BEHP | 23.0% | 0.033 µg/L |
| Fecal Coliform | 6.25% | 1,775 CFU/100 mL |

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

**Table 5. Media Filter Drain Performance Parameter Data.**

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | 86.2% | 9.45 µg/L |
| Dissolved Copper | 40.8% | 6.25 µg/L |
| Total Zinc | 85.1% | 22.0 µg/L |
| Dissolved Zinc | 80.8% | 16.0 µg/L |
| Total Phosphorus | 85.7% | 0.033 mg/L |
| Total Nitrogen | NF | NF |
| Total Suspended Solids | 94.1% | 2.8 mg/L |
| Total PCBs | 94.1% | 74.3 pg/L |
| Total PBDEs | 80.9% | 0.007 ng/L |
| Total PAHs | 94.1% | 0.00035 µg/L |
| BEHP | 76.2% | 0.0091 µg/L |
| Fecal Coliform | NF | NF |

NF = No data found

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

**Table 6. Stormwater Treatment Wetland Performance Parameter Data.**

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | 25.0% | 3.0 µg/L |
| Dissolved Copper | 0.0% | 2.0 µg/L |
| Total Zinc | 45.9% | 12.0 µg/L |
| Dissolved Zinc | 0.0% | 10.0 µg/L |
| Total Phosphorus | 24.2% | 0.071 mg/L |
| Total Nitrogen | 5.81% | 0.932 mg/L |
| Total Suspended Solids | 52.4% | 6.81 mg/L |
| Total PCBs | 78.1% | 165 pg/L |
| Total PBDEs | 45.1% | 0.017 ng/L |
| Total PAHs | 85.6% | 0.024 µg/L |
| BEHP | 42.4% | 0.022 µg/L |
| Fecal Coliform | 19.1% | 425 CFU/100 mL |

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

**Table 7. Detention Pond Performance Parameter Data.**

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | 26.2% | 4.17 µg/L |
| Dissolved Copper | 3.23% | 3.0 µg/L |
| Total Zinc | 44.0% | 18.0 µg/L |
| Dissolved Zinc | 13.6% | 16.1 µg/L |
| Total Phosphorus | 17.7% | 0.113 mg/L |
| Total Nitrogen | 7.80% | 0.674 mg/L |
| Total Suspended Solids | 57.6% | 12.9 mg/L |
| Total PCBs | 57.6% | 342 pg/L |
| Total PBDEs | *56.9%* | *93.5 ng/L* |
| Total PAHs | *52.1%* | *0.228 µg/L* |
| BEHP | 46.7% | 0.042 µg/L |
| Fecal Coliform | 31.5% | 500 CFU/100 mL |

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.
*Italicized values* derived from surrogate BMP (Detention vault).

**Table 8. Detention Vault Performance Parameter Data.**

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | *26.2%* | *4.17 µg/L* |
| Dissolved Copper | *3.23%* | *3.0 µg/L* |
| Total Zinc | *44.0%* | *18.0 µg/L* |
| Dissolved Zinc | *13.6%* | *16.1 µg/L* |
| Total Phosphorus | *17.7%* | *0.113 mg/L* |
| Total Nitrogen | *7.80%* | *0.674 mg/L* |
| Total Suspended Solids | *57.6%* | *12.9 mg/L* |
| Total PCBs | *57.6%* | *342 pg/L* |
| Total PBDEs | 56.9% | 93.5 ng/L |
| Total PAHs | 52.1% | 0.228 µg/L |
| BEHP | *46.7%* | *0.042 µg/L* |
| Fecal Coliform | *31.5%* | *500 CFU/100 mL* |

*Italicized values* derived from surrogate BMP (Detention pond).

**Table 9. Wetpond Performance Parameter Data.**

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | 45.0% | 3.0 µg/L |
| Dissolved Copper | 22.7% | 3.0 µg/L |
| Total Zinc | 62.5% | 13.0 µg/L |
| Dissolved Zinc | 36.8% | 10.0 µg/L |
| Total Phosphorus | 49.5% | 0.071 mg/L |
| Total Nitrogen | 27.6% | 0.904 mg/L |
| Total Suspended Solids | 76.2% | 7.5 mg/L |
| Total PCBs | 76.2% | 199 pg/L |
| Total PBDEs | 65.5% | 0.019 ng/L |
| Total PAHs | 76.2% | 0.00093 µg/L |
| BEHP | 61.7% | 0.025 µg/L |
| Fecal Coliform | 60.0% | 85.5 CFU/100 mL |

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

**Table 10. Wetvault Performance Parameter Data.**

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | *45.0%* | *3.0 µg/L* |
| Dissolved Copper | *22.7%* | *3.0 µg/L* |
| Total Zinc | *62.5%* | *13.0 µg/L* |
| Dissolved Zinc | *36.8%* | *10.0 µg/L* |
| Total Phosphorus | *49.5%* | *0.071 mg/L* |
| Total Nitrogen | *27.6%* | *0.904 mg/L* |
| Total Suspended Solids | *76.2%* | *7.5 mg/L* |
| Total PCBs | *76.2%* | *199 pg/L* |
| Total PBDEs | *65.5%* | *0.019 ng/L* |
| Total PAHs | *76.2%* | *0.00093 µg/L* |
| BEHP | *61.7%* | *0.025 µg/L* |
| Fecal Coliform | *60.0%* | *85.5 CFU/100 mL* |

*Italicized values* derived from surrogate BMP (Wetpond).

**Table 11. Underground Filter System Performance/Stormwater Park (Water Quality Treatment) Performance Parameter Data.**

| Target Pollutants | Median Percent Removal[a,b] | 25th Percentile Effluent Concentration[a,b] |
|---|---|---|
| Total Copper | 51.6% | 3.1 µg/L |
| Dissolved Copper | 34.2% | 2.0 µg/L |
| Total Zinc | 56.4% | 20.1 µg/L |
| Dissolved Zinc | 53.4% | 26.0 µg/L |
| Total Phosphorus | 42.4% | 0.034 mg/L |
| Total Nitrogen | 45.8% | 0.422 mg/L |
| Total Suspended Solids | 86.4% | 2.45 mg/L |
| Total PCBs | 84.1% | 414.1 pg/L |
| Total PBDEs | 74.3% | 0.0061 ng/L |
| Total PAHs | 86.4% | 0.00031 µg/L |
| BEHP | 70.0% | 0.008 µg/L |
| Fecal Coliform | NF | NF |

[a] Underground filter systems and stormwater park (water quality treatment) are assumed to have equivalent performance (see assumptions in Attachment A).

[b] Performance based on proprietary Filterra® engineered media.

NF = No data found; Assigned a value of 0 in SUSTAIN since no data was found.

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

**Table 12. Sports Field and Parks Detention**

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | *26.2%* | *4.17 µg/L* |
| Dissolved Copper | *3.23%* | *3.0 µg/L* |
| Total Zinc | *44.0%* | *18.0 µg/L* |
| Dissolved Zinc | *13.6%* | *16.1 µg/L* |
| Total Phosphorus | *17.7%* | *0.113 mg/L* |
| Total Nitrogen | *7.80%* | *0.674 mg/L* |
| Total Suspended Solids | *57.6%* | *12.9 mg/L* |
| Total PCBs | *57.6%* | *342 pg/L* |
| Total PBDEs | *56.9%* | *93.5 ng/L* |
| Total PAHs | *52.1%* | *0.228 µg/L* |
| BEHP | *46.7%* | *0.042 µg/L* |
| Fecal Coliform | *31.5%* | *500 CFU/100 mL* |

*Italicized values* derived from surrogate BMP (Detention pond).

# Limitations and Future Considerations

This document summarizes the pollutant removal performance data and approach used to represent the typical performance of the Actions included in the WQBE toolkit. The following text provides a summary of the limitations in the data available:

- When performance parameter data were not identified through the literature review, data gaps were filled based on data from surrogate Actions and pollutants as appropriate. Periodic reviews should be conducted to identify new data that could be used to quantify the pollutant removal performance of an Action.
- To simplify modeling assumptions, the 25th percentile effluent concentration was used as a surrogate for the irreducible concentration for each pollutant based on best professional judgement.
- The influent and effluent concentration data from individual sampling events were analyzed to compute the median percent removal for each Action and pollutant combination. These data were then used to represent the typical pollutant removal performance of each Action. However, these data do not capture complex dynamics that occur in association with specific unit processes for pollutant removal. For example, these data do not reflect variations in pollutant removal performance stemming from biological processes that may be influenced by seasonal factors (e.g., nutrient capture in plants during the growing season and subsequent release with plant senescence). Due to model limitations, it is generally not possible to capture the influence of these complex dynamics in the model output.
- Correction factors were derived using the data from Table 2 to quantify the partitioning of organic pollutants between the solid and aqueous phase in stormwater. These correction factors were then used to derive a final estimate of the effluent organic pollutant concentration for each Action. These estimates could be refined in future phases of the project using partition coefficient (Kow) that are derived from literature.

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# Attachment A

## Phase 2 and Phase 3 Action Screening Process, Data Sources, and Key Assumptions

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| Table A-1. Phase 2 and Phase 3 Action Screening Process, Data Sources, and Key Assumptions. | | | | | |
|---|---|---|---|---|---|
| Action | WQBE Phase | Primary Unit Processes | Screening Process Category | Data Source | Modeling and Performance Assumptions |
| Bioretention | 2 | Sedimentation, sorption, filtration, biological uptake, Infiltration | 4 | Herrera (2015), Herrera (2020) | Concentration percent reductions from this review are assigned to underdrain outflow. All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.<br>Performance results were gathered from lab studies, which used the Puget Sound region's new High Performance Bioretention Media (HPBSM) specification, a mixture of sand, coconut coir, and biochar (Herrera 2020). |
| Rain garden | 2 | Sedimentation, sorption, filtration, biological uptake, Infiltration | 3 | | All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. |
| Bioretention Planter | 2 | Sedimentation, sorption, filtration, biological uptake, Infiltration | 4 | Herrera (2015), Herrera (2020) | Concentration percent reductions from this review are assigned to underdrain outflow. All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.<br>These systems function equivalent to bioretention. |
| Bioswale | 2 | Sedimentation, filtration, biological uptake, infiltration | 4 | ISBMPD (2019) | Bioswales are modelled as a flow through system. Concentration percent reductions from this review are assigned to water that exits the bioswale. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. |
| Media filter drain | 2 | Sedimentation, sorption, filtration, infiltration | 4 | Herrera (2006), WSDOT (2013) | Concentration percent reductions from this review are assigned to underdrain outflow. All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. |
| Dry well | 2 | Infiltration | 3 | | All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Action will be paired with a pretreatment Action when included in a Program. |

| Table A-1 (continued). Phase 2 and Phase 3 Action Screening Process, Data Sources, and Key Assumptions. | | | | | |
|---|---|---|---|---|---|
| **Action** | **WQBE Phase** | **Primary Unit Processes** | **Screening Process Category** | **Data Source** | **Modeling Assumptions** |
| Deep underground injection control (UIC) well | 2 | Infiltration | 3 | | All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Action will be paired with a pretreatment Action when included in a Program. |
| Permeable pavement | 2 | Infiltration | 3 | | All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. |
| Depaving | 2 | – | 2 | | Action will be modeled in SUSTAIN by converting the depaved area from an impervious to pervious surface. Load reduction would be the result of the differences in pollution generating in surface runoff from the different land surfaces. |
| Detention vault | 2 | Sedimentation | 4 | Sebastian et al. (2014), ISBMPD (2019) | Water that flows through the orifice is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (while not designed for treatment, there will be some pollutant removal via sedimentation). Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.<br>Performance assumed equivalent to a detention pond except for the specific data found for detention vaults for PBDEs and Total PAHs. |
| Detention pond | 2 | Sedimentation | 4 | Sebastian et al. (2014), ISBMPD (2019) | Water that flows through the orifice is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (while not designed for treatment, there will be some pollutant removal via sedimentation). Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.<br>Performance for PBDEs and Total PAHs assumed equivalent to detention vaults. |

| Table A-1 (continued). Phase 2 and Phase 3 Action Screening Process, Data Sources, and Key Assumptions. | | | | | |
|---|---|---|---|---|---|
| **Action** | **WQBE Phase** | **Primary Unit Processes** | **Screening Process Category** | **Data Source** | **Modeling Assumptions** |
| Infiltration vault | 2 | Sedimentation, infiltration | 3 | Sebastian et al. (2014), ISBMPD (2019) | All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Action will be paired with a pretreatment Action when included in a Program.<br>Assumed same performance as detention pond/vault, but will be part of a treatment train. |
| Infiltration pond | 2 | Sedimentation, infiltration | 3 | Sebastian et al. (2014), ISBMPD (2019) | All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Action will be paired with a pretreatment Action when included in a Program.<br>Assumed same performance as detention pond/vault, but will be part of a treatment train. |
| Cistern | 2 | – | 1 | | Model will assume no treatment provided unless Program includes manual operation of orifice valve by property owner. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. |
| Stormwater treatment wetland | 2 | Sedimentation, sorption, filtration, biological uptake | 4 | ISBMPD (2019), King County (2019) | Water that flows through the Action (to the max flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. |
| Wetponds | 2 | Sedimentation, biological uptake (depends on pond quality) | 4 | ISBMPD (2019) | Water that flows through the Action (to the max flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. |
| Wetvaults | 2 | Sedimentation | 4 | ISBMPD (2019) | Water that flows through the Action (to the max flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.<br>Performance assumed equivalent to Wetpond. |

| Table A-1 (continued). Phase 2 and Phase 3 Action Screening Process, Data Sources, and Key Assumptions. | | | | | |
|---|---|---|---|---|---|
| **Action** | **WQBE Phase** | **Primary Unit Processes** | **Screening Process Category** | **Data Source** | **Modeling Assumptions** |
| High Rate Underground Filtration System | 2 | Sedimentation, sorption, filtration | 4 | Gilbreath et al. (2018), ISBMPD (2019) | Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Performance assumed equivalent to Filterra®. |
| Stormwater park (water quality treatment) | 2 | Sedimentation, sorption, filtration | 4 | Gilbreath et al. (2018), ISBMPD (2019) | Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Performance assumed equivalent to Filterra®. |
| Sports field and park detention | 3 | Sedimentation | 4 | Sebastian et al. (2014), ISBMPD (2019) | Water that flows through the orifice is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (while not designed for treatment, there will be some pollutant removal via sedimentation). Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. |
| Compost Amendment | 3 | Sedimentation, sorption, filtration, infiltration | 3 | | All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. |
| Blue roof | 3 | – | 1 | | Model will assume no treatment. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. |
| Reforest High Density Development | 3 | – | 2 | | Action will be modeled in SUSTAIN by converting the reforested area from an impervious to forested surface. Load reduction would be the result of the differences in pollution generating in surface runoff from the different land surfaces. |
| Reforest Pervious Area | 3 | – | 2 | | Action will be modeled in SUSTAIN by converting the reforested area from a pervious to forested surface. Load reduction would be the result of the differences in pollution generating in surface runoff from the different land surfaces. |

# Appendix E

## Phase 3 Action Costs

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# TECHNICAL MEMORANDUM

| | |
|---|---|
| Date: | October 4, 2024 |
| To: | Carly Greyell, King County Department of Natural Resources and Parks, Water and Land Resources Division |
| From: | Edith Hadler, HDR Engineering, Inc.<br>Cindy Kinzer, HDR Engineering, Inc.<br>John Lenth, Herrera Environmental Consultants, Inc.<br>Olivia Wright, Herrera Environmental Consultants, Inc. |
| Subject: | Phase 3 Unit Cost Basis for Water Quality Benefits Evaluation (439-TM1) |

# Contents




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**WASHINGTON | OREGON | CALIFORNIA | MONTANA | WYOMING**

# Tables



# Figures



# Attachments

# Glossary of Terms

| | |
|---|---|
| AACE | Association for the Advancement of Cost Engineering |
| AFI | allowance for indeterminates |
| BMP | best management practice |
| BOE | Basis of Estimate |
| CCI | Construction Cost Index |
| CF | cubic foot/feet |
| County | King County |
| CSO | combined sewer overflow |
| CWP | Clean Water Plan |
| DNR | (Washington State) Department of Natural Resources |
| Ecology | Washington State Department of Ecology |
| ENR | *Engineering News-Record* |
| FV | future value |
| GIS | geographic information system |
| GSI | green stormwater infrastructure |
| Herrera | Herrera Environmental Consultants, Inc. |
| in | inch(es) |
| KCSWDM | *King County Surface Water Design Manual* |
| LCC | life-cycle cost |
| L&I | Washington State Department of Labor & Industries |
| LSPC | Loading Simulation Program in C++ |
| LTCP | Long-Term Control Plan |
| mo | month(s) |
| NLCD | National Land Cover Database |
| NPV | net present value |
| O&M | operations and maintenance |
| PDF | Portable Document Format |
| PRISM | Project Reporting and Information System Management |
| PV | present value |
| RKI | Robin Kirschbaum Inc. |
| ROW | right-of-way |
| SDOT | Seattle Department of Transportation |
| SF | square foot/feet |
| SPU | Seattle Public Utilities |

| | |
|---|---|
| SUSTAIN | System for Urban Stormwater Treatment and Analysis Integration |
| SSWM | City of Seattle Stormwater Manual |
| SWMMWW | *Stormwater Management Manual for Western Washington* |
| TM | technical memorandum |
| UIC | underground injection control |
| WLRD | Water and Land Resources Division |
| WQBE | Water Quality Benefits Evaluation |
| WRIA | Water Resource Inventory Area |
| WSDOT | Washington State Department of Transportation |
| WTD | (King County) Wastewater Treatment Division |
| yr | year(s) |

# Purpose and Background

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes for selecting cost-effective water quality investments, reducing pollutant load and improving ecological and human health outcomes. The WQBE Toolkit will include a set of computational models:

- Integrated pollutant loading models, which estimate pollutant loads for major King County waterbodies taking into account major pollutant pathways and sources.
- System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) models, which identify cost-effective combinations of potential water quality for reduction of pollutant loads or stormwater volumes.
- Qualitative causal models, which define relationships between potential water quality projects and programs and five ecological/human health endpoints (southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches).

The WQBE Toolkit provides information that will be used in planning and prioritization of water quality investments. However, it is not the only information that informs these decisions. These efforts will also consider information not provided by the WQBE Toolkit, including how well different actions would advance equity and social justice, meet regulatory requirements, impact the cost of wastewater rates, and reflect other regional priorities (e.g., sustainability, community well-being, and more).

Part of this effort has involved the development of model inputs for “Actions” composed of structural or nonstructural stormwater controls that improve water quality and/or provide flow control. These Actions provide the unit building blocks (or “unit Actions”) that are aggregated and combined to develop "Programs,” or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. SUSTAIN models are then developed for each Program to evaluate cost effectiveness combinations of Actions, or “Packages,” for improving water quality or providing flow control.

The WQBE Toolkit is being developed in three phases over a period extending from 2020 through 2024.

***Phase 1 (2020):*** Assumptions for a preliminary set of nineteen Actions and three Programs focused on improving water quality were developed to be modeled with the WQBE Toolkit. The Action unit costs were developed using the WTD cost estimate workbook, which uses the Project Reporting and Information System Management (PRISM) cost calculators to calculate indirect costs that varies based on construction costs and complexity factors. Appendix D of Herrera (2020) documented the Action cost development, including the estimating basis, methodology, approach, and life-cycle cost (LCC) model assumptions.

***Phase 2 (2021–2022):*** Preliminary Actions and Programs from Phase 1 were refined to improve their representation in SUSTAIN (Herrera 2022). The Phase 2 cost-estimating approach was documented in Appendix D of Herrera (2022). Notable recommendations that were implemented include the following:

- The WTD estimate workbook cost allowances were reassigned based on assigned complexity for each Unit Action. Low complexity costs for Unit Actions (such as bioretention) were assigned lower contingency and uncertainty factors than more complex Actions (such as wet vault).
- Property costs were adjusted from Seattle area appraised land values to land values that represented an average cost across King County.
- The Actions were scaled within the WTD workbook to provide indirect costs that were more reflective of the anticipated cost for a suite of Actions or anticipated Program size.

***Phase 3 (2023–2024):*** An additional five Actions and four Programs focused on providing flow control were developed and the Phase 2 Action costs were refined using a simplified approach that allows for more direct comparison to similar planning level cost estimates in the region. Notable updates to the cost models are listed below:

- Replaced the WTD Estimate workbook and WTD Capital Program Life Cycle Cost sheet with a single spreadsheet to provide ease in estimate assumption updates. The updated workbook offers a one-stop view of the cost estimate sheet, Basis of Estimate (BOE) summary tab, and LCC model with operations and maintenance (O&M) documentation. The estimate workbook was designed to be interactive, eliminating the need to toggle between more than 140 individual estimating workbooks used in prior phases.
- Prior phases used the WTD cost estimate workbook, which used PRISM cost calculators to calculate indirect costs that varied based on construction costs and complexity factors. PRISM worksheet costs were not developed from green stormwater infrastructure (GSI) and green projects, contributing to elevated indirect and contingency costs. A new workbook was developed to replace the WTD cost estimate workbook. The Phase 3 estimate workbook offered greater transparency by calculating indirect costs based on the Unit Action assigned complexity and related percentages of construction cost.
- Simplified the LCC estimates by replacing the seven-page WTD Capital Project Life Cycle Cost Workbook with a single sheet in the Phase 3 estimate workbook. The new LCC sheet maintained the WTD standardized financial and economic assumptions. Life cycle cost assumptions inputs from the WTC LCC workbook were used in development of the interactive workbook except for financing, which is not included with the LCC analysis. O&M equipment and labor hours were revisited for drywell and deep UIC Actions.
- Property costs in WQBE Phase 2 were based on an average cost spread across King County. The Phase 3 estimate summary sheet was updated to include three separate property costs that represent a low, medium and high property cost across King County estimated using compiled 2023 total appraised values for parcels in King County, Pierce County and Snohomish County that

fell within the project area. A selection toggle was added to each Unit Action cost summary tab to allow the user to adjust real estate costs based on a targeted region.

- Because of considerable market volatility, construction unit costs were updated or escalated to winter 2023 costs.
- Workshop 410 recommendation to normalize costs for small facilities (i.e., bioretention 25-square-foot [SF] facility) and shallow underground concrete facilities (i.e., wet vault) were implemented. For small facilities, construction costs were calculated based on a “typical” facility size and then the costs were scaled to the assigned facility dimensions. Shallow underground storage vaults, such as wet vault costs, were revisited to assign a typical storage depth, length, and width ratio.

This technical memorandum documents the WQBE Phase 3 estimate approach, assumptions, and methodology. While some approaches may coincide with prior Phase 1 and Phase 2 work, the estimate approach and methodologies contained within this TM are considered specific to the WQBE Phase 3 cost models.

# Cost-Estimating Methodology and Approach

This section provides an overview of the methodology and approach used to estimate direct construction cost, indirect non-construction cost, project cost, and LCC for each Action.

## Overview

The Herrera team developed modeling assumptions for a suite of Actions comprising structural and non-structural practices that improve water quality and/or provide flow control. A "Unit Action" represents a typical vertical profile, areal footprint, and associated design-drainage area for a specific Action being modeled in SUSTAIN. These Unit Actions provide a representative footprint of an Action defined to be modeled with SUSTAIN.

Planning-level cost estimates were developed based on the following:

- Limited design concepts that were based on engineering judgement and agency design requirements that include the King County Surface Water Design Manual (KCSWDM) (King County 2016), City of Seattle Stormwater Manual (SSWM), Washington State Department of Ecology (Ecology) Stormwater Management Manual for Western Washington (SWMMWW), and proprietary design and detail information from online sources.  Details on design concept assumptions and refinement are provided in Appendix B.
- General site assumptions, such as if the installation were in right-of-way, on property, or in outwash or till soils, were provided by Herrera and RKI consultants. The assumptions are documented in the Action Factsheets, located in Appendix G.

- Project complexity factors were used to assign indirect costs based on a percentage of the Unit Action's subtotal construction costs. Table 1 provides the complexity assignment for each Action and a description is provided below.
  - Low complexity indicates a simplified or straightforward cost profile. For example, the Rain Garden Action, which uses a simple, preapproved design with little permitting required, was assigned a low complexity profile.
  - Routine complexity indicates typical design or duties without unique issues or concerns. For example, the Detention Vault Action was assumed to require typical design and construction monitoring. While the Action requires permitting, no unique permitting issues were anticipated with this installation. The Detention Vault Action was assigned a routine complexity profile.
  - Moderate complexity indicates that there will be elevated costs or concerns associated that are higher than normally found with that type of project. For example, the Stormwater Treatment Wetland Action was assumed to require elevated support for permitting, and environmental planning and management. The Stormwater Treatment Wetland Action was assigned a moderate complexity profile.
  - High complexity indicates that the project may have risks associated with it that can require intense support or concerns that may cause significant delivery and schedule delays. For example, a tunnel project that crosses a bay or requires disturbance along the shoreline area may require extensive permitting, have elevated risk associated with the construction, or may require extensive community-relations outreach. The tunnel project may be assigned a high complexity profile. None of the WQBE Actions were considered to have a high complexity profile.

General and specific assumptions that influence estimate costs for each Action are documented in Attachment A. The cost workbook for each Action is located in Attachment B.

The cost estimate for Rain garden was updated from a capital project to a programmatic Unit Action. Costs and allowances were developed based on RainWise program historical data provided by County and City of Seattle staff. All remaining Unit Action costs were developed based on capital improvement costs.

WQBE Phase 3 estimates include a suite of Unit Actions that were carried forward from Phase 2 and include new Unit Actions that are specific to WQBE Phase 3 development. A summary of the planning-level Unit Action cost estimates and variations is listed in Table 1. See Appendix B and C of Herrera (2024) design details and assumptions of the Actions developed in Phase 2 and Phase 3, respectively.

| Table 1. WQBE Actions and Variations. | | |
|---|---|---|
| **Action** | **Complexity** | **Description** |
| **Green Stormwater Infrastructure** | | |
| Rain garden installation (Program) | Low | WQBE_01_Rain Garden Installation on Property (Program) |
| Bioretention HPBSM planter (previously named "bioretention planter" in Phase 2) | Low | WQBE_02A_Bioretention Planter on Property |
| | | WQBE_02B_Bioretention Planter in ROW |
| | | WQBE_02C_Bioretention Planter with Property Cost |
| Bioretention HPBSM installation (previously named "bioretention" in Phase 2) | Low | WQBE_03A_Bioretention Underdrain on Property |
| | | WQBE_03Aa_Bioretention Underdrain with Property Cost |
| | | WQBE_03B_Bioretention No Underdrain on Property |
| | | WQBE_03Bb_Bioretention No Underdrain with Property Cost |
| | | WQBE_03C_Bioretention Underdrain in ROW |
| | | WQBE_03D_Bioretention No Underdrain in ROW |
| Bioswale installation | Low | WQBE_04A_Bioswale in ROW |
| | | WQBE_04B_Bioswale on Public Property |
| | | WQBE_04C_Bioswale with Property Cost |
| Media filter drains | Low | WQBE_05A_Media Filter Drain Underdrain |
| | | WQBE_05B_Media Filter Drain No Underdrain |
| Drywell | Low | WQBE_06A_Drywell on Property |
| | | WQBE_06B_Drywell with Bioretention Planter on Property |
| **Green Stormwater Infrastructure (continued)** | | |
| Deep UIC wells | Low | WQBE_07A_Deep UIC Well on Property |
| | | WQBE_07B_Deep UIC Well in ROW |
| | | WQBE_07C_Deep UIC Well with Property Cost |
| | | WQBE_07D_Deep UIC Well with Filter in ROW |
| | | WQBE_07E_Deep UIC Well with Bioretention Planter in ROW |
| | | WQBE_07E_Deep UIC Well with Bioretention Planter in ROW |
| | | WQBE_07F_Deep UIC Well with Bioretention Planter on Property |
| Permeable pavement | Low | WQBE_08A_Pervious Concrete Sidewalk (no sand layer) |
| | | WQBE_08B_Porous Asphalt Driveway (with sand layer) |
| | | WQBE_08C_Permeable Paver Driveway (with sand layer) |
| | | WQBE_08D_Permeable Paver Plaza (no sand layer) |

**Table 1 (continued). WQBE Actions and Variations.**

| Action | Complexity | Description |
|---|---|---|
| **Stormwater Retention/Detention/Infiltration** | | |
| Depaving (removal of impervious surfaces) | Low | WQBE_9A_Removal of Impervious Surfaces on Property (wheel strips) |
| | | WQBE_9B_Removal of Impervious Surfaces on Property (no wheel strips) |
| Detention vault | Routine | WQBE_11A_Detention Vault on Public Property |
| | | WQBE_11B_Detention Vault in ROW |
| | | WQBE_11C_Detention Vault with Property Cost |
| **Stormwater Retention/Detention/Infiltration (continued)** | | |
| Detention pond | Routine | WQBE_12A_Detention Pond on Public Property |
| | | WQBE_12B_Detention Pond with Property Cost |
| Infiltration pond | Routine | WQBE_13A_Infiltration Pond Till Soil on Public Property |
| | | WQBE_13B_Infiltration Pond Outwash Soil on Public Property |
| | | WQBE_13C_Infiltration Pond Till Soil with Property Cost |
| | | WQBE_13D_Infiltration Pond Outwash Soil with Property Cost |
| | | WQBE_13E_Infiltration Pond Outwash Soil with High Rate Underground Filter on Public Property |
| | | WQBE_13F_Infiltration Pond Outwash Soil with High Rate Underground Filter System with Property Cost |
| Infiltration vault | Routine | WQBE_14A_Infiltration Vault Till Soil on Public Property |
| | | WQBE_14B_Infiltration Vault Outwash Soil on Public Property |
| | | WQBE_14C_Infiltration Vault Till Soil in ROW |
| | | WQBE_14D_Infiltration Vault Outwash Soil in ROW |
| | | WQBE_14E_Infiltration Vault Till Soil with Property Cost |
| | | WQBE_14F_Infiltration Vault Outwash Soil with Property Cost |
| | | WQBE_14G_Infiltration Vault Outwash Soil with High Rate Underground Filter System in ROW |
| | | WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System with Property Cost |
| | | WQBE_14I_Infiltration Vault Outwash Soil with High Rate Underground Filter System without Property Cost |
| Cistern | Low | WQBE_16_Cistern on Property |
| **Gray Stormwater Treatment** | | |
| Wet pond | Routine | WQBE_18A_ Wet Pond on Public Property |
| | | WQBE_18B_ Wet Pond with Property Cost |
| Wet vault | Routine | WQBE_19A_ Wet Vault on Public Property |
| | | WQBE_19B_ Wet Vault in ROW |
| | | WQBE_19C_ Wet Vault with Property Cost |

**Table 1 (continued). WQBE Actions and Variations.**

| Action | Complexity | Description |
|---|---|---|
| **Gray Stormwater Treatment (continued)** | | |
| Stormwater treatment wetland | Routine | WQBE_20A_ Stormwater Treatment Wetland on Public Property |
| | | WQBE_20B_ Stormwater Treatment Wetland with Property Cost |
| High-rate underground filter system installation | Low | WQBE_21A_High Rate Underground Filter in Urban ROW PCCP |
| | | WQBE_21B_High Rate Underground Filter in Highway ROW PCCP |
| | | WQBE_21C_High Rate Underground Filter in Urban ROW HMA |
| | | WQBE_21D_High Rate Underground Filter in Highway ROW HMA |
| | | WQBE_21E_High Rate Underground Filter on Public Property |
| | | WQBE_21F_High Rate Underground Filter with Property Cost |
| **Gray (Regional) Stormwater Treatment** | | |
| Stormwater Park (water quality treatment); previously named Regional stormwater treatment facility in Phase 2 | Moderate | WQBE_22A_Regional Vegetated Media Stormwater Facility on Public Property |
| | | WQBE_22B_Regional Vegetated Media Stormwater Facility with Property Cost |
| **WQBE Phase 3 New Actions** | | |
| Sports field | Routine | WQBE_23_Sports Field on Public Property |
| Blue roof | Low | WQBE_24_Blue Roof on Public Property |
| Compost amendment | Low | WQBE_25_Compost Amendment on Property |
| Reforest High Density Development | Routine | WQBE_26A_Reforest High Density Development on Property |
| | | WQBE_26B_ Reforest High Density Development on Property with Property Cost |
| Reforest Pervious Area | Routine | WQBE_26C_Reforest Pervious Area on Property |
| | | WQBE_26C_Reforest Pervious Area with Property Cost |

Note: "On property" means no property costs included.

# Estimating Basis

An assigned conceptual design basis combined with accepted design practice and engineering judgment were used to develop Action Unit costs. It is understood that differing estimating assumptions and approach may meet an acceptable standard of care and still have a significant effect upon cost development. Cost modeling assumptions were assigned for each Action to guide the cost development process and maintain consistency with WQBE goals and accepted design practices. Cost modeling assumption definitions include the following:

- Design standards (e.g., KCSWDM, SSWM, Ecology SWMMWW, etc.)
- Facility assumptions (e.g., treatment media type and depth, drains, piping, location and surface restoration, etc.)

- Facility location and area (e.g., urban roadway, residential property, etc.)

A summary of the Basis of Estimate (BOE )assumptions prepared for each Unit Action cost model is included in Attachment A. BOE information provided includes the following:

- Design basis (specific to cost assumptions)
- Planning basis
- Cost basis
- Allowances (e.g., sales tax, indeterminates, change orders, etc.)
- Estimating assumptions

The BOE is housed on a tab within each estimate workbook, located in Attachment B, and should be considered a "living document" with the information updated when the Unit Action definition or approach is revised or further defined.

## Cost Estimate Development

Cost estimates were developed in general conformance with the Association for the Advancement of Cost Engineering (AACE) and King County WTD estimating guidelines. AACE classifies estimates into six class types as outlined in AACE Recommended Practice 18R-97 (AACE 2020). The cost estimate classification varies, depending upon the project definition and primary estimating characteristics. The estimate classification is distinguished by the degree of project definition and the intended purpose or use of the estimate. The AACE guideline matrix for estimate classification system is provided in Table 2 below.

**Table 2. AACE Estimate Class and Characteristics.**

| AACE[a] Estimate | Degree of Project Definition | Typical Estimate Purpose | AACE Expected Accuracy Range |
|---|---|---|---|
| Class 10 | 0%–2% | Conceptual screening (long range) | Unassigned [b] |
| Class 5 | 0%–2% | Conceptual screening | -50% to +100% |
| Class 4 | 1%–15% | Concept study, order of magnitude, feasibility study | -30% to +50% |
| Class 3 | 10%–40% | Budget, authorization, control | -20% to +30% |
| Class 2 | 30%–70% | Control | -15% to +20% |
| Class 1 | 70%–100% | Check estimate, bid/tender, change order | -10% to +15% |

a Source: AACE International 2005.
b A range of -50% to +100% was assigned for these estimates.

In addition to the estimate classes listed above, AACE recognizes that special considerations apply when developing costs intended for planning-level screening or long-range strategic planning. These estimates were designated as Class 10 estimates in AACE publication Recommended Practice 111R-20 (AACE 2021).

Class 10 estimates can be characterized by a larger accuracy range to communicate potential unpredictable changes in scope and risk challenges over extended long-range planning.

The WQBE Unit Action cost estimates were designated and prepared as Class 10 estimates to provide for comparison and screening between different Unit Actions or a suite of Actions as part of long-term planning activities seeking to predict potential investments years in the future. For this specific project were assigned the same accuracy range, contingency, and uncertainty allowances as the AACE Class 5 estimate.

Unit cost models were developed using design basis information prepared by the Herrera team. The design basis for each Unit Action (located in Attachment A and B) included concept scope description, siting assumptions, dimensions, and applicable design standards.

Referenced requirements and sources used to supplement design BOE information are documented below:

- KCSWDM (2016 & 2021)
- *SSWM (City of Seattle Stormwater Manual 2016 & 2021)*
- Ecology SWMMWW
- Ecology's "Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13"
- Historical agency and vendor design and detail information

The BOE summary sheet prepared for each Unit Action documents key estimating assumptions, design details, estimating factors, and exclusions. A copy of the BOE summary sheet is included with the cost estimate sheets in Attachment A.

# Total Project Cost Estimates

The total project cost consists of the following costs:

- Direct construction cost, which represents the probable cost of construction.
- Indirect or non-construction costs, which represent design, permitting, real estate, and other costs associated with the development and administration of a project.

## Direct Construction Cost

This section describes the methodologies and assumptions used to estimate direct construction costs for the Unit Actions. Direct construction costs represent the costs associated with physical construction of a project and include the following costs:

- Subtotal construction costs, which is also called the probable cost of construction bid. The subtotal construction costs include the following costs:
  - Contractor overhead and profit and general conditions (included in line-item unit prices)
  - Contractor bonds and insurance (included in line-item unit prices)
  - Contractor mobilization and demobilization (10 percent) based on County experience.
- Allowance for indeterminates (AFI) or design allowance for undefined scope work multipliers were assigned based on Unit Action complexity. Assigned complexities are listed in Table 1 with AFI multipliers listed below:
  - 15 percent for low-complexity Actions
  - 20 percent for routine-complexity Actions
  - 25 percent for moderate-complexity Actions
- Street use permit allowance: Seattle Department of Transportation (SDOT) street use permit fees for work within Seattle right-of-way (ROW) (varies by Unit Action).
- Project contingency multipliers were assigned based on anticipated project complexity (see Table 1) as listed below:
  - 15 percent for low-complexity Actions
  - 30 percent for routine-complexity Actions
  - 25% for Moderate Complexity Actions

## Additional Construction Costs

Additional direct construction costs include the following costs:

- Construction change order allowance (10 percent) based on County experience
- Retail sales tax at 10.25 percent in Seattle and 10.10 percent in King County outside of Seattle
- Outside agency construction (e.g., utility relocations; user-defined, varies by Unit Action)

### Year of Construction Cost

*Engineering News-Record* (ENR) monitors construction costs across the country. The ENR Construction Cost Index (CCI) averages the cost of a set amount of labor and materials over a 20-city average of labor rates and material costs. In addition, ENR has specific CCI average values for the Seattle area.

To maintain estimating consistency between Unit Actions, costs that were not directly updated using current construction values were escalated to December 2023 dollars using Seattle ENR CCI values. Should a Unit Action be selected for future development, it is recommended that construction costs be adjusted to the projected mid-year of construction.

## Indirect Non-Construction Costs

Indirect costs represent “soft costs,” which are costs outside of those that are directly part of the construction (or installation) but that are required to complete the construction. Examples of indirect costs include design, real estate procurement, etc. Indirect costs for the WQBE Actions were assigned as a percentage of direct construction costs based on assigned project complexity for the categories listed in Table 3.

**Table 3. Complexity Categories and Assigned Direct Construction Cost Percentage.**

| Complexity Factor | Indirect Cost Category | | | |
|---|---|---|---|---|
| | Design Engineering & Services During Construction | Construction Management Services | Permitting & Support (if applicable) | WTD Staff Labor (Finance, Community Service, Planning, CM, Controls, etc.) |
| Low | 12% | 8% | 0.5% | 5% |
| Routine | 22% | 10% | 1% | 6% |
| Moderate | 28% | 13% | 2% | 9% |
| High | 34% | 16% | 3% | 11% |

### Real Estate Costs

A low, medium, and high land acquisition cost was calculated to represent the range of costs across the jurisheds in the project area. A jurished is the result of intersecting the jurisdictional boundaries and the delineated drainage areas. The cost analysis included the following steps:

1. Compiled 2023 total appraised values for each parcel in King, Pierce, and Snohomish Counties that fell within the project area. The cost per square foot was calculated for each parcel.
2. The parcel spatial layer was intersected with the jurished layer to split the parcels along the jurished boundaries and assign the parcel areas along the boundaries to the jurisheds they fall in. The cost per square foot of each parcel was multiplied by the associated area within each jurished.
3. The average area weighted cost per square foot was calculated for each jurished using the total parcel costs calculated in step 2. The area of the parcels with a total appraised value of zero was excluded from the analysis.

4. Based on the jurished area weighted cost per square foot, each jurished within the project area was assigned a low, medium, or high cost category using the natural breaks classification (Jenks) in ArcGIS Pro. Figure 1 displays the range of costs per square foot and the cost categories assigned to jurisheds in the project area.
5. The final step in the analysis was calculating the low, medium, and high cost per square foot representative of each cost category. The Actions being modeled with the WQBE toolkit will not be applied in forested areas and no land acquisition would be needed in public parks. Therefore, based on best professional judgement, jurisheds with greater than 85 percent coverage from a combination of the following data sets were excluded from the land acquisition cost analysis:
   - State parks: Washington State park boundaries
   - County parks: King, Pierce, and Snohomish County publicly available park geographic information system (GIS) data sets
   - National forest: U.S. Forest Service forest administrative boundaries
   - Wilderness area: U.S. Forest Service national wilderness areas
   - Forested area: National Land Cover Database (NLCD) land cover 2021 for deciduous, evergreen, and mixed forest

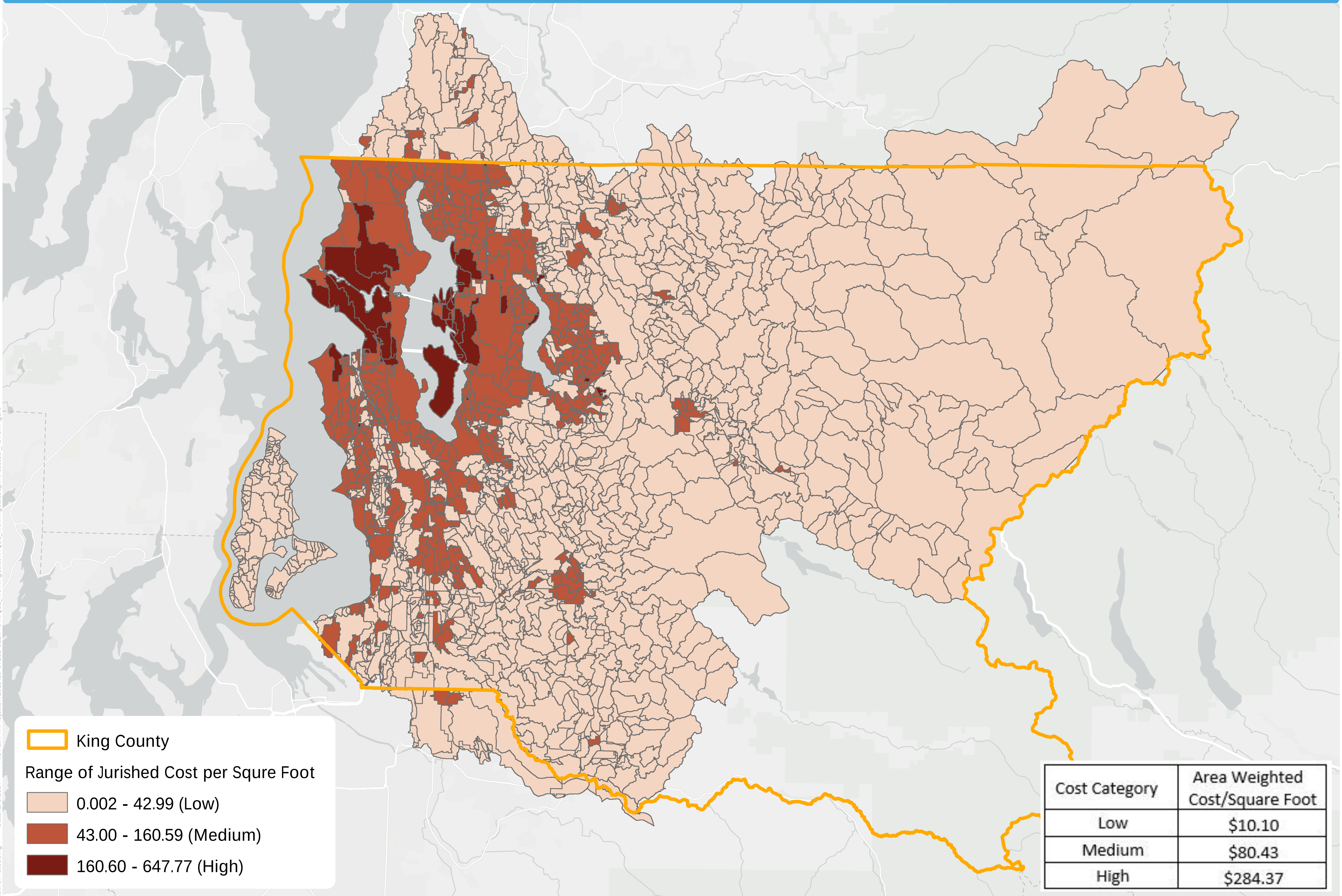
   The cost for each category (i.e., low, medium, and high) was calculated by taking the area-weighted average cost per square foot of the remaining jurisheds within each cost category. Table 4 provides the results of this analysis. Although, the jurisheds with greater than 85% coverage from the datasets described above were not included in calculating the area-weighted cost/SF, these jurisheds may still have land uses where Actions may be applied and therefore, were assigned the cost categories associated with them as calculated in step 4.

**Table 4. Low, Medium, and High Land Acquisition Costs.**

| Jurished Cost Category | Area-Weighted Cost/SF |
|---|---|
| Low | $10.10 |
| Medium | $80.43 |
| High | $284.37 |

Land acquisition cost assumptions, where used, are documented in Attachment A and included in the cost workbooks located in Attachment B for each Unit Action. Attachment A and B display the medium land acquisition costs. When applying the Unit Action to jurisheds that fall under different cost categories, the user can change the land acquisition costs to low, medium or high in the cost workbooks located in Attachment B.

Figure 1.
Land Acquisition Cost Analysis Results.




| Cost Category | Area Weighted Cost/Square Foot |
|---|---|
| Low | $10.10 |
| Medium | $80.43 |
| High | $284.37 |

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# Total Project Costs

Total project costs were estimated for each Unit Action by summing the direct construction costs and indirect non-construction costs and include the following information:

- Total direct construction costs, which include the following costs:
  - Estimated probable cost of construction bid (directly estimated using engineered quantities and unit pricing analysis)
  - AFI
  - Street use permit allowance
  - Additional construction costs (includes change order allowance, construction sales tax, and outside agency construction)
- Total indirect non-construction costs, which include the following costs:
  - Design engineering & construction management consulting services
  - Permitting & support
  - Land purchase, easements, and acquisition cost
  - King County staff costs & non-WTD support

As detailed under the Cost Estimate Development section, the WQBE estimates were prepared as Class 10 estimates intended for planning-level screening or alternative comparison for long-range strategic planning. Attachment A contains Portable Document Format (PDF) files of the cost workbook for each Unit Action cost estimate.

# Life-Cycle Cost

A life-cycle cost (LCC) analysis was prepared using standard King County analysis assumptions referenced from the WTD LCC worksheet. The LCC analysis considers initial capital costs and future costs, such as capital replacement and O&M costs. A 30-year analysis period was selected for the LCC analysis.

For the WQBE Actions, the LCC was the total project capital cost plus the net present value (NPV) of ongoing capital replacement and O&M over the analysis period of the project. Project LCCs combine capital replacement and O&M costs to allow reasonable comparisons between concepts with high project costs and those with high O&M costs. Project LCCs were estimated by considering the following factors:

- Total project cost comprising both direct construction cost and indirect project costs
- Capital replacement cost, which was the cost to replace components during the life-cycle period
- Annual O&M costs, which included labor, supplies, and equipment

The LCC estimates are to be considered preliminary level because of the limited information available and the planning-level engineering that has occurred.

## Life-Cycle Cost Analysis Assumptions

The following general assumptions were used:

- Initial capital cost:
  - Initial capital cost is input into the LCC analysis sheet as total project cost and not construction cost.
  - Initial capital cost was assumed to occur in a single year.
- Capital replacement schedule assumptions for each Action were documented within the LCC analysis sheet located in Attachment A and B. Capital replacement general assumptions were as follows:
  - GSI replacement costs (e.g., mulch, plants, etc.) were placed on a 10-year schedule.
  - Gray stormwater infrastructure (e.g., weirs, outlets, etc.) were placed on a 20-year schedule.

The following is a general representation of how NPV is calculated within the LCC worksheet:

$$Project\ net\ present\ value\ (NPV) =$$

$$PV\ (initial\ capital\ costs) + PV(capital\ replacment\ costs) + PV\ (O\&M\ costs)$$

In general, future values (FVs) are converted to present values (PVs) by the following equation:

$$PV = FV\frac{FV}{(1+i)^n}$$

Where: $i$ = annual interest rate (provided by County), $n$ = year of expenditure.

- Life-cycle assumptions:
  - Period: 30 years
  - Initial year of operations: 2026
  - Year of analysis: 2023
  - Construction start: 2025
- Cost assumptions:
  - Cost estimate dollar basis year: 2023
  - Construction cost escalation: 3.5 percent

- O&M and general cost escalation:
  - Projects: 3.0 percent
  - Programs: 3.5 percent (because it is associated with Program implementation and not necessarily O&M)
  - O&M labor rate growth: 3.2 percent
  - Direct labor rate as of year of analysis: $54.39
  - Washington (retail) sales tax: 10.25 percent (King County in the City Seattle)
  - WTD labor overhead: 150 percent (this is a County-controlled rate applied to raw labor costs calculated for O&M activities)
  - The O&M labor cost formula is listed below:

$$O\&M\ labor\ costs\ =$$

$$Labor\ hours\ per\ year\ \times direct\ labor\ rate\ \times WTD\ overhead\ rate$$

- Economic assumptions:
  - Discount rate, WTD (cost of capital): 5.25 percent. The discount rate accounts for both inflation and the time value of money.
  - WTD real discounted rate: 2.18 percent (if O&M escalation is 3.0 percent) or 1.69 percent (if O&M escalation is 3.5 percent).

Attachment A contains a PDF file of the LCC worksheets for each Unit Action.

## Operations and Maintenance Cost

Annual O&M cost was estimated for each Unit Action and generally included the following:

- O&M activities were based on the type of activity provided in the most current version of the Cost and Modeling Assumptions worksheet. Activity sources included the following:
  - KCSWDM, (2016 & 2021)
  - *SSWM*, (2016 & 2021)
  - Ecology SWMMWW, 2019
  - Kitsap County *Manchester Stormwater Retrofit Drainage Report*, 2014
  - Vendor recommendations
- Annual labor hours required by maintenance crews for cleanup after major storm events or for periodic inspections and remediation of materials (grass, plantings, permeable pavement, concrete cracks and joints, etc.) and regular maintenance activities for the specific Unit Action, where applicable.

- Annual material replacement, such as plant replacement, grass seed mix, mulch, etc. for the specific Unit Action, where applicable.
- Annual equipment rentals needed to perform maintenance activities for the specific Action, where applicable. Equipment rates were obtained from EquipmentWatch (Rental Rate Blue Book) adjusted for Seattle pricing or RSMeans.

### Capital Replacement Cost

Capital replacement cost (items requiring replacement prior to the 30-year life of the Unit Action) was estimated for each Unit Action. The replacement costs for each action are scheduled and not prorated based on the timelines indicated below. The following was assumed:

- Complete replacement of vegetation along with soils that had been compacted every 10 years, where applicable
- Complete replacement of access gates every 10 years, where applicable
- Complete replacement of mechanical equipment (e.g., flow restrictor, access hatch, outlet structure, baffle, etc.) every 20 years, where applicable

Capital replacement costs were estimated for each Unit Action by summing the construction costs of the specific line items assumed for replacement for the specified interval (e.g., 10 years), including mobilization/demobilization. The replacement schedules identified for each Action were based on the KCSWDM, SSWM and vendor recommendations.

### Total Life-Cycle Cost

The total LCC included initial capital costs, capital replacement costs, and regular maintenance costs over the 30-year analysis period. The total LCC is presented as the NPV for each Action.

# Cost Sources

This section outlines the process used to collect cost information in support of the WQBE toolkit (construction, program, and O&M costs). The costs for each Unit Action were characterized for a defined unit or footprint specific within the SUSTAIN model. Costs developed for use in the SUSTAIN model were preliminary, planning-level costs, based on limited or generalized engineering design assumptions.

The following sources were reviewed to support development of unit cost data considered representative of the Seattle/King County region. The costs reflect owner's anticipated construction costs (construction contractor pricing) presented in fourth quarter 2023 dollars:

- Washington State Department of Transportation (WSDOT) unit bid analysis: The WSDOT unit bid analysis database contains a bid history for standard unit bid prices from WSDOT projects. This tool contains cost information for excavation, conveyance, best management practices (BMPs), or other typical roadway construction items. The WSDOT database search can be limited to projects within western Washington or other nearby localities, such as the Olympic Peninsula (WSDOT 2023).

- Puget Sound BMP cost database: The Puget Sound BMP cost database (Herrera 2012) report contains cost information from the Puget Sound region for stormwater treatment and BMP elements (e.g., wet ponds, porous pavement, cisterns, constructed wetlands, etc.). Costs from this database report are based on 2012 dollars.
- King County TMs and reports: King County TMs (e.g., the University GSI projects) and existing reports (e.g., Puget Sound BMP Cost Database, Water Resource Inventory Area [WRIA] 9 reports, and University Green Stormwater Infrastructure with GSI cost benchmarking by CH2M Hill) contain both estimated construction costs and historical maintenance cost data. Construction and other cost data within the reports are based on various dates and any applied escalation or inflationary values should be considered on a case-by-case basis.
- King County and Seattle RainWise Program: King County and the City of Seattle provided historical cost information for both RainWise programmatic costs and cistern costs.
- Internet sources: Internet websites and online data sources were used to estimate or validate contractor quotes on area-specific costs such as King County landfill disposal costs.
- Contractor and vendor quotes: Vendor quotes were used to calculate bid costs or to verify reported unit cost data for specialty items, such as proprietary stormwater treatment (i.e., Filterra), sports field ADS StormTech system, blue roof, and porous asphalt pavement costs. Vendor quotes reflect current market conditions at the time the quote was obtained. Direct vendor quotes were adjusted to account for installation costs and labor, shipping and handling, and contractor markup and profit.
- Estimator and agency historical databases: Herrera, King County (WTD and Water and Land Resources Division [WLRD]), SPU, the Washington State Department of Natural Resources (DNR), Kitsap County, and other agencies within the Puget Sound area maintain and may post contractor bid prices for publicly bid projects. Bid costs from these sources and those from the estimators database of recent projects were used to fill in data gaps from the other sources or for specialty work. Data obtained from these sources were reviewed to ensure that the quantities and other project parameters were relevant. Costs obtained from these sources were based on various dates and any applied escalation or inflationary values were considered on a case-by-case basis.
- EquipmentWatch: HDR Engineering, Inc. maintains a subscription to EquipmentWatch, which provides access to Rental Rate Blue Book pricing. The pricing is kept current by extensive ongoing research. This pricing tool is an industry standard for determining equipment values for both use and rental. The rates can be applied across the country or can be adjusted for a specific region, such as the Seattle area. Additional information on EquipmentWatch is available on its website at equipmentwatch.com.
- Gordian RSMeans (RSMeans): Gordian RSMeans (2020) online, an industry resource used in estimating construction costs, was used to provide construction costs for materials, labor, transportation costs, and equipment rental rates. The rates can be applied across the country or can

be adjusted for a specific region, such as the Seattle area. RSMeans online is available on its website at www.RSMeans.com.

- Labor rates: Craft rates and related benefits were estimated using Washington State Department of Labor & Industries (L&I) prevailing wage rates for King County. These labor rates include base wage rate, all applicable fringe benefits, unemployment insurance, and payroll taxes. Workers' compensation insurance is included separately in each work activity based on risk histories. Additional information is available at the L&I website at https://lni.wa.gov/licensing-permits/public-works-projects/prevailing-wage-rates/.

## Cost Source Data Summary

The cost sources used in development of the Unit Action costs are summarized in 5 below. The cost estimates and estimating approaches used for the WQBE Phase 3 Actions were evaluated against peer projects and programs.

**Table 5. Cost Data Summary.**

| Action | Cost Source |
|---|---|
| Rain garden installation | • City of Seattle and King County RainWise program costs; WSDOT unit bid analysis, estimator and historical databases<br>• Equipment rates from RSMeans and personnel costs from Washington State L&I prevailing wage rates for King County<br>• O&M guidelines per SWMMWW, 2019 |
| Bioretention HPBSM planter | • King County University GSI, Puget Sound BMP cost database, WSDOT unit bid analysis, and historical databases<br>• Equipment rates from RSMeans and personnel costs from Washington State L&I prevailing wage rates for King County<br>• O&M guidelines per SWMMWW, 2019 |
| Bioretention HPBSM | • King County University GSI, Puget Sound BMP cost database, WSDOT unit bid analysis, estimator and historical databases<br>• Equipment rates from RSMeans and personnel costs from Washington State L&I prevailing wage rates for King County<br>• O&M guidelines per SWMMWW, 2019 |
| Bioswale (treatment) | • Construction costs based on WRIA 9 Reports, WSDOT Unit Bid Analysis, SPU/County and estimator and historical databases<br>• Equipment rates from RSMeans and personnel costs from Washington State L&I prevailing wage rates for King County<br>• O&M guidelines per SWMMWW, 2019 |
| Media filter drains | • King County University GSI, Puget Sound BMP cost database, WSDOT unit bid analysis, and historical databases<br>• O&M guidelines per SWMMWW, 2019 |
| Drywell | • King County University GSI, Puget Sound BMP cost database, WSDOT unit bid analysis, and historical databases<br>• O&M guidelines per KCSWDM, 2016 and SSWM 2021 |

**Table 5 (continued). Cost Data Summary.**

| Action | Cost Source |
|---|---|
| Deep UIC wells | • Construction costs based on University GSI report, Puget Sound BMP cost database, and estimator and historical cost database<br>• O&M guidelines per KCSWDM, 2016 and SSWM 2021 |
| Permeable pavement | • Construction costs based on University GSI report and estimator and historical cost database<br>• O&M guidelines per SWMMWW, 2019 |
| Depaving (removal of impervious surface) | • Construction costs based on SPU/County and estimator and historical database<br>• O&M minimal and based on professional judgment |
| Detention vault | • Construction costs based on WSDOT Unit Bid Analysis, vendor quotes, SPU/County and estimator and historical databases<br>• Equipment rates from RSMeans and personnel costs from Washington State prevailing wage rates<br>• O&M guidelines per SWMMWW, 2019 |
| Detention pond | • Construction costs based on WSDOT Unit Bid Analysis, vendor quotes, SPU/County and estimator and historical databases<br>• Equipment rates from RSMeans and personnel costs from Washington State prevailing wage rates<br>• O&M guidelines per SWMMWW, 2019 |
| Infiltration pond | • King County University GSI, Puget Sound BMP cost database, WSDOT unit bid analysis, estimator and historical databases<br>• O&M guidelines per SWMMWW, 2019 |
| Infiltration vault | • Construction costs based on WSDOT Unit Bid Analysis, tabula, vendor quotes, SPU/County and estimator and historical databases<br>• O&M guidelines per SWMMWW, 2019 |
| Cistern | • City of Seattle and King County RainWise program costs, vendor cost information, and online sources including https://www.700milliongallons.org/rainwise/ (SPU and King County 2020)<br>• O&M guidelines per SWMMWW, 2019 and KCSWDM, 2016 |
| Wet pond | • King County University GSI, Puget Sound BMP cost database, WSDOT unit bid analysis, estimator and historical databases<br>• Equipment rates from RSMeans and personnel costs from Washington State prevailing wage rates<br>• O&M guidelines per SWMMWW, 2019 |
| Wet vault | • Construction costs based on WSDOT Unit Bid Analysis, vendor quotes, SPU/County and estimator and historical databases<br>• O&M guidelines per SWMMWW, 2019 |
| Stormwater treatment wetland | • Construction costs based on Manchester Stormwater Retrofit (Kitsap County), King County University GSI, Puget Sound BMP cost database, WSDOT unit bid analysis, Puget Sound BMP Cost Database, SPU/County and estimator and historical databases<br>• Equipment rates from RSMeans and personnel costs from Washington State prevailing wage rates<br>• O&M guidelines per KCSWDM, 2016 |

**Table 5 (continued). Cost Data Summary.**

| Action | Cost Source |
|---|---|
| High-rate underground filter system and Stormwater Park | • Construction cost based on vendor quotes and estimator and historical databases<br>• Equipment rates from EquipmentWatch (Blue Book) and personnel costs from LCC model<br>• O&M guidelines per Kitsap County Operations and Maintenance Manual: Manchester Stormwater Park, 2015 |
| Sports field and park detention | • Construction cost based on vendor quotes, King County internet sources, and estimator and historical databases.<br>• Equipment rates from RSMeans and personnel costs from Washington State prevailing wage rates<br>• O&M guidelines per manufacturers requirements and O&M guidelines per SWMMWW. 2019 |
| Blue roof | • Construction cost based on vendor quotes, internet sources, and estimator and historical databases.<br>• Equipment rates from RSMeans and personnel costs from Washington State prevailing wage rates<br>• O&M guidelines per Philadelphia Stormwater Management Guidance Manual and online manufacturers requirements, and SWMMWW. 2019 |
| Compost amendment | • King County University GSI, Puget Sound BMP cost database, WSDOT unit bid analysis, estimator and historical databases.<br>• Equipment rates from RSMeans and personnel costs from Washington State L&I prevailing wage rates for King County<br>• O&M guidelines per SWMMWW, 2019 |
| Reforest High Density Development | • Puget Sound BMP cost database, WSDOT unit bid analysis, King County internet sources, estimator and historical databases.<br>• Equipment rates from RSMeans and personnel costs from Washington State L&I prevailing wage rates for King County<br>• O&M guidelines per SWMMWW, 2019 |
| Reforest Pervious Area | • Puget Sound BMP cost database, WSDOT unit bid analysis, King County internet sources, estimator and historical databases.<br>• Equipment rates from RSMeans and personnel costs from Washington State L&I prevailing wage rates for King County<br>• O&M guidelines per SWMMWW, 2019 |

# Summary of Costs by Unit Action

A summary of the costs for each Unit Action is provided in Table 6. Property acquisition costs, where shown, represent medium property costs as detailed in the Real Estate Cost section of this report.

**Table 6. Costs by Unit Action.**

| Action | Description | Action Unit Footprint Area | Design Drainage Area | Total Direct Construction Cost (a) | Property Acquisition Cost (b) | Total Indirect Non-Construction Cost (c) | Total Project Cost (d) | O&M Costs (Annual) (e) | Net Present Value 30-year Life-Cycle Cost (2023) |
|---|---|---|---|---|---|---|---|---|---|
| **Equations** | | | | | | | (a)+(b)+(c) | | PV(d)+PV(e) |
| **Green Stormwater Infrastructure (GSI)** | | | | | | | | | |
| Rain garden installation | WQBE 01_Rain Garden Installation on Property (Program) | 25 SF | Till 806 SF; Outwash 2,844 SF | $5,800 | $0 | $2,400 | $8,200 | $2,100 | $56,700 |
| Bioretention HPBSM planter installation | WQBE_02A_Bioretention Planter on Property | 25 SF | 2,357 SF | $18,700 | $0 | $7,800 | $26,500 | $2,800 | $86,600 |
| | WQBE_02B_Bioretention Planter in ROW | 25 SF | 2,357 SF | $25,800 | $0 | $10,700 | $36,500 | $2,800 | $96,600 |
| | WQBE_02C_Bioretention Planter with Property Cost | 25 SF | 2,357 SF | $18,700 | $2,011 | $10,100 | $28,800 | $2,800 | $88,900 |
| Bioretention HPBSM installation | WQBE_03A_Bioretention Underdrain on Property | 85 SF | 12,148 SF | $35,400 | $0 | $14,700 | $50,100 | $3,100 | $121,500 |
| | WQBE_03Aa_Bioretention Underdrain with Property Cost | 85 SF | 12,148 SF | $35,400 | $19,995 | $37,700 | $73,100 | $3,100 | $144,500 |
| | WQBE_03B_Bioretention No Underdrain on Property | 85 SF | 9,570 SF | $32,800 | $0 | $13,700 | $46,500 | $3,100 | $117,900 |
| | WQBE_03Bb_Bioretention No Underdrain with Property Cost | 85 SF | 9,570 SF | $32,800 | $19,995 | $36,600 | $69,400 | $3,100 | $140,800 |
| | WQBE_03C_Bioretention Underdrain in ROW | 85 SF | 12,148 SF | $63,900 | $0 | $26,400 | $90,300 | $3,100 | $161,700 |
| | WQBE_03D_Bioretention No Underdrain in ROW | 85 SF | 9,570 SF | $63,700 | $0 | $26,300 | $90,000 | $3,100 | $161,400 |
| Bioswale installation | WQBE_04A_Bioswale in ROW | 200 SF | 27,878 SF | $20,500 | $0 | $8,500 | $29,000 | $2,600 | $85,300 |
| | WQBE_04B_Bioswale on Public Property | 200 SF | 27,878 SF | $11,400 | $0 | $4,800 | $16,200 | $2,600 | $72,500 |
| | WQBE_04C_Bioswale with Property Cost | 200 SF | 27,878 SF | $11,400 | $59,116 | $72,700 | $84,100 | $2,600 | $140,400 |
| Media filter drains | WQBE_05A_Media Filter Drain Underdrain | 200 SF | 2,000 SF | $25,300 | $0 | $10,500 | $35,800 | $2,400 | $90,800 |
| | WQBE_05B_Media Filter Drain No Underdrain | 200 SF | 2,000 SF | $23,100 | $0 | $9,500 | $32,600 | $2,400 | $87,600 |
| Drywell | WQBE_06A_Drywell on Property | 13 SF | Till 261 SF; Outwash 780 SF | $14,000 | $0 | $5,800 | $19,800 | $1,000 | $41,400 |
| | WQBE_06B_Drywell on Outwash with Bioretention Planter on Property | Drywell is 13 SF; Planter is 4.3 SF | 395 SF | $30,200 | $0 | $12,600 | $42,800 | $1,500 | $76,000 |
| Deep UIC well | WQBE_07A_Deep UIC Well on Property | 42 SF | NA[a] | $40,400 | $0 | $16,800 | $57,200 | $900 | $75,900 |
| | WQBE_07B_Deep UIC Well in ROW | 42 SF | NA[a] | $58,000 | $0 | $23,900 | $81,900 | $900 | $100,600 |
| | WQBE_07C_Deep UIC Well with Property Cost | 42 SF | NA[a] | $40,400 | $2,011 | $19,100 | $59,500 | $900 | $78,200 |
| | WQBE_07D_Deep UIC Well with Filter in ROW | Well is 42 SF; Filter is 24 SF | 52,164 SF | $158,700 | $0 | $65,400 | $224,100 | $2,400 | $274,000 |
| | WQBE_07E_Deep UIC Well with Bioretention Planter in ROW | Well is 42 SF; Planter is 579 SF | 54,546 SF | $946,600 | $0 | $390,200 | $1,336,800 | $5,900 | $1,466,700 |
| | WQBE_07F_Deep UIC Well with Bioretention Planter on Property | Well is 42 SF; Planter is 579 SF | 54,546 SF | $811,500 | $0 | $337,600 | $1,149,100 | $5,900 | $1,279,600 |
| | WQBE_07G_Deep UIC Well with High Rate Underground Filter on Property | Well is 42 SF; Filter is 24 SF | 52,164 SF | $141,300 | $0 | $58,800 | $200,100 | $2,400 | $250,000 |
| Permeable pavement | WQBE_08A_Pervious Concrete Sidewalk (no sand layer) | 200 SF | 200 SF | $11,200 | $0 | $4,600 | $15,800 | $2,300 | $75,700 |
| | WQBE_08B_Porous Asphalt Driveway (with sand layer) | 200 SF | 200 SF | $5,900 | $0 | $2,400 | $8,300 | $2,300 | $63,800 |
| | WQBE_08C_Permeable Paver Driveway (with sand layer) | 200 SF | 200 SF | $7,800 | $0 | $3,200 | $11,000 | $2,300 | $68,400 |
| | WQBE_08D_Permeable Paver Plaza (no sand layer) | 200 SF | 200 SF | $6,700 | $0 | $2,800 | $9,500 | $2,300 | $64,800 |
| Depaving (removal of impervious surfaces) | WQBE_9A_Removal of Impervious Surfaces on Property (wheel strips) | 100 SF | 100 SF | $1,800 | $0 | $800 | $2,600 | $700 | $16,800 |
| | WQBE_9B_Removal of Impervious Surfaces on Property (no wheel strips) | 100 SF | 100 SF | $1,400 | $0 | $600 | $2,000 | $700 | $16,200 |

| Table 6 (continued). Costs by Unit Action. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Action** | **Description** | **Action Unit Footprint Area** | **Design Drainage Area** | **Total Direct Construction Cost (a)** | **Property Acquisition Cost (b)** | **Total Indirect Non-Construction Cost (c)** | **Total Project Cost (d)** | **O&M Costs (Annual) (e)** | **Net Present Value 30-year Life-Cycle Cost (2023)** |
| **Equations** | | | | | | | **(a)+(b)+(c)** | | **PV(d)+PV(e)** |
| **Stormwater Retention/Detention/Infiltration** | | | | | | | | | |
| Detention vault | WQBE_11A_Detention Vault on Public Property | 2,592 SF | 28,658 SF | $3,281,800 | $0 | $2,493,700 | $5,775,500 | $5,200 | $5,905,200 |
| | WQBE_11B_Detention Vault in ROW | 2,592 SF | 28,658 SF | $3,638,400 | $0 | $2,664,000 | $6,302,400 | $5,200 | $6,432,100 |
| | WQBE_11C_Detention Vault with Property Cost | 2,592 SF | 28,658 SF | $3,281,800 | $422,603 | $3,043,100 | $6,324,900 | $5,200 | $6,454,600 |
| Detention pond | WQBE_12A_Detention Pond on Public Property | 4,500 SF | 36,569 SF | $694,600 | $0 | $527,800 | $1,222,400 | $10,000 | $1,444,200 |
| | WQBE_12B_Detention Pond with Property Cost | 4,500 SF | 36,569 SF | $694,200 | $1,144,543 | $2,015,400 | $2,709,600 | $10,000 | $2,931,400 |
| Infiltration pond | WQBE_13A_Infiltration Pond Till Soil on Public Property | 2,785 SF | 36,595 SF | $500,500 | $0 | $380,300 | $880,800 | $5,900 | $1,016,100 |
| | WQBE_13B_Infiltration Pond Outwash Soil on Public Property | 1,479 SF | 46,396 SF | $448,200 | $0 | $340,600 | $788,800 | $3,700 | $878,000 |
| | WQBE_13C_Infiltration Pond Till Soil with Property Cost | 2,785 SF | 36,595 SF | $500,500 | $891,189 | $1,538,800 | $2,039,300 | $5,900 | $2,174,600 |
| | WQBE_13D_Infiltration Pond Outwash Soil with Property Cost | 1,479 SF | 46,396 SF | $448,200 | $891,189 | $1,499,100 | $1,947,300 | $3,700 | $2,036,500 |
| | WQBE_13E_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Public Property | Pond is 1,479 SF; Filter is 24 SF | 52,164 SF | $529,400 | $0 | $402,300 | $931,700 | $6,600 | $1,082,700 |
| | WQBE_13F_Infiltration Pond Outwash Soil with High Rate Underground Filter System with Property Cost | Pond is 1,479 SF; Filter is 24 SF | 52,164 SF | $529,400 | $893,119 | $1,563,300 | $2,092,700 | $6,600 | $2,243,700 |
| Infiltration vault | WQBE_14A_Infiltration Vault Till Soil on Public Property | 1,836 SF | 28,719 SF | $2,262,300 | $0 | $1,719,000 | $3,981,300 | $4,800 | $4,104,000 |
| | WQBE_14B_Infiltration Vault Outwash Soil on Public Property | 1,156 SF | 39,365 SF | $1,870,200 | $0 | $1,421,100 | $3,291,300 | $4,800 | $3,414,000 |
| | WQBE_14C_Infiltration Vault Till Soil in ROW | 1,836 SF | 28,719 SF | $2,782,300 | $0 | $2,038,800 | $4,821,100 | $4,800 | $4,943,800 |
| | WQBE_14D_Infiltration Vault Outwash Soil in ROW | 1,156 SF | 39,365 SF | $2,282,500 | $0 | $1,673,800 | $3,956,300 | $4,800 | $4,079,000 |
| | WQBE_14E_Infiltration Vault Till Soil with Property Cost | 1,836 SF | 28,719 SF | $2,262,300 | $340,082 | $2,161,200 | $4,423,500 | $4,800 | $4,546,200 |
| | WQBE_14F_Infiltration Vault Outwash Soil with Property Cost | 1,156 SF | 39,365 SF | $1,870,200 | $340,082 | $1,863,200 | $3,733,400 | $4,800 | $3,856,100 |
| | WQBE_14G_Infiltration Vault Outwash Soil with High Rate Underground Filter System in ROW | Vault is 1,156 SF; Filter is 24 SF | 52,164 SF | $2,211,100 | $0 | $1,621,700 | $3,832,800 | $6,600 | $3,992,400 |
| | WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System with Property Cost | Vault is 1,156 SF; Filter is 24 SF | 52,164 SF | $2,175,500 | $342,013 | $2,040,300 | $4,215,800 | $6,600 | $4,375,400 |
| | WQBE_14I_Infiltration Vault Outwash Soil with High Rate Underground Filter System on Property Cost | Vault is 1,156 SF; Filter is 24 SF | 52,164 SF | $2,175,500 | $0 | $1,595,700 | $3,771,200 | $6,600 | $3,930,800 |
| Cistern | WQBE_16_Cistern on Property | 18 SF | 1,300 SF | $21,600 | $0 | $9,000 | $30,600 | $700 | $46,100 |
| **Gray Stormwater Treatment** | | | | | | | | | |
| Wet pond | WQBE_18A_ Wet Pond on Public Property | 553 SF | 63,075 SF | $493,900 | $0 | $375,300 | $869,200 | $2,200 | $929,200 |
| | WQBE_18B_ Wet Pond with Property Cost | 553 SF | 63,075 SF | $493,900 | $615,475 | $1,175,400 | $1,669,300 | $2,200 | $1,729,300 |
| Wet vault | WQBE_19A_ Wet Vault on Public Property | 1,615 SF | 63,010 SF | $2,981,300 | $0 | $2,265,400 | $5,246,700 | $3,100 | $5,333,600 |
| | WQBE_19B_ Wet Vault in ROW | 1,615 SF | 63,010 SF | $3,342,400 | $0 | $2,447,900 | $5,790,300 | $3,100 | $5,877,200 |
| | WQBE_19C_ Wet Vault with Property Cost | 1,615 SF | 63,010 SF | $2,981,300 | $347,803 | $2,717,500 | $5,698,800 | $3,100 | $5,785,700 |
| Stormwater treatment wetland | WQBE_20A_ Stormwater Treatment Wetland on Public Property | 503 SF | 62,988 SF | $463,100 | $0 | $351,900 | $815,000 | $2,500 | $880,800 |
| | WQBE_20B_ Stormwater Treatment Wetland with Property Cost | 503 SF | 62,988 SF | $463,100 | $555,554 | $1,074,100 | $1,537,200 | $2,500 | $1,603,000 |

**Table 6 (continued). Costs by Unit Action.**

| Action | Description | Action Unit Footprint Area | Design Drainage Area | Total Direct Construction Cost (a) | Property Acquisition Cost (b) | Total Indirect Non-Construction Cost (c) | Total Project Cost (d) | O&M Costs (Annual) (e) | Net Present Value 30-year Life-Cycle Cost (2023) |
|---|---|---|---|---|---|---|---|---|---|
| **Equations** | | | | | | | (a)+(b)+(c) | | PV(d)+PV(e) |
| High-rate underground filter system | WQBE_21A_High Rate Underground Filter in Urban ROW PCCP | 16 SF | 34,956 SF | $147,500 | $0 | $60,800 | $208,300 | $2,500 | $262,000 |
| | WQBE_21B_High Rate Underground Filter in Highway ROW PCCP | 16 SF | 34,956 SF | $108,500 | $0 | $44,800 | $153,300 | $2,500 | $207,000 |
| | WQBE_21C_High Rate Underground Filter in Urban ROW HMA | 16 SF | 34,956 SF | $106,000 | $0 | $43,700 | $149,700 | $2,500 | $203,400 |
| | WQBE_21D_High Rate Underground Filter in Highway ROW HMA | 16 SF | 34,956 SF | $96,100 | $0 | $39,600 | $135,700 | $2,500 | $189,400 |
| | WQBE 21E_High Rate Underground Filter on Public Property | 16 SF | 34,956 SF | $73,300 | $0 | $30,500 | $103,800 | $2,500 | $157,500 |
| | WQBE 21F_High Rate Underground Filter with Property Cost | 16 SF | 34,956 SF | $73,300 | $1,287 | $32,000 | $105,300 | $2,500 | $159,000 |
| Stormwater park | WQBE_22A_Regional Vegetated Media SW Facility on Public Property | 5,940 SF | 17,249,760 SF | $4,021,600 | $0 | $3,672,400 | $7,694,000 | $11,300 | $8,006,000 |
| | WQBE_22B_Regional Vegetated Media SW Facility with Property Cost | 5,940 SF | 17,249,760 SF | $4,021,600 | $ 583,580 | $4,431,000 | $8,452,600 | $11,300 | $8,764,600 |
| **Phase 3 New Actions** | | | | | | | | | |
| Sports field and park detention | WQBE_23_Sports Field and Park Detention | 29,600 SF | 103,800 SF | $10,224,600 | $0 | $7,769,300 | $17,993,900 | $33,300 | $18,700,900 |
| Blue roof | WQBE_24_Blue Roof | 1,000 SF | 1,000 SF | $82,300 | $0 | $34,200 | $116,500 | $2,600 | $170,900 |
| Compost amendment | WQBE_25_Compost Amendment | 500 SF | 500 SF | $4,200 | $0 | $1,700 | $5,900 | 300 | $13,400 |
| Reforest High Density Development | WQBE_26A_Reforestation High Density Development - On Property | 43,560 SF | 43,560 SF | $11,075,000 | $0 | $8,415,500 | $19,490,500 | $3,300 | $19,577,100 |
| | WQBE26B_Reforestation High Density Development with Property Cost | 43,560 SF | 43,560 SF | $11,075,000 | $3,503,531 | $12,970,100 | $24,045,100 | $3,300 | $24,131,700 |
| Reforest Pervious Area | WQBE_26C_Reforestation Pervious Area on Property | 43,560 SF | 43,560 SF | $992,900 | $0 | $754,500 | $1,747,400 | $0 | $1,747,400 |
| | WQBE_26C_Reforestation Pervious Area with Property Cost | 43,560 SF | 43,560 SF | $992,900 | $3,503,531 | $5,309,100 | $6,302,000 | $0 | $6,302,000 |

N/A: Not Applicable

[a] Unit Drainage Area based on drainage area of pre-treatment Action

# Benchmarking and Cost Comparison

The Phase 3 cost models were compared to national cost modeling using the CLASIC Tool and benchmarked against peer projects and programs.

## Benchmark Evaluation

Cost models used for the WQBE Actions were evaluated against peer projects and programs. The results of Phase 1 and Phase 2 benchmarking evaluations prepared by Lotus Water are documented in the *Program Cost Benchmarking* TM (Lotus Water 2021a), hereafter called the Benchmarking TM and Benchmarking TM supplemental (Lotus Water 2021b). A copy of the Benchmarking TM and supplemental TM are included as an attachment to TM 431-TM1 Appendix D.

During Phase 3 Lotus Water provided peer review and input as the prior Action cost models (carried forward from Phase 2) were updated and during cost model development for new Actions (blue roof, composting, sports field, and reforestation).

## CLASIC Cost Model Comparison

A high-level comparison was conducted between the CLASIC Tool–reported costs and WQBE Phase 3 cost modeling used to support SUSTAIN modeling. CLASIC is a screening tool that aids to support planning of stormwater infrastructure through the lenses of LCCs, co-benefits, and performance. The CLASIC Tool was used to develop an LCC comparison for two GSI actions, bioretention and wet pond. The CLASIC LCCs were compared to WQBE_02A_Bioretention Planter with Underdrain on Property, and WQBE_13B_Infiltration Pond Outwash Soil on Public Property. Table 7 presents a comparison between the CLASIC Tool and the WQBE LCC cost development assumptions for similar Actions.

**Table 7. Facility Model Input Values CLASIC and WQBE.**

| Model Input Category | CLASIC Bioretention | WQBE 2A Bioretention on Property | CLASIC Wet Pond | WQBE 13B Infiltration Pond on Public Property |
|---|---|---|---|---|
| Ponding depth (in) | 6 | 6 | 24 | 48 |
| Filter media depth (in) | 18 | 18 | - | - |
| Captured depth (in) | 0.15 | - | 1.85 | - |
| Storage capacity (CF) | 29 | 29 | 7,214 | 7,214 |
| Maintenance considerations | Diverse vegetation, 3-month irrigation season. | Crew of 2 with 2 visits/year to remove trash and sediment, mulch and plant replacement (no mowing). | Seeded with routine mowing season 6 mo/yr and 3 mo irrigation season. | Crew of 2 with 2 visits/year to remove trash and sediment, tree replacement, fix erosion and reseed (no mowing). |

Both the CLASIC Tool and WQBE Action LCC models were developed using a 30-year period. Table 8 provides a comparison between the LCC model values and outlines differences in the model assumptions.

**Table 8. CLASIC 30-year LCC Results and WQBE Cost Comparison.**

| Model type | CLASIC | WQBE 2A | CLASIC | WQBE 13B |
|---|---|---|---|---|
| Description | Bioretention | Bioretention planter on property | Wet pond | Infiltration pond (outwash soil) on public property |
| Initial portfolio cost | Part of a capital project $2,000,000 | Part of a capital project (10M to <$20M) | Part of a capital project $2,000,000 | Part of a capital project (10M to <$20M) |
| Number of units | 100 SF bottom area | 1 unit at 25 SF bottom area | 5,000 SF bottom area | 1 unit at 2,785 SF bottom area |
| Construction cost/unit (2023 dollars) | $14,100 | $18,700 | $67,700 | $500,500 |
| Annual O&M cost | $367 | $2,800 | $3,400- | $5,900 |
| NPV/unit | $19,660 | $85,300 | $119,205 | $1,016,100 |
| No. of units at NPV with $20M capital investment | 1,020 | 230 | 170 | 20 |

The cost model comparison indicates some similarity between direct construction costs for CLASIC Tool bioretention and WQBE bioretention planter but reported a large cost difference between CLASIC Tool wet pond and WQBE infiltration pond. Noted differences in the cost models for initial capital construction cost, annual O&M cost, and NPV/unit cost were as follows:

- CLASIC Tool and WQBE initial capital cost were driven by design basis assumptions.
  - CLASIC Tool adopts generalized design basis assumptions for both bioretention and wet pond facilities. Costs are based on generalized national costs.
  - WQBE costs were developed based on County design standards and use costs that are specific to King County and the Seattle area.
  - CLASIC bioretention and WQBE bioretention designs appeared to share similar design basis assumptions.
  - CLASIC wet pond and WQBE infiltration pond were not comparable in design basis and construction cost approach.
- CLASIC Tool used an outlined basin area with selections limited to “small, medium, or large” facilities and did not allow for input of a specific facility bottom area footprint size. WQBE facilities were set to a specific (small) bottom area footprint that supported SUSTAIN modeling over a broad area.
- Annual O&M costs for CLASIC Tool were set over a seasonal window (e.g., 3-month window for bioretention). WQBE O&M costs were set over a 12-month window and based on specific activities (including time, equipment, and materials) and based on information provided by King County WTD operations and recommendations from the SWMMWW.
- NPV costs for bioretention was not comparable between CLASIC Tool and WQBE cost models and may be attributed to differences in annual O&M assumptions.

The CLASIC Tool contained few GSI cost selections and was developed to reflect generalized design basis and O&M costs assumptions. Initial capital cost and LCC developed with the CLASIC Tool offered limited comparison or were not considered directly comparable to the area-specific design basis and localized cost model assumptions used are WQBE cost model development.

## Recommendations and Considerations

Many of the recommendations to normalize costs for small facilities were implemented with the Phase 3 Action cost models. The Herrera team met with Lotus Water to review the Phase 3 cost modeling approach (see Attachment C for Benchmarking Review Form). Actions that the County may consider taking in future phases of work include:

- Detention Vault unit costs were high compared to Evans Creek.  It was recommended that the ratio to dead storage vs. live storage be evaluated for the vault actions (#11 14, & 19), which can be a cost driver.  It is recommended that the storage depth/small storage volume assumptions be evaluated using a depth to storage cost sensitivity analysis or in comparison with existing regional facility installations within King County or western Washington.
- Costs for Detention Pond, Infiltration Pond, Wet Pond, and Stormwater Treatment Wetland Actions (#12, 13, 18, and 20) were driven by coupling a smaller facility footprint with minimum to low storage depth for the facility area. It is recommended that the pond Unit Action cost models design basis and approach be revisited using a larger scale or more regionalized type of facility.
- Life cycle costs include replacement of Actions within the 30 year period. Replacement costs were not prorated for replacement beyond the 30 year period. County may consider calculating prorated replacement costs in future phases of work.

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# Attachment A

## Cost Estimates with Life-Cycle Cost Analysis

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# Attachment B

## Cost Estimates with Life-Cycle Cost Analysis Workbooks

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# Attachment C

## Benchmarking Review Form

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**Description: WQBE 01 - Rain Garden Installation On Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 25 | ft2 |
| **Initial Capital Cost** | **$ 8,200** | |
| Capital cost | $ 328 | $/Unit |
| Total Direct O&M/Year | $ 1,360 | |
| Direct O&M cost | $ 54.39 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 3,528 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 56,700** | **$/unit** |
| **Annual O&M Cost** | **$ 2,100** | **$/year** |
| Annualized Cost | $1,220 | $/year |

**Materials, Supplies, Other Costs**

| | | | | |
|---|---|---|---|---|
| | | $ - | $/year | |
| Mulch and Media Replacement | 2023 dollars | $ 270 | $/year | |
| | 2023 dollars | $ 500 | $/year | |
| Subtotal | | $770 | | |
| Labor | | | | |
| Remove Trash | 2 | hr | | |
| Plant Health | 4 | hr | | |
| Remediation of erosion | 4 | hr | | |
| | 0 | hr | | |
| **Total hours per year** | 10 | | | |
| Raw Labor Rate/Hr | | $ 54 | | |
| Raw labor cost | (embedded) | $ 544 | | |
| Labor cost, burdened | O/H 150.0% | $ 1,360 | $ | 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | | |
| Life Cycle Period: | 30 | years | | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 36,633 | | $ 64,691 | **$116,581** | **$ 56,739** | | | |
| 0 | 1.000 | **$ 8,200** | | | $8,200 | $ 8,200 | $ 8,200 | $ 8,200 | $ 56,739 |
| 1 | 0.950 | $770 | $ - | $ 1,360 | $2,130 | $ 2,024 | $ 10,330 | $ 10,224 | $ 48,539 |
| 2 | 0.903 | $ 793 | $ - | $ 1,401 | $ 2,194 | $ 1,980 | $ 12,523 | $ 12,204 | $ 46,516 |
| 3 | 0.858 | $ 817 | $ - | $ 1,443 | $ 2,259 | $ 1,938 | $ 14,783 | $ 14,142 | $ 44,536 |
| 4 | 0.815 | $ 841 | $ - | $ 1,486 | $ 2,327 | $ 1,896 | $ 17,110 | $ 16,038 | $ 42,598 |
| 5 | 0.774 | $ 867 | $ - | $ 1,530 | $ 2,397 | $ 1,856 | $ 19,507 | $ 17,894 | $ 40,701 |
| 6 | 0.736 | $ 893 | $ - | $ 1,576 | $ 2,469 | $ 1,816 | $ 21,976 | $ 19,710 | $ 38,845 |
| 7 | 0.699 | $ 919 | $ - | $ 1,624 | $ 2,543 | $ 1,777 | $ 24,519 | $ 21,488 | $ 37,029 |
| 8 | 0.664 | $ 947 | $ - | $ 1,672 | $ 2,619 | $ 1,739 | $ 27,138 | $ 23,227 | $ 35,252 |
| 9 | 0.631 | $ 975 | $ - | $ 1,722 | $ 2,698 | $ 1,702 | $ 29,836 | $ 24,930 | $ 33,512 |
| 10 | 0.599 | $ 1,005 | $ 3,528 | $ 1,774 | $ 6,307 | $ 3,781 | $ 36,144 | $ 28,711 | $ 31,810 |
| 11 | 0.570 | $ 1,035 | $ - | $ 1,827 | $ 2,862 | $ 1,630 | $ 39,006 | $ 30,341 | $ 28,029 |
| 12 | 0.541 | $ 1,066 | $ - | $ 1,882 | $ 2,948 | $ 1,595 | $ 41,954 | $ 31,936 | $ 26,399 |
| 13 | 0.514 | $ 1,098 | $ - | $ 1,939 | $ 3,037 | $ 1,561 | $ 44,990 | $ 33,498 | $ 24,803 |
| 14 | 0.489 | $ 1,131 | $ - | $ 1,997 | $ 3,128 | $ 1,528 | $ 48,118 | $ 35,026 | $ 23,242 |
| 15 | 0.464 | $ 1,165 | $ - | $ 2,057 | $ 3,221 | $ 1,495 | $ 51,339 | $ 36,521 | $ 21,714 |
| 16 | 0.441 | $ 1,200 | $ - | $ 2,118 | $ 3,318 | $ 1,463 | $ 54,658 | $ 37,984 | $ 20,219 |
| 17 | 0.419 | $ 1,236 | $ - | $ 2,182 | $ 3,418 | $ 1,432 | $ 58,075 | $ 39,416 | $ 18,755 |
| 18 | 0.398 | $ 1,273 | $ - | $ 2,247 | $ 3,520 | $ 1,401 | $ 61,595 | $ 40,818 | $ 17,323 |
| 19 | 0.378 | $ 1,311 | $ - | $ 2,315 | $ 3,626 | $ 1,371 | $ 65,221 | $ 42,189 | $ 15,922 |
| 20 | 0.359 | $ 1,350 | $ 3,528 | $ 2,384 | $ 7,263 | $ 2,610 | $ 72,484 | $ 44,799 | $ 14,550 |
| 21 | 0.341 | $ 1,391 | $ - | $ 2,456 | $ 3,847 | $ 1,313 | $ 76,331 | $ 46,113 | $ 11,940 |
| 22 | 0.324 | $ 1,432 | $ - | $ 2,530 | $ 3,962 | $ 1,285 | $ 80,293 | $ 47,398 | $ 10,627 |
| 23 | 0.308 | $ 1,475 | $ - | $ 2,605 | $ 4,081 | $ 1,258 | $ 84,373 | $ 48,656 | $ 9,341 |
| 24 | 0.293 | $ 1,520 | $ - | $ 2,684 | $ 4,203 | $ 1,231 | $ 88,577 | $ 49,887 | $ 8,084 |
| 25 | 0.278 | $ 1,565 | $ - | $ 2,764 | $ 4,329 | $ 1,205 | $ 92,906 | $ 51,092 | $ 6,853 |
| 26 | 0.264 | $ 1,612 | $ - | $ 2,847 | $ 4,459 | $ 1,179 | $ 97,365 | $ 52,270 | $ 5,648 |
| 27 | 0.251 | $ 1,661 | $ - | $ 2,932 | $ 4,593 | $ 1,154 | $ 101,958 | $ 53,424 | $ 4,469 |
| 28 | 0.239 | $ 1,710 | $ - | $ 3,020 | $ 4,731 | $ 1,129 | $ 106,689 | $ 54,553 | $ 3,315 |
| 29 | 0.227 | $ 1,762 | $ - | $ 3,111 | $ 4,873 | $ 1,105 | $ 111,562 | $ 55,658 | $ 2,186 |
| 30 | 0.215 | $ 1,815 | $ - | $ 3,204 | $ 5,019 | $ 1,081 | $ 116,581 | $ 56,739 | $ 1,081 |

**Description: WQBE 01 - Rain Garden Installation On Property**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.

Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

2 Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a one person using hand tools (1 hour at 2 times per year).

4 Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by one person using hand tools (1 hour at 4 times per year).

4 Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit).

**Replacement Assumptions:**

Media and Mulch Replacement at $270/year

Annual plant replacement will cost $500. Comprised of (10) small plant replacements at $50/each.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Royce Robertson (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_01 - Rain Garden Installation On Property (Program) | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| | ***Rain Garden Installation*** | *25* | *SF* | | $ - |
| | *Rain Garden Length* | 7 | LF | | $ - |
| | *Rain Garden Width* | 4 | LF | | $ - |
| | *GSI Facility (3.5'WX7.1'L bottom dimensions)* | 25 | SF | | $ - |
| | *Top Dimensions @ 3:1 Side Slopes (9.5'WX13.1'L)* | 125 | SF | | $ - |
| | *Rain Garden Excavation Depth* | 1.3 | FT | | $ - |
| | Facility Excavation to Waste | 4 | CY | $ 79 | $ 285 |
| | Mulch Compost est @ 0.3' and tilled to 8" depth | 1 | CY | $ 60 | $ 83 |
| | Rain Garden Landscape | 14 | SY | $ 225 | $ 3,124 |
| | Grass seeding and restoration of are disturbed by construction | 14 | SY | $ 10 | $ 139 |
| | | | | | $ - |
| | **Additional Costs** | | | | $ - |
| | Removals @ 4% Construction Costs | 4.0% | LS | $ 3,632 | $ 145 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | | | $ 3,777 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| General Conditions | | | 0% | 1 | $ - |
| Mobilization/Demobilization | | | 10% | 1.1 | $ 378 |
| Overhead & Profit (OHP) | | | 0% | 1 | $ - |
| Insurance | | | 0.0% | 1 | $ - |
| Bonding | | | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | | | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | | | $ 4,155 |
| ***Direct: Subtotal Construction Costs (25 SF Area)*** | | | | | ***$ 4,155*** |

**Description: WQBE 01 - Rain Garden Installation (On Property) - Program**

A shallow, landscaped depression with compost-amended native soils and adapted plants. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas, and to allow stormwater to pass through the amended soil profile.

**Cost Estimating Assumptions:**

Facility design is per Seattle Stormwater Manual, "Rain Garden" (Volume 3 Section 5.4.5)
It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.
Treatment media is 3" of compost tilled in to the top 8" of soil depth.
The facility bottom treatment area is 25 sf with a 2:1 L:W ratio and 3:1 (run:rise) minimum side slopes
A maximum ponding depth of 6" with a 6" minimum freeboard depth are assumed.
The facility does not have an underdrain.
Seeded grass restoration is assumed for disturbed areas
Removals are estimated at 4% of the item construction costs.
It is assumed that all stormwater is maintained on the property and not TESC is needed.
The facility is located on property and it is assumed that traffic control is not required
A street use permit is not required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Steven Van Loo (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_02A - Bioretention Planter On Property | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Bioretention Planter with Underdrain on Property (25 SF Bottom Area) | 25 | SF | $ 535 | $ 13,375 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 13,375*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 2,006 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 15,381*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 1,538 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 16,919*** |
| | | | | Construction Sales Tax | $ 1,734 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 18,700*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 2,030 |
| | | | | Construction Management | $ 1,354 |
| | | | | Permitting & Support | $ 85 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 846 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 4,314*** |
| | | | | Project Contingency | $ 3,452 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 7,800*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 26,500*** |

**Description: WQBE 02A - Bioretention Planter on Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 25 | ft2 |
| **Initial Capital Cost** | **$ 26,500** | |
| Capital cost | $ 1,060 | $/Unit |
| Total Direct O&M/Year | $ 2,176 | |
| Direct O&M cost | $ 87.02 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 636 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 86,600** | **$/unit** |
| **Annual O&M Cost** | **$ 2,800** | **$/year** |
| Annualized Cost | $1,000 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Annual plant replacement | 2023 dollars | $ 270 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $630 | |
| Labor | | | |
| Remove Trash | 4 | hr | |
| Plant Health | 8 | hr | |
| Remediation of erosion | 4 | hr | |
| | 0 | hr | |
| **Total hours per year** | 16 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 870 | |
| Labor cost, burdened | O/H 150.0% | $ 2,176 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 29,973 | | $ 103,505 | **$161,250** | **$ 86,596** | | | |
| 0 | 1.000 | **$ 26,500** | | | $26,500 | $ 26,500 | $ 26,500 | $ 26,500 | $ 86,596 |
| 1 | 0.950 | $630 | $ - | $ 2,176 | $ 2,806 | $ 2,666 | $ 29,306 | $ 29,166 | $ 60,096 |
| 2 | 0.903 | $ 649 | $ - | $ 2,241 | $ 2,890 | $ 2,609 | $ 32,195 | $ 31,774 | $ 57,431 |
| 3 | 0.858 | $ 668 | $ - | $ 2,308 | $ 2,976 | $ 2,553 | $ 35,172 | $ 34,327 | $ 54,822 |
| 4 | 0.815 | $ 688 | $ - | $ 2,377 | $ 3,066 | $ 2,498 | $ 38,238 | $ 36,826 | $ 52,269 |
| 5 | 0.774 | $ 709 | $ - | $ 2,449 | $ 3,158 | $ 2,445 | $ 41,395 | $ 39,270 | $ 49,771 |
| 6 | 0.736 | $ 730 | $ - | $ 2,522 | $ 3,252 | $ 2,393 | $ 44,648 | $ 41,663 | $ 47,326 |
| 7 | 0.699 | $ 752 | $ - | $ 2,598 | $ 3,350 | $ 2,342 | $ 47,998 | $ 44,005 | $ 44,933 |
| 8 | 0.664 | $ 775 | $ - | $ 2,676 | $ 3,451 | $ 2,291 | $ 51,448 | $ 46,296 | $ 42,592 |
| 9 | 0.631 | $ 798 | $ - | $ 2,756 | $ 3,554 | $ 2,242 | $ 55,002 | $ 48,539 | $ 40,300 |
| 10 | 0.599 | $ 822 | $ 636 | $ 2,839 | $ 4,297 | $ 2,576 | $ 59,299 | $ 51,115 | $ 38,058 |
| 11 | 0.570 | $ 847 | $ - | $ 2,924 | $ 3,770 | $ 2,148 | $ 63,070 | $ 53,262 | $ 35,482 |
| 12 | 0.541 | $ 872 | $ - | $ 3,012 | $ 3,884 | $ 2,102 | $ 66,954 | $ 55,364 | $ 33,334 |
| 13 | 0.514 | $ 898 | $ - | $ 3,102 | $ 4,000 | $ 2,057 | $ 70,954 | $ 57,421 | $ 31,232 |
| 14 | 0.489 | $ 925 | $ - | $ 3,195 | $ 4,120 | $ 2,013 | $ 75,074 | $ 59,433 | $ 29,176 |
| 15 | 0.464 | $ 953 | $ - | $ 3,291 | $ 4,244 | $ 1,970 | $ 79,318 | $ 61,403 | $ 27,163 |
| 16 | 0.441 | $ 982 | $ - | $ 3,390 | $ 4,371 | $ 1,928 | $ 83,689 | $ 63,331 | $ 25,193 |
| 17 | 0.419 | $ 1,011 | $ - | $ 3,491 | $ 4,502 | $ 1,886 | $ 88,191 | $ 65,217 | $ 23,265 |
| 18 | 0.398 | $ 1,041 | $ - | $ 3,596 | $ 4,637 | $ 1,846 | $ 92,828 | $ 67,063 | $ 21,379 |
| 19 | 0.378 | $ 1,073 | $ - | $ 3,704 | $ 4,776 | $ 1,807 | $ 97,604 | $ 68,870 | $ 19,533 |
| 20 | 0.359 | $ 1,105 | $ 636 | $ 3,815 | $ 5,556 | $ 1,997 | $ 103,160 | $ 70,867 | $ 17,726 |
| 21 | 0.341 | $ 1,138 | $ - | $ 3,929 | $ 5,067 | $ 1,730 | $ 108,228 | $ 72,597 | $ 15,729 |
| 22 | 0.324 | $ 1,172 | $ - | $ 4,047 | $ 5,219 | $ 1,693 | $ 113,447 | $ 74,290 | $ 13,999 |
| 23 | 0.308 | $ 1,207 | $ - | $ 4,169 | $ 5,376 | $ 1,657 | $ 118,823 | $ 75,947 | $ 12,306 |
| 24 | 0.293 | $ 1,243 | $ - | $ 4,294 | $ 5,537 | $ 1,622 | $ 124,360 | $ 77,569 | $ 10,649 |
| 25 | 0.278 | $ 1,281 | $ - | $ 4,423 | $ 5,703 | $ 1,587 | $ 130,063 | $ 79,156 | $ 9,027 |
| 26 | 0.264 | $ 1,319 | $ - | $ 4,555 | $ 5,874 | $ 1,553 | $ 135,937 | $ 80,709 | $ 7,440 |
| 27 | 0.251 | $ 1,359 | $ - | $ 4,692 | $ 6,051 | $ 1,520 | $ 141,988 | $ 82,229 | $ 5,887 |
| 28 | 0.239 | $ 1,399 | $ - | $ 4,833 | $ 6,232 | $ 1,487 | $ 148,220 | $ 83,716 | $ 4,367 |
| 29 | 0.227 | $ 1,441 | $ - | $ 4,978 | $ 6,419 | $ 1,456 | $ 154,639 | $ 85,172 | $ 2,880 |
| 30 | 0.215 | $ 1,485 | $ - | $ 5,127 | $ 6,612 | $ 1,424 | $ 161,250 | $ 86,596 | $ 1,424 |

**Description: WQBE 02A - Bioretention Planter on Property**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by
4 a crew of two using hand tools (2 visits per year, 1 hour per visit).
Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per
8 year, 1 hour per visit).
Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per
4 visit).
Annual mulch and plan replacements 5 plants at $54/Plant
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Replacement Assumptions:**

Replacement of treatment media, compost, and vegatation will take place every ten years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Steven Van Loo (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_02A - Bioretention Planter On Property | | | **Version:** | 2 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Bioretention Planter on Property Bottom Area** | 125 | SF | | $ - |
| 2 | **Curbed, vertical sides - Top Area** | 125 | SF | | $ - |
| 3 | **Bioretention Planter Length** | 25 | LF | | $ - |
| 4 | **Bioretention Planter: Width** | 5 | LF | | $ - |
| 5 | **Bioretention Planter: Depth** | 5.4 | LF | | $ - |
| 6 | Structural Excavation to Waste | 98 | CY | $ 79 | $ 7,753 |
| 7 | Imported Structural Fill | 64 | CY | $ 44 | $ 2,818 |
| 8 | Formed Concrete Walls (6" Thick) | 6 | CY | $ 1,560 | $ 9,886 |
| 9 | Formed Concrete Base (6" thick) | 3 | CY | $ 590 | $ 1,704 |
| 10 | Treatment Media (18" Thick)w biochar | 7 | CY | $ 270 | $ 1,875 |
| 11 | Mulch Compost (@ 0.3'D) | 1 | CY | $ 86 | $ 119 |
| 12 | Vegetated Entrance | 2 | SY | $ 10 | $ 22 |
| 13 | Trench Shoring Facility (Shallow) | 400 | SF | $ 10 | $ 4,000 |
| 14 | | | | | $ - |
| 15 | **Underdrain Items:** | 25 | LF | | $ - |
| 16 | Underdrain Aggregate (2.2' Thick) | 10 | CY | $ 133 | $ 1,355 |
| 17 | Overflow & Drain Pipe Pipe 8" Dia. (Length + 4') | 29 | LF | $ 48 | $ 1,392 |
| 18 | | | | | $ - |
| 19 | **Restoration:** | | | | $ - |
| 20 | Landscaping, Planting, and Restoration | 58 | SY | $ 59 | $ 3,442 |
| 21 | Trees (Not in Design Basis) | 0 | EA | $ 720 | $ - |
| 22 | | | | | $ - |
| 23 | **Outlet Pipe** | | | | $ - |
| 24 | Pipe 8" Diameter | 50 | LF | $ 80 | $ 4,000 |
| 25 | 5' Wide Trench x 7'D to waste | 65 | CY | $ 79 | $ 5,120 |
| 26 | Trench Box Shoring (Shallow) | 800 | SF | $ 10 | $ 8,000 |
| 27 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 28 | Parking Lot Pavement Patch HMA 4" HM/4"CSBC | 28 | SY | $ 71 | $ 1,972 |
| 29 | | | | | $ - |
| 30 | **Additional Costs** | | | | $ - |
| 31 | Removals @ 4% Construction Costs | 4.0% | LS | $ 57,358 | $ 2,294 |
| 32 | TESC @2% Construction Costs | 2% | LS | $ 59,653 | $ 1,193 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 60,846 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 6,085 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 66,930 |
| | | ***Direct: Subtotal Construction Costs (125 SF Area)*** | ***$ 66,930*** |

**Description: WQBE 2A - Bioretention Planter With Underdrain on Property**

Designed soil mix and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants within a vertical walled container usually constructed from formed concrete, but could include other materials. These designs are often used in ultra-urban settings. For this analysis, the Action is assumed to have an underdrain and closed bottom.

**Cost Estimating Assumptions:**

Bioretention planter installation is per the Seattle Stormwater Manual, "Non-infiltrating Bioretention" (Volume 3 Section 5.8.2)
It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.
Filter fabrics not used between the subgrade and the Bioretention Soil Mix
Facility is sited in an open space with outlet pipe beneath a parking area
18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.
0.3' of composted media is included.
The facility treatment area has curbed, vertical sides.
A bioretention planter with a 125 sf area (5' wide by 10 ' long) was selected to represent a typical installation size. The 125 s.f. facility subtotal construction costs were then scaled to represent the selected Action Item area of 25 sf.
A maximum ponding depth of 6" and a 6" of freeboard depth are assumed.
Facilities have a closed bottom and include an underdrain.
A total of 50 LF of 8" storm pipe is required to connect to the downstream main or structure.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the box.
Trench Box shoring is used.
Parking lot restoration is assumed for the outlet pipe and consists of 4" HMA/4" CSTC.
Concrete curb, gutter, and sidewalk removal and restoration will not be required for the installation.
Landscape restoration is required for the facility, earth berm and area of disturbance.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on Property and Traffic control is not required.
A street use permit is not required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Steven Van Loo (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_02B - Bioretention Planter In ROW | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Bioretention Planter with Underdrain in ROW (25 SF Bottom Area) | 25 | SF | $ 710 | $ 17,750 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 17,750*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 2,663 |
| | | | Street Use Permit (Y/N) | Y | $ 700 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 21,113*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 2,041 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 23,154*** |
| | | | | Construction Sales Tax | $ 2,302 |
| | | | | Outside Agency Construction | $ 355 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 25,800*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 2,778 |
| | | | | Construction Management | $ 1,852 |
| | | | | Permitting & Support | $ 116 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 1,158 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 5,904*** |
| | | | | Project Contingency | $ 4,756 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 10,700*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 36,500*** |

**Description: WQBE 02B - Bioretention Planter In ROW (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 25 | ft2 |
| **Initial Capital Cost** | **$ 36,500** | |
| Capital cost | $ 1,460 | $/Unit |
| Total Direct O&M/Year | $ 2,176 | |
| Direct O&M cost | $ 87.02 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 636 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 96,600** | **$/unit** |
| **Annual O&M Cost** | **$ 2,800** | **$/year** |
| Annualized Cost | $4,450 | $/year |

**Materials, Supplies, Other Costs**

| | | | | |
|---|---|---|---|---|
| | $ - | $ - | $/year | |
| Annual plant and mulch replacement | 2023 dollars | $ 270 | $/year | |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year | |
| Subtotal | | $630 | | |
| Labor | | | | |
| Remove Trash | 4 | hr | | |
| Plant Health | 8 | hr | | |
| Remediation of erosion | 4 | hr | | |
| | | hr | | |
| **Total hours per year** | 16 | | | |
| Raw Labor Rate/Hr | | $ 54 | | |
| Raw labor cost | (embedded) | $ 870 | | |
| Labor cost, burdened | O/H 150.0% | $ 2,176 | $ | 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | | |
| Life Cycle Period: | 30 | years | | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 29,973 | | $ 103,505 | **$171,250** | **$ 96,596** | | | |
| 0 | 1.000 | **$ 36,500** | | | $36,500 | $ 36,500 | $ 36,500 | $ 36,500 | $ 96,596 |
| 1 | 0.950 | $630 | $ - | $ 2,176 | $ 2,806 | $ 2,666 | $ 39,306 | $ 39,166 | $ 60,096 |
| 2 | 0.903 | $ 649 | $ - | $ 2,241 | $ 2,890 | $ 2,609 | $ 42,195 | $ 41,774 | $ 57,431 |
| 3 | 0.858 | $ 668 | $ - | $ 2,308 | $ 2,976 | $ 2,553 | $ 45,172 | $ 44,327 | $ 54,822 |
| 4 | 0.815 | $ 688 | $ - | $ 2,377 | $ 3,066 | $ 2,498 | $ 48,238 | $ 46,826 | $ 52,269 |
| 5 | 0.774 | $ 709 | $ - | $ 2,449 | $ 3,158 | $ 2,445 | $ 51,395 | $ 49,270 | $ 49,771 |
| 6 | 0.736 | $ 730 | $ - | $ 2,522 | $ 3,252 | $ 2,393 | $ 54,648 | $ 51,663 | $ 47,326 |
| 7 | 0.699 | $ 752 | $ - | $ 2,598 | $ 3,350 | $ 2,342 | $ 57,998 | $ 54,005 | $ 44,933 |
| 8 | 0.664 | $ 775 | $ - | $ 2,676 | $ 3,451 | $ 2,291 | $ 61,448 | $ 56,296 | $ 42,592 |
| 9 | 0.631 | $ 798 | $ - | $ 2,756 | $ 3,554 | $ 2,242 | $ 65,002 | $ 58,539 | $ 40,300 |
| 10 | 0.599 | $ 822 | $ 636 | $ 2,839 | $ 4,297 | $ 2,576 | $ 69,299 | $ 61,115 | $ 38,058 |
| 11 | 0.570 | $ 847 | $ - | $ 2,924 | $ 3,770 | $ 2,148 | $ 73,070 | $ 63,262 | $ 35,482 |
| 12 | 0.541 | $ 872 | $ - | $ 3,012 | $ 3,884 | $ 2,102 | $ 76,954 | $ 65,364 | $ 33,334 |
| 13 | 0.514 | $ 898 | $ - | $ 3,102 | $ 4,000 | $ 2,057 | $ 80,954 | $ 67,421 | $ 31,232 |
| 14 | 0.489 | $ 925 | $ - | $ 3,195 | $ 4,120 | $ 2,013 | $ 85,074 | $ 69,433 | $ 29,176 |
| 15 | 0.464 | $ 953 | $ - | $ 3,291 | $ 4,244 | $ 1,970 | $ 89,318 | $ 71,403 | $ 27,163 |
| 16 | 0.441 | $ 982 | $ - | $ 3,390 | $ 4,371 | $ 1,928 | $ 93,689 | $ 73,331 | $ 25,193 |
| 17 | 0.419 | $ 1,011 | $ - | $ 3,491 | $ 4,502 | $ 1,886 | $ 98,191 | $ 75,217 | $ 23,265 |
| 18 | 0.398 | $ 1,041 | $ - | $ 3,596 | $ 4,637 | $ 1,846 | $ 102,828 | $ 77,063 | $ 21,379 |
| 19 | 0.378 | $ 1,073 | $ - | $ 3,704 | $ 4,776 | $ 1,807 | $ 107,604 | $ 78,870 | $ 19,533 |
| 20 | 0.359 | $ 1,105 | $ 636 | $ 3,815 | $ 5,556 | $ 1,997 | $ 113,160 | $ 80,867 | $ 17,726 |
| 21 | 0.341 | $ 1,138 | $ - | $ 3,929 | $ 5,067 | $ 1,730 | $ 118,228 | $ 82,597 | $ 15,729 |
| 22 | 0.324 | $ 1,172 | $ - | $ 4,047 | $ 5,219 | $ 1,693 | $ 123,447 | $ 84,290 | $ 13,999 |
| 23 | 0.308 | $ 1,207 | $ - | $ 4,169 | $ 5,376 | $ 1,657 | $ 128,823 | $ 85,947 | $ 12,306 |
| 24 | 0.293 | $ 1,243 | $ - | $ 4,294 | $ 5,537 | $ 1,622 | $ 134,360 | $ 87,569 | $ 10,649 |
| 25 | 0.278 | $ 1,281 | $ - | $ 4,423 | $ 5,703 | $ 1,587 | $ 140,063 | $ 89,156 | $ 9,027 |
| 26 | 0.264 | $ 1,319 | $ - | $ 4,555 | $ 5,874 | $ 1,553 | $ 145,937 | $ 90,709 | $ 7,440 |
| 27 | 0.251 | $ 1,359 | $ - | $ 4,692 | $ 6,051 | $ 1,520 | $ 151,988 | $ 92,229 | $ 5,887 |
| 28 | 0.239 | $ 1,399 | $ - | $ 4,833 | $ 6,232 | $ 1,487 | $ 158,220 | $ 93,716 | $ 4,367 |
| 29 | 0.227 | $ 1,441 | $ - | $ 4,978 | $ 6,419 | $ 1,456 | $ 164,639 | $ 95,172 | $ 2,880 |
| 30 | 0.215 | $ 1,485 | $ - | $ 5,127 | $ 6,612 | $ 1,424 | $ 171,250 | $ 96,596 | $ 1,424 |

**Description: WQBE 02B - Bioretention Planter In ROW**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be
4 performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4
8 visits per year, 1 hour per visit).

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour
4 per visit).

Annual mulch and plant replacements 5 plants at $54/Plant

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Replacement Assumptions:**

Replacement of treatment media, compost, and vegatation will take place every ten years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Steven Van Loo (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_02B - Bioretention Planter In ROW | | | **Version:** | 3 |

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| | **CONSTRUCTION COSTS** | | | | |
| 1 | **Bioretention Planter on Property Bottom Area** | 125 | SF | | $ - |
| 2 | **Curbed, vertical sides - Top Area** | 125 | SF | | |
| 3 | **Bioretention Planter Length** | 25 | LF | | |
| 4 | **Bioretention Planter: Width** | 5 | LF | | |
| 5 | **Bioretention Planter: Depth** | 5.4 | LF | | |
| 6 | Structural Excavation to Waste | 98 | CY | $ 79 | $ 7,753 |
| 7 | Imported Structural Fill | 64 | CY | $ 44 | $ 2,818 |
| 8 | Formed Concrete Walls (6" Thick) | 6 | CY | $ 1,560 | $ 9,886 |
| 9 | Formed Concrete Base (6" thick) | 3 | CY | $ 590 | $ 1,704 |
| 10 | Treatment Media (18" Thick)w biochar | 7 | CY | $ 270 | $ 1,875 |
| 11 | Mulch Compost (@ 0.3'D) | 1 | CY | $ 86 | $ 119 |
| 12 | Vegetated Entrance | 2 | SY | $ 10 | $ 22 |
| | Trench Shoring Facility (Shallow) | 400 | SF | $ 10 | $ 4,000 |
| 13 | | | | | |
| 14 | **Underdrain Items:** | 25 | LF | | |
| 15 | Underdrain Aggregate (2.2' Thick) | 10 | CY | $ 133 | $ 1,355 |
| 16 | Overflow & Drain Pipe Pipe 8" Dia. (Length + 4') | 29 | LF | $ 48 | $ 1,392 |
| 17 | | | | | $ - |
| 18 | **Restoration:** | 30 | LF | | $ - |
| 19 | Pavement Patch - Adj. to facility @5'W (6"HMA/6"CSBC) | 17 | SY | $ 110 | $ 1,833 |
| 20 | Sidewalk 6' Wide | 20 | SY | $ 125 | $ 2,500 |
| 21 | Concrete Curb and Gutter | 30 | LF | $ 111 | $ 3,330 |
| 22 | Landscaping (Planter Only) | 14 | SY | $ 59 | $ 819 |
| 23 | Trees (Not in Design Basis) | 0 | EA | $ 720 | $ - |
| 24 | | | | | |
| 25 | **Outlet Pipe** | | | | $ - |
| 26 | DI Cl 50 Pipe 8" Diameter | 50 | LF | $ 160 | $ 8,000 |
| 27 | 5' Wide Trench x 7'D to waste | 65 | CY | $ 79 | $ 5,120 |
| 28 | Trench Box Shoring (Shallow) | 700 | SF | $ 10 | $ 7,000 |
| 29 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 30 | Pavement Patch - Pipe@5'W (6"HMA/6"CSBC) | 28 | SY | $ 110 | $ 3,056 |
| 31 | | | | | |
| 32 | **Additional Costs** | | | | $ - |
| 33 | Removals @ 4% Construction Costs | 4.0% | LS | $ 66,483 | $ 2,659 |
| 34 | Traffic Control (Heavy) | 0.5 | MO | $ 20,000 | $ 10,000 |
| 35 | TESC @2% Construction Costs | 2% | LS | $ 79,142 | $ 1,583 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 80,725 |

| DIRECT: CONSTRUCTION COST MARK-UPS | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 8,072 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 88,797 |
| | | ***Direct: Subtotal Construction Costs (125 SF Area)*** | ***$ 88,797*** |

**Description: WQBE 2B - Bioretention Planter in ROW**

Designed soil mix and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants within a vertical walled container usually constructed from formed concrete, but could include other materials. These designs are often used in ultra-urban settings. For this analysis, the Action is assumed to have an underdrain and closed bottom.

**Cost Estimating Assumptions:**

Bioretention planter installation is per the Seattle Stormwater Manual, "Non-infiltrating Bioretention" (Volume 3 Section 5.8.2)
Installation is in ROW and does not require easements or acquisition
Filter fabrics not used between the subgrade and the Bioretention Soil Mix
Facility is sited in an open space with outlet pipe beneath a parking area
18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.
0.3' of composted media is included.
The facility treatment area has curbed, vertical sides.
A bioretention planter with a 125 sf area (5' wide by 25' long) was selected to represent a typical installation size. The 125 s.f. facility subtotal construction costs were then scaled to represent the selected Action item area of 25 sf.
A maximum ponding depth of 6" and a 6" of freeboard depth are assumed.
Facilities have a closed bottom and include an underdrain.
A total of 50 LF of 8" storm pipe is required to connect to the downstream main or structure.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the box.
Trench Box shoring is used.
Roadway patching and restoration is assumed for the outlet pipe and consists of 6" HMA/6" CSTC
Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.
Landscape restoration is required for the facility, earth berm and area of disturbance.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is in a ROW on an urban street and traffic control is required.
A street use permit is required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Steven Van Loo (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 02C_Bioretention Planter With Property Cost | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Bioretention Planter with Underdrain on Property (25 SF Bottom Area) | 25 | SF | $ 535 | $ 13,375 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 13,375*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 2,006 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 15,381*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 1,538 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 16,919*** |
| | | | | Construction Sales Tax | $ 1,734 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 18,700*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 2,030 |
| | | | | Construction Management | $ 1,354 |
| | | | | Permitting & Support | $ 85 |
| 25 | s.f. Land Area | Medium | Land Purchase/ROW Acquisition | | $ 2,011 |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 846 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 6,325*** |
| | | | | Project Contingency | $ 3,754 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 10,100*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 28,800*** |

**Description: WQBE 02C - Bioretention Planter W/Property Cost (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 25 | ft2 |
| **Initial Capital Cost** | **$ 28,800** | |
| Capital cost | $ 1,152 | $/Unit |
| Total Direct O&M/Year | $ 2,176 | |
| Direct O&M cost | $ 87.02 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 636 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 88,900** | **$/unit** |
| **Annual O&M Cost** | **$ 2,800** | **$/year** |
| Annualized Cost | $1,000 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Annual plant replacement | 2023 dollars | $ 270 | |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $630 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash | 4 | hr | |
| Plant Health | 8 | hr | |
| Remediation of erosion | 4 | hr | |
| | | hr | |
| **Total hours per year** | 16 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 870 | |
| Labor cost, burdened | O/H 150.0% | $ 2,176 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 29,973 | | $ 103,505 | **$163,550** | **$ 88,896** | | | |
| 0 | 1.000 | **$ 28,800** | | | $28,800 | $ 28,800 | $ 28,800 | $ 28,800 | $ 88,896 |
| 1 | 0.950 | $ 630 | $ - | $ 2,176 | $ 2,806 | $ 2,666 | $ 31,606 | $ 31,466 | $ 60,096 |
| 2 | 0.903 | $ 649 | $ - | $ 2,241 | $ 2,890 | $ 2,609 | $ 34,495 | $ 34,074 | $ 57,431 |
| 3 | 0.858 | $ 668 | $ - | $ 2,308 | $ 2,976 | $ 2,553 | $ 37,472 | $ 36,627 | $ 54,822 |
| 4 | 0.815 | $ 688 | $ - | $ 2,377 | $ 3,066 | $ 2,498 | $ 40,538 | $ 39,126 | $ 52,269 |
| 5 | 0.774 | $ 709 | $ - | $ 2,449 | $ 3,158 | $ 2,445 | $ 43,695 | $ 41,570 | $ 49,771 |
| 6 | 0.736 | $ 730 | $ - | $ 2,522 | $ 3,252 | $ 2,393 | $ 46,948 | $ 43,963 | $ 47,326 |
| 7 | 0.699 | $ 752 | $ - | $ 2,598 | $ 3,350 | $ 2,342 | $ 50,298 | $ 46,305 | $ 44,933 |
| 8 | 0.664 | $ 775 | $ - | $ 2,676 | $ 3,451 | $ 2,291 | $ 53,748 | $ 48,596 | $ 42,592 |
| 9 | 0.631 | $ 798 | $ - | $ 2,756 | $ 3,554 | $ 2,242 | $ 57,302 | $ 50,839 | $ 40,300 |
| 10 | 0.599 | $ 822 | $ 636 | $ 2,839 | $ 4,297 | $ 2,576 | $ 61,599 | $ 53,415 | $ 38,058 |
| 11 | 0.570 | $ 847 | $ - | $ 2,924 | $ 3,770 | $ 2,148 | $ 65,370 | $ 55,562 | $ 35,482 |
| 12 | 0.541 | $ 872 | $ - | $ 3,012 | $ 3,884 | $ 2,102 | $ 69,254 | $ 57,664 | $ 33,334 |
| 13 | 0.514 | $ 898 | $ - | $ 3,102 | $ 4,000 | $ 2,057 | $ 73,254 | $ 59,721 | $ 31,232 |
| 14 | 0.489 | $ 925 | $ - | $ 3,195 | $ 4,120 | $ 2,013 | $ 77,374 | $ 61,733 | $ 29,176 |
| 15 | 0.464 | $ 953 | $ - | $ 3,291 | $ 4,244 | $ 1,970 | $ 81,618 | $ 63,703 | $ 27,163 |
| 16 | 0.441 | $ 982 | $ - | $ 3,390 | $ 4,371 | $ 1,928 | $ 85,989 | $ 65,631 | $ 25,193 |
| 17 | 0.419 | $ 1,011 | $ - | $ 3,491 | $ 4,502 | $ 1,886 | $ 90,491 | $ 67,517 | $ 23,265 |
| 18 | 0.398 | $ 1,041 | $ - | $ 3,596 | $ 4,637 | $ 1,846 | $ 95,128 | $ 69,363 | $ 21,379 |
| 19 | 0.378 | $ 1,073 | $ - | $ 3,704 | $ 4,776 | $ 1,807 | $ 99,904 | $ 71,170 | $ 19,533 |
| 20 | 0.359 | $ 1,105 | $ 636 | $ 3,815 | $ 5,556 | $ 1,997 | $ 105,460 | $ 73,167 | $ 17,726 |
| 21 | 0.341 | $ 1,138 | $ - | $ 3,929 | $ 5,067 | $ 1,730 | $ 110,528 | $ 74,897 | $ 15,729 |
| 22 | 0.324 | $ 1,172 | $ - | $ 4,047 | $ 5,219 | $ 1,693 | $ 115,747 | $ 76,590 | $ 13,999 |
| 23 | 0.308 | $ 1,207 | $ - | $ 4,169 | $ 5,376 | $ 1,657 | $ 121,123 | $ 78,247 | $ 12,306 |
| 24 | 0.293 | $ 1,243 | $ - | $ 4,294 | $ 5,537 | $ 1,622 | $ 126,660 | $ 79,869 | $ 10,649 |
| 25 | 0.278 | $ 1,281 | $ - | $ 4,423 | $ 5,703 | $ 1,587 | $ 132,363 | $ 81,456 | $ 9,027 |
| 26 | 0.264 | $ 1,319 | $ - | $ 4,555 | $ 5,874 | $ 1,553 | $ 138,237 | $ 83,009 | $ 7,440 |
| 27 | 0.251 | $ 1,359 | $ - | $ 4,692 | $ 6,051 | $ 1,520 | $ 144,288 | $ 84,529 | $ 5,887 |
| 28 | 0.239 | $ 1,399 | $ - | $ 4,833 | $ 6,232 | $ 1,487 | $ 150,520 | $ 86,016 | $ 4,367 |
| 29 | 0.227 | $ 1,441 | $ - | $ 4,978 | $ 6,419 | $ 1,456 | $ 156,939 | $ 87,472 | $ 2,880 |
| 30 | 0.215 | $ 1,485 | $ - | $ 5,127 | $ 6,612 | $ 1,424 | $ 163,550 | $ 88,896 | $ 1,424 |

**Description: WQBE 02C - Bioretention Planter W/Property Cost**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by
4 a crew of two using hand tools (2 visits per year, 1 hour per visit).

Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per
8 year, 1 hour per visit).

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per
4 visit).

Annual mulch and plan replacements 5 plants at $54/Plant

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Replacement Assumptions:**

Replacement of treatment media, compost, and vegatation will take place every ten years.

| Estimate - AACEI Class 10 | | | |
|---|---|---|---|
| Project Name: | King County Water Quality Benefits Evaluation | Date: | 6/7/2024 |
| Location: | King County, WA | Estimator: | Steven Van Loo (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| Description: | WQBE 02C_Bioretention Planter With Property Cost | Version: | 3 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Bioretention Planter on Property Bottom Area** | 125 | SF | | $ - |
| 2 | **Curbed, vertical sides - Top Area** | 125 | SF | | $ - |
| 3 | **Bioretention Planter Length** | 25 | LF | | $ - |
| 4 | **Bioretention Planter: Width** | 5 | LF | | $ - |
| 5 | **Bioretention Planter: Depth** | 5.4 | LF | | $ - |
| 6 | Structural Excavation to Waste | 98 | CY | $ 79 | $ 7,753 |
| 7 | Imported Structural Fill | 64 | CY | $ 44 | $ 2,818 |
| 8 | Formed Concrete Walls (6" Thick) | 6 | CY | $ 1,560 | $ 9,886 |
| 9 | Formed Concrete Base (6" thick) | 3 | CY | $ 590 | $ 1,704 |
| 10 | Treatment Media (18" Thick)w biochar | 7 | CY | $ 270 | $ 1,875 |
| 11 | Mulch Compost (@ 0.3'D) | 1 | CY | $ 86 | $ 119 |
| 12 | Vegetated Entrance | 2 | SY | $ 10 | $ 22 |
| | Trench Shoring Facility (Shallow) | 400 | SF | $ 10 | $ 4,000 |
| 13 | | | | | $ - |
| 14 | **Underdrain Items:** | 25 | LF | | $ - |
| 15 | Underdrain Aggregate (2.2' Thick) | 10 | CY | $ 133 | $ 1,355 |
| 16 | Overflow & Drain Pipe Pipe 8" Dia. (Length + 4') | 29 | LF | $ 48 | $ 1,392 |
| 17 | | | | | $ - |
| 18 | **Restoration:** | | | | $ - |
| 19 | Landscaping, Planting, and Restoration | 58 | SY | $ 59 | $ 3,442 |
| 20 | Trees (Not in Design Basis) | 0 | EA | $ 720 | $ - |
| 21 | | | | | $ - |
| 22 | **Outlet Pipe** | | | | $ - |
| 23 | Pipe 8" Diameter | 50 | LF | $ 80 | $ 4,000 |
| 24 | 5' Wide Trench x 7'D to waste | 65 | CY | $ 79 | $ 5,120 |
| 25 | Trench Box Shoring (Shallow) | 800 | SF | $ 10 | $ 8,000 |
| 26 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 27 | Parking Lot Pavement Patch HMA 4" HM/4"CSBC | 28 | SY | $ 71 | $ 1,972 |
| 28 | | | | | $ - |
| 29 | **Additional Costs** | | | | $ - |
| 30 | Removals @ 4% Construction Costs | 4.0% | LS | $ 57,358 | $ 2,294 |
| 31 | TESC @2% Construction Costs | 2% | LS | $ 59,653 | $ 1,193 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | ***Item Subtotal Construction Costs (Year 2023)*** | | | | $ 60,846 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 6,085 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 66,930 |
| ***Direct: Subtotal Construction Costs (125 SF Area)*** | | | ***$ 66,930*** |

**Description: WQBE 02C - Bioretention Planter With Property Cost**

Designed soil mix and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants within a vertical walled container usually constructed from formed concrete, but could include other materials. These designs are often used in ultra-urban settings. For this analysis, the Action is assumed to have an underdrain and closed bottom.

**Cost Estimating Assumptions:**

Bioretention planter installation is per the Seattle Stormwater Manual, "Non-infiltrating Bioretention" (Volume 3 Section 5.8.2)
It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.
Filter fabrics not used between the subgrade and the Bioretention Soil Mix
Facility is sited in an open space with outlet pipe beneath a parking area
18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.
0.3' of composted media is included.
The facility treatment area has curbed, vertical sides.
A bioretention planter with a 125 sf area (5' wide by 10 ' long) was selected to represent a typical installation size. The 125 s.f. facility subtotal construction costs were then scaled to represent the selected Action item area of 25 sf.
A maximum ponding depth of 6" and a 6" of freeboard depth are assumed.
Facilities have a closed bottom and include an underdrain.
A total of 50 LF of 8" storm pipe is required to connect to the downstream main or structure.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the box.
Trench Box shoring is used.
Parking lot restoration is assumed for the outlet pipe and consists of 4" HMA/4" CSTC.
Concrete curb, gutter, and sidewalk removal and restoration will not be required for the installation.
Landscape restoration is required for the facility, earth berm and area of disturbance.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on Property and Traffic control is not required.
A street use permit is not required.
Property and easement acquisition are included.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

**Benchmarking:**

Real estate property values and easement costs, where used, were based on KC Assessor property values combined with information provided by WTD in July 2020 for use on the CSO LTCP cost estimates. Property costs were assigned based on general property values for the assumed land use category being estimated. Property costs were escalated by 15%.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 03A_Bioretention Underdrain on Property | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Bioretention with Underdrain On Property (85 SF Bottom Area) | 85 | SF | $ 299 | $ 25,415 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 25,415*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 3,812 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 29,227*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 2,923 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 32,150*** |
| | | | | Construction Sales Tax | $ 3,295 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 35,400*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 3,858 |
| | | | | Construction Management | $ 2,572 |
| | | | | Permitting & Support | $ 161 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 1,607 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 8,198*** |
| | | | | Project Contingency | $ 6,540 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 14,700*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 50,100*** |

**Description: WQBE 03A - Bioretention Underdrain on Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 85 | ft2 |
| **Initial Capital Cost** | **$ 50,100** | |
| Capital cost | $ 589 | $/Unit |
| Total Direct O&M/Year | $ 2,176 | |
| Direct O&M cost | $ 25.60 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 6,495 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 121,500** | **$/unit** |
| **Annual O&M Cost** | **$ 3,100** | **$/year** |
| Annualized Cost | $1,430 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Annual plant replacement | 2023 dollars | $ 540 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $900 | |
| Labor | | | |
| Remove Trash | 4 | hr | |
| Plant Health | 8 | hr | |
| Remediation of erosion | 4 | hr | |
| | 0 | hr | |
| **Total hours per year** | 16 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 870 | |
| Labor cost, burdened | O/H 150.0% | $ 2,176 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 42,818 | | $ 103,505 | **$209,412** | **$ 121,538** | | | |
| 0 | 1.000 | **$ 50,100** | | | $50,100 | $ 50,100 | $ 50,100 | $ 50,100 | $ 121,538 |
| 1 | 0.950 | $ 900 | $ - | $ 2,176 | $ 3,076 | $ 2,922 | $ 53,176 | $ 53,022 | $ 71,438 |
| 2 | 0.903 | $ 927 | $ - | $ 2,241 | $ 3,168 | $ 2,860 | $ 56,343 | $ 55,882 | $ 68,516 |
| 3 | 0.858 | $ 955 | $ - | $ 2,308 | $ 3,263 | $ 2,799 | $ 59,606 | $ 58,680 | $ 65,656 |
| 4 | 0.815 | $ 983 | $ - | $ 2,377 | $ 3,361 | $ 2,739 | $ 62,967 | $ 61,419 | $ 62,858 |
| 5 | 0.774 | $ 1,013 | $ - | $ 2,449 | $ 3,462 | $ 2,680 | $ 66,429 | $ 64,099 | $ 60,119 |
| 6 | 0.736 | $ 1,043 | $ - | $ 2,522 | $ 3,565 | $ 2,623 | $ 69,994 | $ 66,722 | $ 57,439 |
| 7 | 0.699 | $ 1,075 | $ - | $ 2,598 | $ 3,672 | $ 2,567 | $ 73,667 | $ 69,289 | $ 54,816 |
| 8 | 0.664 | $ 1,107 | $ - | $ 2,676 | $ 3,783 | $ 2,512 | $ 77,449 | $ 71,801 | $ 52,249 |
| 9 | 0.631 | $ 1,140 | $ - | $ 2,756 | $ 3,896 | $ 2,458 | $ 81,345 | $ 74,259 | $ 49,737 |
| 10 | 0.599 | $ 1,174 | $ 6,495 | $ 2,839 | $ 10,508 | $ 6,299 | $ 91,853 | $ 80,559 | $ 47,279 |
| 11 | 0.570 | $ 1,210 | $ - | $ 2,924 | $ 4,133 | $ 2,354 | $ 95,986 | $ 82,913 | $ 40,980 |
| 12 | 0.541 | $ 1,246 | $ - | $ 3,012 | $ 4,257 | $ 2,304 | $ 100,244 | $ 85,217 | $ 38,625 |
| 13 | 0.514 | $ 1,283 | $ - | $ 3,102 | $ 4,385 | $ 2,255 | $ 104,629 | $ 87,471 | $ 36,321 |
| 14 | 0.489 | $ 1,322 | $ - | $ 3,195 | $ 4,517 | $ 2,207 | $ 109,145 | $ 89,678 | $ 34,067 |
| 15 | 0.464 | $ 1,361 | $ - | $ 3,291 | $ 4,652 | $ 2,159 | $ 113,797 | $ 91,837 | $ 31,860 |
| 16 | 0.441 | $ 1,402 | $ - | $ 3,390 | $ 4,792 | $ 2,113 | $ 118,589 | $ 93,950 | $ 29,701 |
| 17 | 0.419 | $ 1,444 | $ - | $ 3,491 | $ 4,935 | $ 2,068 | $ 123,524 | $ 96,018 | $ 27,588 |
| 18 | 0.398 | $ 1,488 | $ - | $ 3,596 | $ 5,083 | $ 2,024 | $ 128,608 | $ 98,042 | $ 25,520 |
| 19 | 0.378 | $ 1,532 | $ - | $ 3,704 | $ 5,236 | $ 1,981 | $ 133,844 | $ 100,023 | $ 23,496 |
| 20 | 0.359 | $ 1,578 | $ 6,495 | $ 3,815 | $ 11,888 | $ 4,272 | $ 145,732 | $ 104,295 | $ 21,515 |
| 21 | 0.341 | $ 1,626 | $ - | $ 3,929 | $ 5,555 | $ 1,897 | $ 151,286 | $ 106,192 | $ 17,243 |
| 22 | 0.324 | $ 1,674 | $ - | $ 4,047 | $ 5,722 | $ 1,856 | $ 157,008 | $ 108,048 | $ 15,346 |
| 23 | 0.308 | $ 1,724 | $ - | $ 4,169 | $ 5,893 | $ 1,817 | $ 162,901 | $ 109,864 | $ 13,490 |
| 24 | 0.293 | $ 1,776 | $ - | $ 4,294 | $ 6,070 | $ 1,778 | $ 168,971 | $ 111,642 | $ 11,674 |
| 25 | 0.278 | $ 1,830 | $ - | $ 4,423 | $ 6,252 | $ 1,740 | $ 175,223 | $ 113,382 | $ 9,896 |
| 26 | 0.264 | $ 1,884 | $ - | $ 4,555 | $ 6,440 | $ 1,702 | $ 181,663 | $ 115,084 | $ 8,156 |
| 27 | 0.251 | $ 1,941 | $ - | $ 4,692 | $ 6,633 | $ 1,666 | $ 188,296 | $ 116,750 | $ 6,454 |
| 28 | 0.239 | $ 1,999 | $ - | $ 4,833 | $ 6,832 | $ 1,630 | $ 195,127 | $ 118,381 | $ 4,788 |
| 29 | 0.227 | $ 2,059 | $ - | $ 4,978 | $ 7,037 | $ 1,596 | $ 202,164 | $ 119,977 | $ 3,157 |
| 30 | 0.215 | $ 2,121 | $ - | $ 5,127 | $ 7,248 | $ 1,562 | $ 209,412 | $ 121,538 | $ 1,562 |

**Description: WQBE 03A - Bioretention Underdrain on Property**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

4 Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).

8 Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per year, 1 hour per visit).

8 Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Annual mulch and plan replacements 10 plants at $54/Plant

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Replacement Assumptions:**

Replacement of treatment media, compost, and vegatation will take place every ten years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 03A_Bioretention Underdrain on Property | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Bioretention Facility w/underdrain on Property** | 175 | SF | | $ - |
| 2 | **GSI Facility (Length - bottom dimensions)** | 35 | LF | | |
| 2 | **GSI Facility (5'W bottom dimensions)** | 5 | LF | | |
| 3 | **Top Dimensions @ 3:1 Side Slopes** | 675 | SF | | |
| 4 | Facility Excavation to Berm and Waste @2.8'D | 44 | CY | $ 79 | $ 3,482 |
| 5 | Mulch Compost (@ 0.3'D) | 8 | CY | $ 86 | $ 645 |
| 6 | Treatment Media - biochar @ 18" D | 38 | CY | $ 270 | $ 10,125 |
| 7 | Rocked Spillway (2'WX5'L) | 10 | SF | $ 43 | $ 430 |
| 8 | | | | | |
| 9 | **Underdrain Items:** | 35 | LF | | |
| 10 | Underdrain Aggregate (2.5'X2.5') | 8 | CY | $ 133 | $ 1,078 |
| 11 | Pipe 8" Diameter Overflow/Drain | 35 | LF | $ 48 | $ 1,680 |
| 12 | Trench Exc to Waste | 8 | CY | $ 79 | $ 640 |
| 13 | | | | | |
| 14 | **Facility Removals and Restoration:** | | | | |
| 15 | Landscaping and Restoration (surface area of disturbance) | 111 | SY | $ 59 | $ 6,556 |
| 16 | Trees (None noted in Design Basis) | 0 | EA | $ 720 | $ - |
| 17 | | | | | $ - |
| 18 | **Outlet Pipe** | | | | $ - |
| 19 | Pipe 8" Dia. | 50 | LF | $ 80 | $ 4,000 |
| 20 | 5' Wide Trench x 6'D to waste | 56 | CY | $ 79 | $ 4,389 |
| 21 | Trench Box Shoring (Shallow) | 600 | SF | $ 10 | $ 6,000 |
| 22 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 23 | Parking Lot Pavement Patch HMA 4" HM/4"CSBC | 28 | SY | $ 71 | $ 1,972 |
| 24 | | | | | |
| 25 | **Additional Costs** | | | | $ - |
| 26 | Removals @ 4% Construction Costs | 4.0% | LS | $ 44,896 | $ 1,796 |
| 27 | TESC @2% Construction Costs | 2% | LS | $ 46,692 | $ 934 |
| | | | | | $ - |
| | | | | | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | | | $ 47,626 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 4,763 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | | | $ 52,388 |
| ***Direct: Subtotal Construction Costs (175 SF Area)*** | | | | | ***$ 52,388*** |

**Description: WQBE 3A - Bioretention with Underdrain on Property**

Shallow earthen depressions or vertical walled open bottom boxes with a designed soil mix and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.

**Cost Estimating Assumptions:**

Facility design is per KC SWDM Section C2.6.1
It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.
Facility is sited in an open space with pipe outlet beneath a parking area.
18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.
0.3' of composted media is included.

The facility treatment area is 85 sf with a 3:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 175 sf area (5' wide by 35' long) was selcted to represent an typical installation. The facility subtotal construction costs were then scaled to represent the selected 85 sf treatment area.
A maximum ponding depth of 6-inches with a minimum of 6-inches of freeboard are assumed.
Facilities placed in till soils require an underdrain system, facilities located in outwash soils do not require an underdrain.
A total of 50 linear feet of 8-inch storm pipe is required to connect to the downstream facility or main.
A rocked spillway is included.
The excavated material is unsuitable for use as backfill.
An excavation width of 3-feet is assumed on each side of the precast box.
Trench Box shoring is used.
Parking lot restoration is assumed for the outlet pipe and consists of 4" HMA/4" CSTS
Concrete curb, gutter, and sidewalk removal and restoration will not be required for the installation.
Landscape restoration is required for the facility, earth berm and area of disturbance.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located outside of ROW and Traffic control is not required
A street use permit is not required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2027 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 03Aa_Bioretention Underdrain With Property Cost | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Bioretention with Underdrain with Property Cost (85 SF Bottom Area) | 85 | SF | $ 299 | $ 25,415 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 25,415*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 3,812 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 29,227*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 2,923 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 32,150*** |
| | | | | Construction Sales Tax | $ 3,295 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 35,400*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 3,858 |
| | | | | Construction Management | $ 2,572 |
| | | | | Permitting & Support | $ 161 |
| 248.6 | s.f. Land Area | Medium | Land Purchase/ROW Acquisition | | $ 19,995 |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 1,607 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 28,193*** |
| | | | | Project Contingency | $ 9,539 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 37,700*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 73,100*** |

**Description: WQBE 03Aa - Bioretention Underdrain With Property Cost (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 85 | ft2 |
| **Initial Capital Cost** | **$ 73,100** | |
| Capital cost | $ 860 | $/Unit |
| Total Direct O&M/Year | $ 2,176 | |
| Direct O&M cost | $ 25.60 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 6,495 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 144,500** | **$/unit** |
| **Annual O&M Cost** | **$ 3,100** | **$/year** |
| Annualized Cost | $1,430 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Annual plant replacement | 2023 dollars | $ 540 | |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $900 | |
| Labor | | | |
| Remove Trash | 4 | hr | |
| Plant Health | 8 | hr | |
| Remediation of erosion | 4 | hr | |
| | 0 | hr | |
| **Total hours per year** | 16 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 870 | |
| Labor cost, burdened | O/H 150.0% | $ 2,176 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 42,818 | | $ 103,505 | **$232,412** | **$ 144,538** | | | |
| 0 | 1.000 | **$ 73,100** | | | $73,100 | $ 73,100 | $ 73,100 | $ 73,100 | $ 144,538 |
| 1 | 0.950 | $ 900 | $ - | $ 2,176 | $ 3,076 | $ 2,922 | $ 76,176 | $ 76,022 | $ 71,438 |
| 2 | 0.903 | $ 927 | $ - | $ 2,241 | $ 3,168 | $ 2,860 | $ 79,343 | $ 78,882 | $ 68,516 |
| 3 | 0.858 | $ 955 | $ - | $ 2,308 | $ 3,263 | $ 2,799 | $ 82,606 | $ 81,680 | $ 65,656 |
| 4 | 0.815 | $ 983 | $ - | $ 2,377 | $ 3,361 | $ 2,739 | $ 85,967 | $ 84,419 | $ 62,858 |
| 5 | 0.774 | $ 1,013 | $ - | $ 2,449 | $ 3,462 | $ 2,680 | $ 89,429 | $ 87,099 | $ 60,119 |
| 6 | 0.736 | $ 1,043 | $ - | $ 2,522 | $ 3,565 | $ 2,623 | $ 92,994 | $ 89,722 | $ 57,439 |
| 7 | 0.699 | $ 1,075 | $ - | $ 2,598 | $ 3,672 | $ 2,567 | $ 96,667 | $ 92,289 | $ 54,816 |
| 8 | 0.664 | $ 1,107 | $ - | $ 2,676 | $ 3,783 | $ 2,512 | $ 100,449 | $ 94,801 | $ 52,249 |
| 9 | 0.631 | $ 1,140 | $ - | $ 2,756 | $ 3,896 | $ 2,458 | $ 104,345 | $ 97,259 | $ 49,737 |
| 10 | 0.599 | $ 1,174 | $ 6,495 | $ 2,839 | $ 10,508 | $ 6,299 | $ 114,853 | $ 103,559 | $ 47,279 |
| 11 | 0.570 | $ 1,210 | $ - | $ 2,924 | $ 4,133 | $ 2,354 | $ 118,986 | $ 105,913 | $ 40,980 |
| 12 | 0.541 | $ 1,246 | $ - | $ 3,012 | $ 4,257 | $ 2,304 | $ 123,244 | $ 108,217 | $ 38,625 |
| 13 | 0.514 | $ 1,283 | $ - | $ 3,102 | $ 4,385 | $ 2,255 | $ 127,629 | $ 110,471 | $ 36,321 |
| 14 | 0.489 | $ 1,322 | $ - | $ 3,195 | $ 4,517 | $ 2,207 | $ 132,145 | $ 112,678 | $ 34,067 |
| 15 | 0.464 | $ 1,361 | $ - | $ 3,291 | $ 4,652 | $ 2,159 | $ 136,797 | $ 114,837 | $ 31,860 |
| 16 | 0.441 | $ 1,402 | $ - | $ 3,390 | $ 4,792 | $ 2,113 | $ 141,589 | $ 116,950 | $ 29,701 |
| 17 | 0.419 | $ 1,444 | $ - | $ 3,491 | $ 4,935 | $ 2,068 | $ 146,524 | $ 119,018 | $ 27,588 |
| 18 | 0.398 | $ 1,488 | $ - | $ 3,596 | $ 5,083 | $ 2,024 | $ 151,608 | $ 121,042 | $ 25,520 |
| 19 | 0.378 | $ 1,532 | $ - | $ 3,704 | $ 5,236 | $ 1,981 | $ 156,844 | $ 123,023 | $ 23,496 |
| 20 | 0.359 | $ 1,578 | $ 6,495 | $ 3,815 | $ 11,888 | $ 4,272 | $ 168,732 | $ 127,295 | $ 21,515 |
| 21 | 0.341 | $ 1,626 | $ - | $ 3,929 | $ 5,555 | $ 1,897 | $ 174,286 | $ 129,192 | $ 17,243 |
| 22 | 0.324 | $ 1,674 | $ - | $ 4,047 | $ 5,722 | $ 1,856 | $ 180,008 | $ 131,048 | $ 15,346 |
| 23 | 0.308 | $ 1,724 | $ - | $ 4,169 | $ 5,893 | $ 1,817 | $ 185,901 | $ 132,864 | $ 13,490 |
| 24 | 0.293 | $ 1,776 | $ - | $ 4,294 | $ 6,070 | $ 1,778 | $ 191,971 | $ 134,642 | $ 11,674 |
| 25 | 0.278 | $ 1,830 | $ - | $ 4,423 | $ 6,252 | $ 1,740 | $ 198,223 | $ 136,382 | $ 9,896 |
| 26 | 0.264 | $ 1,884 | $ - | $ 4,555 | $ 6,440 | $ 1,702 | $ 204,663 | $ 138,084 | $ 8,156 |
| 27 | 0.251 | $ 1,941 | $ - | $ 4,692 | $ 6,633 | $ 1,666 | $ 211,296 | $ 139,750 | $ 6,454 |
| 28 | 0.239 | $ 1,999 | $ - | $ 4,833 | $ 6,832 | $ 1,630 | $ 218,127 | $ 141,381 | $ 4,788 |
| 29 | 0.227 | $ 2,059 | $ - | $ 4,978 | $ 7,037 | $ 1,596 | $ 225,164 | $ 142,977 | $ 3,157 |
| 30 | 0.215 | $ 2,121 | $ - | $ 5,127 | $ 7,248 | $ 1,562 | $ 232,412 | $ 144,538 | $ 1,562 |

**Description: WQBE 03Aa - Bioretention Underdrain With Property Cost**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be
4 performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4
8 visits per year, 1 hour per visit).

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour
8 per visit).

Annual mulch and plan replacements 10 plants at $54/Plant

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Replacement Assumptions:**

Replacement of treatment media, compost, and vegatation will take place every ten years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2027 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 03Aa_Bioretention Underdrain With Property Cost | | | **Version:** | 3 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Bioretention Facility w/underdrain on Property** | 175 | SF | | |
| 2 | **GSI Facility (Length - bottom dimensions)** | 35 | LF | | |
| 2 | **GSI Facility (5'W bottom dimensions)** | 5 | LF | | |
| 3 | **Top Dimensions @ 3:1 Side Slopes** | 675 | SF | | |
| 4 | Facility Excavation to Berm and Waste @2.8'D | 44 | CY | $ 79 | $ 3,482 |
| 5 | Mulch Compost (@ 0.3'D) | 8 | CY | $ 86 | $ 645 |
| 6 | Treatment Media - biochar @ 18" D | 38 | CY | $ 270 | $ 10,125 |
| 7 | Rocked Spillway (2'WX5'L) | 10 | SF | $ 43 | $ 430 |
| 8 | | | | | |
| 9 | **Underdrain Items:** | 35 | LF | | |
| 10 | Underdrain Aggregate (2.5'X2.5') | 8 | CY | $ 133 | $ 1,078 |
| 11 | Pipe 8" Diameter Overflow/Drain | 35 | LF | $ 48 | $ 1,680 |
| 12 | Trench Exc to Waste | 8 | CY | $ 79 | $ 640 |
| 13 | | | | | |
| 14 | **Facility Removals and Restoration:** | | | | |
| 15 | Landscaping and Restoration | 111 | SY | $ 59 | $ 6,556 |
| 16 | Trees (None noted in Design Basis) | 0 | EA | $ 720 | $ - |
| 17 | | | | | $ - |
| 18 | **Outlet Pipe** | | | | $ - |
| 19 | Pipe 8" Dia. | 50 | LF | $ 80 | $ 4,000 |
| 20 | 5' Wide Trench x 6'D to waste | 56 | CY | $ 79 | $ 4,389 |
| 21 | Trench Box Shoring (Shallow) | 600 | SF | $ 10 | $ 6,000 |
| 22 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 23 | Parking Lot Pavement Patch HMA 4" HM/4"CSBC | 28 | SY | $ 71 | $ 1,972 |
| 24 | | | | | |
| 25 | **Additional Costs** | | | | $ - |
| 26 | Removals @ 4% Construction Costs | 4.0% | LS | $ 44,896 | $ 1,796 |
| 27 | TESC @2% Construction Costs | 2% | LS | $ 46,692 | $ 934 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 47,626 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 4,763 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 52,388 |
| ***Direct: Subtotal Construction Costs (175 SF Area)*** | | | ***$ 52,388*** |

**Description: WQBE 03Aa - Bioretention Underdrain With Property Cost**

Shallow earthen depressions or vertical walled open bottom boxes with a designed soil mix and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.

**Cost Estimating Assumptions:**

Facility design is per KC SWDM Section C2.6.1
It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.
Facility is sited in an open space with pipe outlet beneath a parking area.
18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.
0.3' of composted media is included.

The facility treatment area is 85 sf with a 3:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 175 sf area (5' wide by 35' long) was selcted to represent an typical installation. The facility subtotal construction costs were then scaled to represent the selected 85 sf treatment area.
A maximum ponding depth of 6-inches with a minimum of 6-inches of freeboard are assumed.
Facilities placed in till soils require an underdrain system, facilities located in outwash soils do not require an underdrain.
A total of 50 linear feet of 8-inch storm pipe is required to connect to the downstream facility or main.
A rocked spillway is included.
The excavated material is unsuitable for use as backfill.
An excavation width of 3-feet is assumed on each side of the precast box.
Trench Box shoring is used.
Parking lot restoration is assumed for the outlet pipe and consists of 4" HMA/4" CSTS
Concrete curb, gutter, and sidewalk removal and restoration will not be required for the installation.
Landscape restoration is required for the facility, earth berm and area of disturbance.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located outside of ROW and Traffic control is not required
A street use permit is not required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 03B_Bioretention No Underdrain on Property | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Bioretention No Underdrain On Property (85 SF Bottom Area) | 85 | SF | $ 277 | $ 23,545 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 23,545*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 3,532 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 27,077*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 2,708 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 29,784*** |
| | | | | Construction Sales Tax | $ 3,053 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 32,800*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 3,574 |
| | | | | Construction Management | $ 2,383 |
| | | | | Permitting & Support | $ 149 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 1,489 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 7,595*** |
| | | | | Project Contingency | $ 6,059 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 13,700*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 46,500*** |

**Description: WQBE 3B - Bioretention No UnderDrain on Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 85 | ft2 |
| **Initial Capital Cost** | **$ 46,500** | |
| Capital cost | $ 547 | $/Unit |
| Total Direct O&M/Year | $ 2,176 | |
| Direct O&M cost | $ 25.60 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 6,495 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 117,900** | **$/unit** |
| **Annual O&M Cost** | **$ 3,100** | **$/year** |
| Annualized Cost | $1,430 | $/year |

**Materials, Supplies, Other Costs**

| | | | | |
|---|---|---|---|---|
| | | $ - | $/year | |
| Annual plant replacement | 2023 dollars | $ 540 | | |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year | |
| Subtotal | | $900 | | |
| Labor | | | | |
| Remove Trash | 4 | hr | | |
| Plant Health | 8 | hr | | |
| Remediation of erosion | 4 | hr | | |
| | 0 | hr | | |
| **Total hours per year** | 16 | | | |
| Raw Labor Rate/Hr | | $ 54 | | |
| Raw labor cost | (embedded) | $ 870 | | |
| Labor cost, burdened | O/H 150.0% | $ 2,176 | | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | | |
| Life Cycle Period: | 30 | years | | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 42,818 | | $ 103,505 | **$205,812** | **$ 117,938** | | | |
| 0 | 1.000 | **$ 46,500** | | | $46,500 | $ 46,500 | $ 46,500 | $ 46,500 | $ 117,938 |
| 1 | 0.950 | $ 900 | $ - | $ 2,176 | $ 3,076 | $ 2,922 | $ 49,576 | $ 49,422 | $ 71,438 |
| 2 | 0.903 | $ 927 | $ - | $ 2,241 | $ 3,168 | $ 2,860 | $ 52,743 | $ 52,282 | $ 68,516 |
| 3 | 0.858 | $ 955 | $ - | $ 2,308 | $ 3,263 | $ 2,799 | $ 56,006 | $ 55,080 | $ 65,656 |
| 4 | 0.815 | $ 983 | $ - | $ 2,377 | $ 3,361 | $ 2,739 | $ 59,367 | $ 57,819 | $ 62,858 |
| 5 | 0.774 | $ 1,013 | $ - | $ 2,449 | $ 3,462 | $ 2,680 | $ 62,829 | $ 60,499 | $ 60,119 |
| 6 | 0.736 | $ 1,043 | $ - | $ 2,522 | $ 3,565 | $ 2,623 | $ 66,394 | $ 63,122 | $ 57,439 |
| 7 | 0.699 | $ 1,075 | $ - | $ 2,598 | $ 3,672 | $ 2,567 | $ 70,067 | $ 65,689 | $ 54,816 |
| 8 | 0.664 | $ 1,107 | $ - | $ 2,676 | $ 3,783 | $ 2,512 | $ 73,849 | $ 68,201 | $ 52,249 |
| 9 | 0.631 | $ 1,140 | $ - | $ 2,756 | $ 3,896 | $ 2,458 | $ 77,745 | $ 70,659 | $ 49,737 |
| 10 | 0.599 | $ 1,174 | $ 6,495 | $ 2,839 | $ 10,508 | $ 6,299 | $ 88,253 | $ 76,959 | $ 47,279 |
| 11 | 0.570 | $ 1,210 | $ - | $ 2,924 | $ 4,133 | $ 2,354 | $ 92,386 | $ 79,313 | $ 40,980 |
| 12 | 0.541 | $ 1,246 | $ - | $ 3,012 | $ 4,257 | $ 2,304 | $ 96,644 | $ 81,617 | $ 38,625 |
| 13 | 0.514 | $ 1,283 | $ - | $ 3,102 | $ 4,385 | $ 2,255 | $ 101,029 | $ 83,871 | $ 36,321 |
| 14 | 0.489 | $ 1,322 | $ - | $ 3,195 | $ 4,517 | $ 2,207 | $ 105,545 | $ 86,078 | $ 34,067 |
| 15 | 0.464 | $ 1,361 | $ - | $ 3,291 | $ 4,652 | $ 2,159 | $ 110,197 | $ 88,237 | $ 31,860 |
| 16 | 0.441 | $ 1,402 | $ - | $ 3,390 | $ 4,792 | $ 2,113 | $ 114,989 | $ 90,350 | $ 29,701 |
| 17 | 0.419 | $ 1,444 | $ - | $ 3,491 | $ 4,935 | $ 2,068 | $ 119,924 | $ 92,418 | $ 27,588 |
| 18 | 0.398 | $ 1,488 | $ - | $ 3,596 | $ 5,083 | $ 2,024 | $ 125,008 | $ 94,442 | $ 25,520 |
| 19 | 0.378 | $ 1,532 | $ - | $ 3,704 | $ 5,236 | $ 1,981 | $ 130,244 | $ 96,423 | $ 23,496 |
| 20 | 0.359 | $ 1,578 | $ 6,495 | $ 3,815 | $ 11,888 | $ 4,272 | $ 142,132 | $ 100,695 | $ 21,515 |
| 21 | 0.341 | $ 1,626 | $ - | $ 3,929 | $ 5,555 | $ 1,897 | $ 147,686 | $ 102,592 | $ 17,243 |
| 22 | 0.324 | $ 1,674 | $ - | $ 4,047 | $ 5,722 | $ 1,856 | $ 153,408 | $ 104,448 | $ 15,346 |
| 23 | 0.308 | $ 1,724 | $ - | $ 4,169 | $ 5,893 | $ 1,817 | $ 159,301 | $ 106,264 | $ 13,490 |
| 24 | 0.293 | $ 1,776 | $ - | $ 4,294 | $ 6,070 | $ 1,778 | $ 165,371 | $ 108,042 | $ 11,674 |
| 25 | 0.278 | $ 1,830 | $ - | $ 4,423 | $ 6,252 | $ 1,740 | $ 171,623 | $ 109,782 | $ 9,896 |
| 26 | 0.264 | $ 1,884 | $ - | $ 4,555 | $ 6,440 | $ 1,702 | $ 178,063 | $ 111,484 | $ 8,156 |
| 27 | 0.251 | $ 1,941 | $ - | $ 4,692 | $ 6,633 | $ 1,666 | $ 184,696 | $ 113,150 | $ 6,454 |
| 28 | 0.239 | $ 1,999 | $ - | $ 4,833 | $ 6,832 | $ 1,630 | $ 191,527 | $ 114,781 | $ 4,788 |
| 29 | 0.227 | $ 2,059 | $ - | $ 4,978 | $ 7,037 | $ 1,596 | $ 198,564 | $ 116,377 | $ 3,157 |
| 30 | 0.215 | $ 2,121 | $ - | $ 5,127 | $ 7,248 | $ 1,562 | $ 205,812 | $ 117,938 | $ 1,562 |

**Description: WQBE 3B - Bioretention No UnderDrain on Property**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by
4 a crew of two using hand tools (2 visits per year, 1 hour per visit).
Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per
8 year, 1 hour per visit).
Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per
8 visit).
Annual mulch and plan replacements 10 plants at $54/Plant
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Replacement Assumptions:**

Replacement of treatment media, compost, and vegatation will take place every ten years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 03B_Bioretention No Underdrain on Property | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Bioretention Facility w/underdrain on Property** | 175 | SF | | $ - |
| 2 | **GSI Facility (Length - bottom dimensions)** | 35 | LF | | |
| 2 | **GSI Facility (5'W bottom dimensions)** | 5 | LF | | |
| 3 | **Top Dimensions @ 3:1 Side Slopes** | 675 | SF | | |
| 4 | Facility Excavation to Berm and Waste @2.8'D | 44 | CY | $ 79 | $ 3,482 |
| 5 | Mulch Compost (@ 0.3'D) | 8 | CY | $ 86 | $ 645 |
| 6 | Treatment Media - biochar @ 18" D | 38 | CY | $ 270 | $ 10,125 |
| 7 | Rocked Spillway (2'WX5'L) | 10 | SF | $ 43 | $ 430 |
| 8 | | | | | |
| 14 | **Facility Removals and Restoration:** | | | | |
| 15 | Landscaping and Restoration (surface area of disturbance) | 111 | SY | $ 59 | $ 6,556 |
| 16 | Trees (None noted in Design Basis) | 0 | EA | $ 720 | $ - |
| 17 | | | | | $ - |
| 18 | **Outlet Pipe** | | | | $ - |
| 19 | Pipe 8" Dia. | 50 | LF | $ 80 | $ 4,000 |
| 20 | 5' Wide Trench x 6'D to waste | 56 | CY | $ 79 | $ 4,389 |
| 21 | Trench Box Shoring (Shallow) | 600 | SF | $ 10 | $ 6,000 |
| 22 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 23 | Parking Lot Pavement Patch HMA 4" HM/4"CSBC | 28 | SY | $ 71 | $ 1,972 |
| 24 | | | | | |
| 25 | **Additional Costs** | | | | $ - |
| 26 | Removals @ 4% Construction Costs | 4.0% | LS | $ 41,499 | $ 1,660 |
| 27 | TESC @2% Construction Costs | 2% | LS | $ 43,158 | $ 863 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 44,022 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | | General Conditions | 0% | 1 | $ - |
| | | | Mobilization/Demobilization | 10% | 1.1 | $ 4,402 |
| | | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | | Insurance | 0.0% | 1 | $ - |
| | | | Bonding | 0.0% | 1 | $ - |
| | | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 48,424 |
| | | | | ***Direct: Subtotal Construction Costs (175 SF Area)*** | ***$ 48,424*** |

**Description: WQBE 3B - Bioretention No UnderDrain on Property**

Shallow earthen depressions or vertical walled open bottom boxes with a designed soil mix and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.

**Cost Estimating Assumptions:**

Facility design is per KC SWDM Section C2.6.1
It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.
Facility is sited in an open space with pipe outlet beneath a parking area.
18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.
0.3' of composted media is included.

The facility treatment area is 85 sf with a 3:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 175 sf area (5' wide by 35' long) was selcted to represent an typical installation. The facility subtotal construction costs were then scaled to represent the selected 85 sf treatment area.
A maximum ponding depth of 6-inches with a minimum of 6-inches of freeboard are assumed.
Facilities placed in till soils require an underdrain system, facilities located in outwash soils do not require an underdrain.
A total of 50 linear feet of 8-inch storm pipe is required to connect to the downstream facility or main.
A rocked spillway is included.
The excavated material is unsuitable for use as backfill.
An excavation width of 3-feet is assumed on each side of the precast box.
Trench Box shoring is used.
Parking lot restoration is assumed for the outlet pipe and consists of 4" HMA/4" CSTS
Concrete curb, gutter, and sidewalk removal and restoration will not be required for the installation.
Landscape restoration is required for the facility, earth berm and area of disturbance.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located outside of ROW and Traffic control is not required
A street use permit is not required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_03Bb_Bioretention No Underdrain With Property Cost | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Bioretention No Underdrain With Property Cost (85 SF Bottom Area) | 85 | SF | $ 277 | $ 23,545 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 23,545*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 3,532 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 27,077*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 2,708 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 29,784*** |
| | | | | Construction Sales Tax | $ 3,053 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 32,800*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 3,574 |
| | | | | Construction Management | $ 2,383 |
| | | | | Permitting & Support | $ 149 |
| 248.6 | s.f. Land Area | Medium | Land Purchase/ROW Acquisition | | $ 19,995 |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 1,489 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 27,590*** |
| | | | | Project Contingency | $ 9,058 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 36,600*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 69,400*** |

**Description: WQBE 03Bb - Bioretention No Underdrain With Property Cost (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 85 | ft2 |
| **Initial Capital Cost** | **$ 69,400** | |
| Capital cost | $ 816 | $/Unit |
| Total Direct O&M/Year | $ 2,175.6000 | |
| Direct O&M cost | $ 25.60 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 6,495 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 140,800** | **$/unit** |
| **Annual O&M Cost** | **$ 3,100** | **$/year** |
| Annualized Cost | $1,430 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Annual plant replacement | 2023 dollars | $ 540 | |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $900 | |
| Labor | | | |
| Remove Trash | 4 | hr | |
| Plant Health | 8 | hr | |
| Remediation of erosion | 4 | hr | |
| | 0 | hr | |
| **Total hours per year** | 16 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 870 | |
| Labor cost, burdened | O/H 150.0% | $ 2,176 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 42,818 | | $ 103,505 | **$228,712** | **$ 140,838** | | | |
| 0 | 1.000 | **$ 69,400** | | | $69,400 | $ 69,400 | $ 69,400 | $ 69,400 | $ 140,838 |
| 1 | 0.950 | $ 900 | $ - | $ 2,176 | $ 3,076 | $ 2,922 | $ 72,476 | $ 72,322 | $ 71,438 |
| 2 | 0.903 | $ 927 | $ - | $ 2,241 | $ 3,168 | $ 2,860 | $ 75,643 | $ 75,182 | $ 68,516 |
| 3 | 0.858 | $ 955 | $ - | $ 2,308 | $ 3,263 | $ 2,799 | $ 78,906 | $ 77,980 | $ 65,656 |
| 4 | 0.815 | $ 983 | $ - | $ 2,377 | $ 3,361 | $ 2,739 | $ 82,267 | $ 80,719 | $ 62,858 |
| 5 | 0.774 | $ 1,013 | $ - | $ 2,449 | $ 3,462 | $ 2,680 | $ 85,729 | $ 83,399 | $ 60,119 |
| 6 | 0.736 | $ 1,043 | $ - | $ 2,522 | $ 3,565 | $ 2,623 | $ 89,294 | $ 86,022 | $ 57,439 |
| 7 | 0.699 | $ 1,075 | $ - | $ 2,598 | $ 3,672 | $ 2,567 | $ 92,967 | $ 88,589 | $ 54,816 |
| 8 | 0.664 | $ 1,107 | $ - | $ 2,676 | $ 3,783 | $ 2,512 | $ 96,749 | $ 91,101 | $ 52,249 |
| 9 | 0.631 | $ 1,140 | $ - | $ 2,756 | $ 3,896 | $ 2,458 | $ 100,645 | $ 93,559 | $ 49,737 |
| 10 | 0.599 | $ 1,174 | $ 6,495 | $ 2,839 | $ 10,508 | $ 6,299 | $ 111,153 | $ 99,859 | $ 47,279 |
| 11 | 0.570 | $ 1,210 | $ - | $ 2,924 | $ 4,133 | $ 2,354 | $ 115,286 | $ 102,213 | $ 40,980 |
| 12 | 0.541 | $ 1,246 | $ - | $ 3,012 | $ 4,257 | $ 2,304 | $ 119,544 | $ 104,517 | $ 38,625 |
| 13 | 0.514 | $ 1,283 | $ - | $ 3,102 | $ 4,385 | $ 2,255 | $ 123,929 | $ 106,771 | $ 36,321 |
| 14 | 0.489 | $ 1,322 | $ - | $ 3,195 | $ 4,517 | $ 2,207 | $ 128,445 | $ 108,978 | $ 34,067 |
| 15 | 0.464 | $ 1,361 | $ - | $ 3,291 | $ 4,652 | $ 2,159 | $ 133,097 | $ 111,137 | $ 31,860 |
| 16 | 0.441 | $ 1,402 | $ - | $ 3,390 | $ 4,792 | $ 2,113 | $ 137,889 | $ 113,250 | $ 29,701 |
| 17 | 0.419 | $ 1,444 | $ - | $ 3,491 | $ 4,935 | $ 2,068 | $ 142,824 | $ 115,318 | $ 27,588 |
| 18 | 0.398 | $ 1,488 | $ - | $ 3,596 | $ 5,083 | $ 2,024 | $ 147,908 | $ 117,342 | $ 25,520 |
| 19 | 0.378 | $ 1,532 | $ - | $ 3,704 | $ 5,236 | $ 1,981 | $ 153,144 | $ 119,323 | $ 23,496 |
| 20 | 0.359 | $ 1,578 | $ 6,495 | $ 3,815 | $ 11,888 | $ 4,272 | $ 165,032 | $ 123,595 | $ 21,515 |
| 21 | 0.341 | $ 1,626 | $ - | $ 3,929 | $ 5,555 | $ 1,897 | $ 170,586 | $ 125,492 | $ 17,243 |
| 22 | 0.324 | $ 1,674 | $ - | $ 4,047 | $ 5,722 | $ 1,856 | $ 176,308 | $ 127,348 | $ 15,346 |
| 23 | 0.308 | $ 1,724 | $ - | $ 4,169 | $ 5,893 | $ 1,817 | $ 182,201 | $ 129,164 | $ 13,490 |
| 24 | 0.293 | $ 1,776 | $ - | $ 4,294 | $ 6,070 | $ 1,778 | $ 188,271 | $ 130,942 | $ 11,674 |
| 25 | 0.278 | $ 1,830 | $ - | $ 4,423 | $ 6,252 | $ 1,740 | $ 194,523 | $ 132,682 | $ 9,896 |
| 26 | 0.264 | $ 1,884 | $ - | $ 4,555 | $ 6,440 | $ 1,702 | $ 200,963 | $ 134,384 | $ 8,156 |
| 27 | 0.251 | $ 1,941 | $ - | $ 4,692 | $ 6,633 | $ 1,666 | $ 207,596 | $ 136,050 | $ 6,454 |
| 28 | 0.239 | $ 1,999 | $ - | $ 4,833 | $ 6,832 | $ 1,630 | $ 214,427 | $ 137,681 | $ 4,788 |
| 29 | 0.227 | $ 2,059 | $ - | $ 4,978 | $ 7,037 | $ 1,596 | $ 221,464 | $ 139,277 | $ 3,157 |
| 30 | 0.215 | $ 2,121 | $ - | $ 5,127 | $ 7,248 | $ 1,562 | $ 228,712 | $ 140,838 | $ 1,562 |

**Description: WQBE 03Bb - Bioretention No Underdrain With Property Cost**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be
4 performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).
Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4
8 visits per year, 1 hour per visit).
Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per
8 year, 1 hour per visit).
Annual mulch and plan replacements 10 plants at $54/Plant
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Replacement Assumptions:**

Replacement of treatment media, compost, and vegatation will take place every ten years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_03Bb_Bioretention No Underdrain With Property Cost | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Bioretention Facility w/underdrain on Property** | 175 | SF | | $ - |
| 2 | **GSI Facility (Length - bottom dimensions)** | 35 | LF | | |
| 2 | **GSI Facility (5'W bottom dimensions)** | 5 | LF | | |
| 3 | **Top Dimensions @ 3:1 Side Slopes** | 675 | SF | | |
| 4 | Facility Excavation to Berm and Waste @2.8'D | 44 | CY | $ 79 | $ 3,482 |
| 5 | Mulch Compost (@ 0.3'D) | 8 | CY | $ 86 | $ 645 |
| 6 | Treatment Media - biochar @ 18" D | 38 | CY | $ 270 | $ 10,125 |
| 7 | Rocked Spillway (2'WX5'L) | 10 | SF | $ 43 | $ 430 |
| 8 | | | | | |
| 14 | **Facility Removals and Restoration:** | | | | |
| 15 | Landscaping and Restoration (30'X50' area of disturbance) | 111 | SY | $ 59 | $ 6,556 |
| 16 | Trees (None noted in Design Basis) | 0 | EA | $ 720 | $ - |
| 17 | | | | | $ - |
| 18 | **Outlet Pipe** | | | | $ - |
| 19 | Pipe 8" Dia. | 50 | LF | $ 80 | $ 4,000 |
| 20 | 5' Wide Trench x 6'D to waste | 56 | CY | $ 79 | $ 4,389 |
| 21 | Trench Box Shoring (Shallow) | 600 | SF | $ 10 | $ 6,000 |
| 22 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 23 | Parking Lot Pavement Patch HMA 4" HM/4"CSBC | 28 | SY | $ 71 | $ 1,972 |
| 24 | | | | | |
| 25 | **Additional Costs** | | | | $ - |
| 26 | Removals @ 4% Construction Costs | 4.0% | LS | $ 41,499 | $ 1,660 |
| 27 | TESC @2% Construction Costs | 2% | LS | $ 43,158 | $ 863 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 44,022 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 4,402 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 48,424 |
| | | | | ***Direct: Subtotal Construction Costs (175 SF Area)*** | ***$ 48,424*** |

**Description: WQBE 03Bb - Bioretention No Underdrain With Property Cost**

Shallow earthen depressions or vertical walled open bottom boxes with a designed soil mix and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.

**Cost Estimating Assumptions:**

Facility design is per KC SWDM Section C2.6.1
It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.
Facility is sited in an open space with pipe outlet beneath a parking area.
18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.
0.3' of composted media is included.

The facility treatment area is 85 sf with a 3:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 175 sf area (5' wide by 35' long) was selcted to represent an typical installation. The facility subtotal construction costs were then scaled to represent the selected 85 sf treatment area.
A maximum ponding depth of 6-inches with a minimum of 6-inches of freeboard are assumed.
Facilities placed in till soils require an underdrain system, facilities located in outwash soils do not require an underdrain.
A total of 50 linear feet of 8-inch storm pipe is required to connect to the downstream facility or main.
A rocked spillway is included.
The excavated material is unsuitable for use as backfill.
An excavation width of 3-feet is assumed on each side of the precast box.
Trench Box shoring is used.
Parking lot restoration is assumed for the outlet pipe and consists of 4" HMA/4" CSTS
Concrete curb, gutter, and sidewalk removal and restoration will not be required for the installation.
Landscape restoration is required for the facility, earth berm and area of disturbance.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located outside of ROW and Traffic control is not required
A street use permit is not required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_03C_Bioretention_Underdrain_In ROW | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Bioretention with Underdrain in ROW (85 SF Bottom Area) | 85 | SF | $ 526 | $ 44,710 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 44,710*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 6,707 |
| | | | Street Use Permit (Y/N) | Y | $ 700 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 52,117*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 5,142 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 57,258*** |
| | | | | Construction Sales Tax | $ 5,797 |
| | | | | Outside Agency Construction | $ 894 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 63,900*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 6,871 |
| | | | | Construction Management | $ 4,581 |
| | | | | Permitting & Support | $ 286 |
| | s.f. Land Area | None | | Land Purchase/ROW Acquisition | $ - |
| | s.f. Land Area | None | | Permanent Easements | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 2,863 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 14,601*** |
| | | | | Project Contingency | $ 11,775 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 26,400*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 90,300*** |

**Description: WQBE 3C - Bioretention Facility With Underdrain in ROW (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 85 | ft2 |
| **Initial Capital Cost** | **$ 90,300** | |
| Capital cost | $ 1,062 | $/Unit |
| Total Direct O&M/Year | $ 2,175.60 | |
| Direct O&M cost | $ 25.60 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 6,495 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 161,700** | **$/unit** |
| **Annual O&M Cost** | **$ 3,100** | **$/year** |
| Annualized Cost | $1,430 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Annual plant replacement | 2023 dollars | $ 540 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $900 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash | 4 | hr | |
| Plant Health | 8 | hr | |
| Remediation of erosion | 4 | hr | |
| | 0 | hr | |
| **Total hours per year** | 16 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 870 | |
| Labor cost, burdened | O/H 150.0% | $ 2,176 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 42,818 | | $ 103,505 | **$249,612** | **$ 161,738** | | | |
| 0 | 1.000 | **$ 90,300** | | | $90,300 | $ 90,300 | $ 90,300 | $ 90,300 | $ 161,738 |
| 1 | 0.950 | $ 900 | $ - | $ 2,176 | $ 3,076 | $ 2,922 | $ 93,376 | $ 93,222 | $ 71,438 |
| 2 | 0.903 | $ 927 | $ - | $ 2,241 | $ 3,168 | $ 2,860 | $ 96,543 | $ 96,082 | $ 68,516 |
| 3 | 0.858 | $ 955 | $ - | $ 2,308 | $ 3,263 | $ 2,799 | $ 99,806 | $ 98,880 | $ 65,656 |
| 4 | 0.815 | $ 983 | $ - | $ 2,377 | $ 3,361 | $ 2,739 | $ 103,167 | $ 101,619 | $ 62,858 |
| 5 | 0.774 | $ 1,013 | $ - | $ 2,449 | $ 3,462 | $ 2,680 | $ 106,629 | $ 104,299 | $ 60,119 |
| 6 | 0.736 | $ 1,043 | $ - | $ 2,522 | $ 3,565 | $ 2,623 | $ 110,194 | $ 106,922 | $ 57,439 |
| 7 | 0.699 | $ 1,075 | $ - | $ 2,598 | $ 3,672 | $ 2,567 | $ 113,867 | $ 109,489 | $ 54,816 |
| 8 | 0.664 | $ 1,107 | $ - | $ 2,676 | $ 3,783 | $ 2,512 | $ 117,649 | $ 112,001 | $ 52,249 |
| 9 | 0.631 | $ 1,140 | $ - | $ 2,756 | $ 3,896 | $ 2,458 | $ 121,545 | $ 114,459 | $ 49,737 |
| 10 | 0.599 | $ 1,174 | $ 6,495 | $ 2,839 | $ 10,508 | $ 6,299 | $ 132,053 | $ 120,759 | $ 47,279 |
| 11 | 0.570 | $ 1,210 | $ - | $ 2,924 | $ 4,133 | $ 2,354 | $ 136,186 | $ 123,113 | $ 40,980 |
| 12 | 0.541 | $ 1,246 | $ - | $ 3,012 | $ 4,257 | $ 2,304 | $ 140,444 | $ 125,417 | $ 38,625 |
| 13 | 0.514 | $ 1,283 | $ - | $ 3,102 | $ 4,385 | $ 2,255 | $ 144,829 | $ 127,671 | $ 36,321 |
| 14 | 0.489 | $ 1,322 | $ - | $ 3,195 | $ 4,517 | $ 2,207 | $ 149,345 | $ 129,878 | $ 34,067 |
| 15 | 0.464 | $ 1,361 | $ - | $ 3,291 | $ 4,652 | $ 2,159 | $ 153,997 | $ 132,037 | $ 31,860 |
| 16 | 0.441 | $ 1,402 | $ - | $ 3,390 | $ 4,792 | $ 2,113 | $ 158,789 | $ 134,150 | $ 29,701 |
| 17 | 0.419 | $ 1,444 | $ - | $ 3,491 | $ 4,935 | $ 2,068 | $ 163,724 | $ 136,218 | $ 27,588 |
| 18 | 0.398 | $ 1,488 | $ - | $ 3,596 | $ 5,083 | $ 2,024 | $ 168,808 | $ 138,242 | $ 25,520 |
| 19 | 0.378 | $ 1,532 | $ - | $ 3,704 | $ 5,236 | $ 1,981 | $ 174,044 | $ 140,223 | $ 23,496 |
| 20 | 0.359 | $ 1,578 | $ 6,495 | $ 3,815 | $ 11,888 | $ 4,272 | $ 185,932 | $ 144,495 | $ 21,515 |
| 21 | 0.341 | $ 1,626 | $ - | $ 3,929 | $ 5,555 | $ 1,897 | $ 191,486 | $ 146,392 | $ 17,243 |
| 22 | 0.324 | $ 1,674 | $ - | $ 4,047 | $ 5,722 | $ 1,856 | $ 197,208 | $ 148,248 | $ 15,346 |
| 23 | 0.308 | $ 1,724 | $ - | $ 4,169 | $ 5,893 | $ 1,817 | $ 203,101 | $ 150,064 | $ 13,490 |
| 24 | 0.293 | $ 1,776 | $ - | $ 4,294 | $ 6,070 | $ 1,778 | $ 209,171 | $ 151,842 | $ 11,674 |
| 25 | 0.278 | $ 1,830 | $ - | $ 4,423 | $ 6,252 | $ 1,740 | $ 215,423 | $ 153,582 | $ 9,896 |
| 26 | 0.264 | $ 1,884 | $ - | $ 4,555 | $ 6,440 | $ 1,702 | $ 221,863 | $ 155,284 | $ 8,156 |
| 27 | 0.251 | $ 1,941 | $ - | $ 4,692 | $ 6,633 | $ 1,666 | $ 228,496 | $ 156,950 | $ 6,454 |
| 28 | 0.239 | $ 1,999 | $ - | $ 4,833 | $ 6,832 | $ 1,630 | $ 235,327 | $ 158,581 | $ 4,788 |
| 29 | 0.227 | $ 2,059 | $ - | $ 4,978 | $ 7,037 | $ 1,596 | $ 242,364 | $ 160,177 | $ 3,157 |
| 30 | 0.215 | $ 2,121 | $ - | $ 5,127 | $ 7,248 | $ 1,562 | $ 249,612 | $ 161,738 | $ 1,562 |

**Description: WQBE 3C - Bioretention Facility With Underdrain in ROW**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be
4 performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).
Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4
8 visits per year, 1 hour per visit).
Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per
8 year, 1 hour per visit).
Annual mulch and plan replacements 10 plants at $54/Plant
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Replacement Assumptions:**

Replacement of treatment media, compost, and vegatation will take place every ten years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_03C_Bioretention_Underdrain_In ROW | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Bioretention Facility with Underdrain in ROW (Roadside)** | 175 | SF | | $ - |
| 2 | **GSI Facility (Length - bottom dimensions)** | 35 | LF | | |
| 3 | **GSI Facility (5'W bottom dimensions)** | 5 | LF | | |
| 4 | **Top Dimensions @ 3:1 Side Slopes** | 675 | SF | | |
| 5 | Facility Excavation to Berm and Waste @2.8'D | 44 | CY | $ 79 | $ 3,482 |
| 6 | Mulch Compost (@ 0.3'D) | 8 | CY | $ 86 | $ 645 |
| 7 | Treatment Media - biochar @ 18" D | 38 | CY | $ 270 | $ 10,125 |
| 8 | Rocked Spillway (2'WX5'L) | 10 | SF | $ 43 | $ 430 |
| 9 | | | | | |
| 10 | **Underdrain Items:** | 35 | LF | | |
| 11 | Underdrain Aggregate (2.5'X2.5') | 8 | CY | $ 133 | $ 1,078 |
| 12 | Pipe 8" Diameter Overflow/Drain | 35 | LF | $ 48 | $ 1,680 |
| 13 | Trench Exc to Waste | 8 | CY | $ 79 | $ 640 |
| 14 | | | | | |
| 15 | **Facility Removals and Restoration:** | 35 | LF | | |
| 16 | Pavement Patch - Facility (6"HMA/6"CSTC) | 39 | SY | $ 110 | $ 4,278 |
| 17 | Sidewalk 6'Wide | 23 | SY | $ 125 | $ 2,917 |
| 18 | Concrete Curb and Gutter | 35 | LF | $ 111 | $ 3,885 |
| 19 | Landscaping and Restoration (surface area of disturbance) | 111 | SY | $ 59 | $ 6,556 |
| 20 | Trees (None noted in Design Basis) | 0 | EA | $ 720 | $ - |
| 21 | | | | | $ - |
| 22 | **Outlet Pipe** | | | | $ - |
| 23 | DI CL 50 Pipe 8" Dia. | 50 | LF | $ 160 | $ 8,000 |
| 24 | 5' Wide Trench x 6'D to waste | 56 | CY | $ 79 | $ 4,389 |
| 25 | Trench Box Shoring (Shallow) | 600 | SF | $ 10 | $ 6,000 |
| 26 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 27 | Parking Lot Pavement Patch HMA 4" HM/4"CSBC | 28 | SY | $ 71 | $ 1,972 |
| 28 | | | | | |
| 29 | **Additional Costs** | | | | $ - |
| 30 | Removals @ 4% Construction Costs | 4.0% | LS | $ 59,976 | $ 2,399 |
| 31 | Traffic Control (Heavy) | 1 | MO | $ 20,000 | $ 20,000 |
| 32 | TESC @2% Construction Costs | 2% | LS | $ 62,375 | $ 1,247 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 83,622 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 8,362 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 91,984 |
| | | | | ***Direct: Subtotal Construction Costs (175 SF Area)*** | ***$ 91,984*** |

**Description: WQBE 3C - Bioretention Facility With Underdrain in ROW**
Shallow earthen depressions or vertical walled open bottom boxes with a designed soil mix and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.

**Cost Estimating Assumptions:**
Facility design is per KC SWDM Section C2.6.1
Installation is in ROW on the roadside and does not require easements or acquisition
Facility is sited on the roadside and assumes curb and gutter and pavement restoration to accommodate the facility width.
18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.
0.3' of composted media is included.

The facility treatment area is 85 sf with a 3:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 175 sf area (5' wide by 35' long) was selcted to represent an typical installation. The facility subtotal construction costs were then scaled to represent the selected 85 sf treatment area.
A maximum ponding depth of 6-inches with a minimum of 6-inches of freeboard are assumed.
Facilities placed in till soils require an underdrain system, facilities located in outwash soils do not require an underdrain.
A total of 50 linear feet of 8-inch storm pipe is required to connect to the downstream facility or main.
A rocked spillway is included.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
Trench Box shoring is used.
Arterial Roadway restoration is assumed for the outlet pipe and consists of 6" HMA/6" CSTS
Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.
Landscape restoration is required for the facility area.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located within the ROW and Traffic control is required
A street use permit is required.

**Planning Basis Assumptions:**
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

**Estimating Assumptions:**
This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_03D_Bioretention_ROW_No Underdrain | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Bioretention No Underdrain in ROW (85 SF Bottom Area) | 85 | SF | $ 524 | $ 44,540 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 44,540*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 6,681 |
| | | | Street Use Permit (Y/N) | Y | $ 700 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 51,921*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 5,122 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 57,043*** |
| | | | | Construction Sales Tax | $ 5,775 |
| | | | | Outside Agency Construction | $ 891 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 63,700*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 6,845 |
| | | | | Construction Management | $ 4,563 |
| | | | | Permitting & Support | $ 285 |
| | s.f. Land Area | None | | Land Purchase/ROW Acquisition | $ - |
| | s.f. Land Area | None | | Permanent Easements | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 2,852 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 14,546*** |
| | | | | Project Contingency | $ 11,737 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 26,300*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 90,000*** |

**Description: WQBE 3D - Bioretention no Underdrain in ROW (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 85 | ft2 |
| **Initial Capital Cost** | **$ 90,000** | |
| Capital cost | $ 1,059 | $/Unit |
| Total Direct O&M/Year | $ 2,176 | |
| Direct O&M cost | $ 25.60 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 6,495 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 161,400** | **$/unit** |
| **Annual O&M Cost** | **$ 3,100** | **$/year** |
| Annualized Cost | $1,430 | $/year |

**Materials, Supplies, Other Costs**

| | | | | |
|---|---|---|---|---|
| | | $ - | $/year | |
| Annual plant replacement | 2023 dollars | $ 540 | $/year | |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year | |
| Subtotal | | $900 | | |
| Labor | | | | |
| Remove Trash | 4 | hr | | |
| Plant Health | 8 | hr | | |
| Remediation of erosion | 4 | hr | | |
| | 0 | hr | | |
| **Total hours per year** | 16 | | | |
| Raw Labor Rate/Hr | | $ 54 | | |
| Raw labor cost | (embedded) | $ 870 | | |
| Labor cost, burdened | O/H 150.0% | $ 2,176 | $ | 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | | |
| Life Cycle Period: | 30 | years | | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 42,818 | | $ 103,505 | **$249,312** | **$ 161,438** | | | |
| 0 | 1.000 | **$ 90,000** | | | $90,000 | $ 90,000 | $ 90,000 | $ 90,000 | $ 161,438 |
| 1 | 0.950 | $ 900 | $ - | $ 2,176 | $ 3,076 | $ 2,922 | $ 93,076 | $ 92,922 | $ 71,438 |
| 2 | 0.903 | $ 927 | $ - | $ 2,241 | $ 3,168 | $ 2,860 | $ 96,243 | $ 95,782 | $ 68,516 |
| 3 | 0.858 | $ 955 | $ - | $ 2,308 | $ 3,263 | $ 2,799 | $ 99,506 | $ 98,580 | $ 65,656 |
| 4 | 0.815 | $ 983 | $ - | $ 2,377 | $ 3,361 | $ 2,739 | $ 102,867 | $ 101,319 | $ 62,858 |
| 5 | 0.774 | $ 1,013 | $ - | $ 2,449 | $ 3,462 | $ 2,680 | $ 106,329 | $ 103,999 | $ 60,119 |
| 6 | 0.736 | $ 1,043 | $ - | $ 2,522 | $ 3,565 | $ 2,623 | $ 109,894 | $ 106,622 | $ 57,439 |
| 7 | 0.699 | $ 1,075 | $ - | $ 2,598 | $ 3,672 | $ 2,567 | $ 113,567 | $ 109,189 | $ 54,816 |
| 8 | 0.664 | $ 1,107 | $ - | $ 2,676 | $ 3,783 | $ 2,512 | $ 117,349 | $ 111,701 | $ 52,249 |
| 9 | 0.631 | $ 1,140 | $ - | $ 2,756 | $ 3,896 | $ 2,458 | $ 121,245 | $ 114,159 | $ 49,737 |
| 10 | 0.599 | $ 1,174 | $ 6,495 | $ 2,839 | $ 10,508 | $ 6,299 | $ 131,753 | $ 120,459 | $ 47,279 |
| 11 | 0.570 | $ 1,210 | $ - | $ 2,924 | $ 4,133 | $ 2,354 | $ 135,886 | $ 122,813 | $ 40,980 |
| 12 | 0.541 | $ 1,246 | $ - | $ 3,012 | $ 4,257 | $ 2,304 | $ 140,144 | $ 125,117 | $ 38,625 |
| 13 | 0.514 | $ 1,283 | $ - | $ 3,102 | $ 4,385 | $ 2,255 | $ 144,529 | $ 127,371 | $ 36,321 |
| 14 | 0.489 | $ 1,322 | $ - | $ 3,195 | $ 4,517 | $ 2,207 | $ 149,045 | $ 129,578 | $ 34,067 |
| 15 | 0.464 | $ 1,361 | $ - | $ 3,291 | $ 4,652 | $ 2,159 | $ 153,697 | $ 131,737 | $ 31,860 |
| 16 | 0.441 | $ 1,402 | $ - | $ 3,390 | $ 4,792 | $ 2,113 | $ 158,489 | $ 133,850 | $ 29,701 |
| 17 | 0.419 | $ 1,444 | $ - | $ 3,491 | $ 4,935 | $ 2,068 | $ 163,424 | $ 135,918 | $ 27,588 |
| 18 | 0.398 | $ 1,488 | $ - | $ 3,596 | $ 5,083 | $ 2,024 | $ 168,508 | $ 137,942 | $ 25,520 |
| 19 | 0.378 | $ 1,532 | $ - | $ 3,704 | $ 5,236 | $ 1,981 | $ 173,744 | $ 139,923 | $ 23,496 |
| 20 | 0.359 | $ 1,578 | $ 6,495 | $ 3,815 | $ 11,888 | $ 4,272 | $ 185,632 | $ 144,195 | $ 21,515 |
| 21 | 0.341 | $ 1,626 | $ - | $ 3,929 | $ 5,555 | $ 1,897 | $ 191,186 | $ 146,092 | $ 17,243 |
| 22 | 0.324 | $ 1,674 | $ - | $ 4,047 | $ 5,722 | $ 1,856 | $ 196,908 | $ 147,948 | $ 15,346 |
| 23 | 0.308 | $ 1,724 | $ - | $ 4,169 | $ 5,893 | $ 1,817 | $ 202,801 | $ 149,764 | $ 13,490 |
| 24 | 0.293 | $ 1,776 | $ - | $ 4,294 | $ 6,070 | $ 1,778 | $ 208,871 | $ 151,542 | $ 11,674 |
| 25 | 0.278 | $ 1,830 | $ - | $ 4,423 | $ 6,252 | $ 1,740 | $ 215,123 | $ 153,282 | $ 9,896 |
| 26 | 0.264 | $ 1,884 | $ - | $ 4,555 | $ 6,440 | $ 1,702 | $ 221,563 | $ 154,984 | $ 8,156 |
| 27 | 0.251 | $ 1,941 | $ - | $ 4,692 | $ 6,633 | $ 1,666 | $ 228,196 | $ 156,650 | $ 6,454 |
| 28 | 0.239 | $ 1,999 | $ - | $ 4,833 | $ 6,832 | $ 1,630 | $ 235,027 | $ 158,281 | $ 4,788 |
| 29 | 0.227 | $ 2,059 | $ - | $ 4,978 | $ 7,037 | $ 1,596 | $ 242,064 | $ 159,877 | $ 3,157 |
| 30 | 0.215 | $ 2,121 | $ - | $ 5,127 | $ 7,248 | $ 1,562 | $ 249,312 | $ 161,438 | $ 1,562 |

**Description: WQBE 3D - Bioretention no Underdrain in ROW**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be
4 performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).
Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4
8 visits per year, 1 hour per visit).
Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour
8 per visit).
Annual mulch and plan replacements 10 plants at $54/Plant
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Replacement Assumptions:**

Replacement of treatment media, compost, and vegatation will take place every ten years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_03D_Bioretention_ROW_No Underdrain | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Bioretention Facility with Underdrain in ROW (Roadside)** | 175 | SF | | $ - |
| 2 | **GSI Facility (Length - bottom dimensions)** | 35 | LF | | |
| 3 | **GSI Facility (5'W bottom dimensions)** | 5 | LF | | |
| 4 | **Top Dimensions @ 3:1 Side Slopes** | 675 | SF | | |
| 5 | Facility Excavation to Berm and Waste @2.8'D | 44 | CY | $ 79 | $ 3,482 |
| 6 | Mulch Compost (@ 0.3'D) | 8 | CY | $ 86 | $ 645 |
| 7 | Treatment Media - biochar @ 18" D | 38 | CY | $ 270 | $ 10,125 |
| 8 | Rocked Spillway (2'WX5'L) | 10 | SF | $ 43 | $ 430 |
| 9 | | | | | |
| 10 | **Facility Removals and Restoration:** | 45 | LF | | |
| 11 | Pavement Patch - Facility (6"HMA/6"CSTC) | 50 | SY | $ 110 | $ 5,500 |
| 12 | Sidewalk 6'Wide | 30 | SY | $ 125 | $ 3,750 |
| 13 | Concrete Curb and Gutter | 45 | LF | $ 111 | $ 4,995 |
| 14 | Landscaping and Restoration (surface area of disturbance) | 111 | SY | $ 59 | $ 6,556 |
| 15 | Trees (None noted in Design Basis) | 0 | EA | $ 720 | $ - |
| 16 | | | | | $ - |
| 17 | **Outlet Pipe** | | | | $ - |
| 18 | DI CL 50 Pipe 8" Dia. | 50 | LF | $ 160 | $ 8,000 |
| 19 | 5' Wide Trench x 6'D to waste | 56 | CY | $ 79 | $ 4,389 |
| 20 | Trench Box Shoring (Shallow) | 600 | SF | $ 10 | $ 6,000 |
| 21 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 22 | Parking Lot Pavement Patch HMA 4" HM/4"CSBC | 28 | SY | $ 71 | $ 1,972 |
| 23 | | | | | |
| 24 | **Additional Costs** | | | | $ - |
| 25 | Removals @ 4% Construction Costs | 4.0% | LS | $ 59,744 | $ 2,390 |
| 26 | Traffic Control (Heavy) | 1 | MO | $ 20,000 | $ 20,000 |
| 27 | TESC @2% Construction Costs | 2% | LS | $ 62,133 | $ 1,243 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 83,376 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 8,338 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 91,714 |
| | | | | ***Direct: Subtotal Construction Costs (175 SF Area)*** | ***$ 91,714*** |

**Description: WQBE 3D - Bioretention no Underdrain in ROW**

Shallow earthen depressions or vertical walled open bottom boxes with a designed soil mix and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.

**Cost Estimating Assumptions:**

Facility design is per KC SWDM Section C2.6.1
Installation is in ROW on the roadside and does not require easements or acquisition
Facility is sited on the roadside and assumes curb and gutter and pavement restoration to accommodate the facility width.
18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.
0.3' of composted media is included.

The facility treatment area is 85 sf with a 3:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 175 sf area (5' wide by 35' long) was selcted to represent an typical installation. The facility subtotal construction costs were then scaled to represent the selected 85 sf treatment area.
A maximum ponding depth of 6-inches with a minimum of 6-inches of freeboard are assumed.
Facilities located in outwash soils do not require an underdrain.
A total of 50 linear feet of 8-inch storm pipe is required to connect to the downstream facility or main.
A rocked spillway is included.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
Trench Box shoring is used.
Arterial Roadway restoration is assumed for the outlet pipe and consists of 6" HMA/6" CSTS
Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.
Landscape restoration is required for the facility area.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located within the ROW and Traffic control is required
A street use permit is required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 04A - Bioswale_ROW | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Bioswale in ROW (200 SF Bottom Area) | 200 | SF | $ 70 | $ 14,000 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 14,000*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 2,100 |
| | | | Street Use Permit (Y/N) | Y | $ 700 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 16,800*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 1,610 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 18,410*** |
| | | | | Construction Sales Tax | $ 1,815 |
| | | | | Outside Agency Construction | $ 280 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 20,500*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 2,209 |
| | | | | Construction Management | $ 1,473 |
| | | | | Permitting & Support | $ 92 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 921 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 4,695*** |
| | | | | Project Contingency | $ 3,779 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 8,500*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 29,000*** |

**Description: WQBE 04A - Bioswale in ROW (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 200 | ft2 |
| **Initial Capital Cost** | **$ 29,000** | |
| Capital cost | $ 145 | $/Unit |
| Total Direct O&M/Year | $ 2,175.60 | |
| Direct O&M cost | $ 10.88 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 707 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 85,300** | **$/unit** |
| **Annual O&M Cost** | **$ 2,600** | **$/year** |
| Annualized Cost | $710 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Grass seed, gravel & soil spot repairs, grass health supplies. | 2023 dollars | $ 450 | $/year |
| | 2023 dollars | $ - | $/year |
| Subtotal | | $450 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash | 4 | hr | |
| Plant Health | 8 | hr | |
| Remediation of erosion | 4 | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 16 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 870 | |
| Labor cost, burdened | O/H 150.0% | $ 2,176 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 21,409 | | $ 103,505 | **$155,328** | **$ 85,347** | | | |
| 0 | 1.000 | **$ 29,000** | | | $29,000 | $ 29,000 | $ 29,000 | $ 29,000 | $ 85,347 |
| 1 | 0.950 | $ 450 | $ - | $ 2,176 | $ 2,626 | $ 2,495 | $ 31,626 | $ 31,495 | $ 56,347 |
| 2 | 0.903 | $ 464 | $ - | $ 2,241 | $ 2,704 | $ 2,441 | $ 34,330 | $ 33,936 | $ 53,853 |
| 3 | 0.858 | $ 477 | $ - | $ 2,308 | $ 2,785 | $ 2,389 | $ 37,115 | $ 36,325 | $ 51,411 |
| 4 | 0.815 | $ 492 | $ - | $ 2,377 | $ 2,869 | $ 2,338 | $ 39,985 | $ 38,663 | $ 49,022 |
| 5 | 0.774 | $ 506 | $ - | $ 2,449 | $ 2,955 | $ 2,288 | $ 42,940 | $ 40,951 | $ 46,684 |
| 6 | 0.736 | $ 522 | $ - | $ 2,522 | $ 3,044 | $ 2,239 | $ 45,983 | $ 43,190 | $ 44,396 |
| 7 | 0.699 | $ 537 | $ - | $ 2,598 | $ 3,135 | $ 2,191 | $ 49,119 | $ 45,382 | $ 42,157 |
| 8 | 0.664 | $ 553 | $ - | $ 2,676 | $ 3,229 | $ 2,144 | $ 52,348 | $ 47,526 | $ 39,966 |
| 9 | 0.631 | $ 570 | $ - | $ 2,756 | $ 3,326 | $ 2,099 | $ 55,674 | $ 49,625 | $ 37,821 |
| 10 | 0.599 | $ 587 | $ 707 | $ 2,839 | $ 4,133 | $ 2,477 | $ 59,806 | $ 52,102 | $ 35,723 |
| 11 | 0.570 | $ 605 | $ - | $ 2,924 | $ 3,529 | $ 2,010 | $ 63,335 | $ 54,112 | $ 33,245 |
| 12 | 0.541 | $ 623 | $ - | $ 3,012 | $ 3,634 | $ 1,967 | $ 66,969 | $ 56,079 | $ 31,235 |
| 13 | 0.514 | $ 642 | $ - | $ 3,102 | $ 3,743 | $ 1,925 | $ 70,713 | $ 58,004 | $ 29,268 |
| 14 | 0.489 | $ 661 | $ - | $ 3,195 | $ 3,856 | $ 1,884 | $ 74,569 | $ 59,887 | $ 27,344 |
| 15 | 0.464 | $ 681 | $ - | $ 3,291 | $ 3,971 | $ 1,843 | $ 78,540 | $ 61,731 | $ 25,460 |
| 16 | 0.441 | $ 701 | $ - | $ 3,390 | $ 4,091 | $ 1,804 | $ 82,631 | $ 63,535 | $ 23,617 |
| 17 | 0.419 | $ 722 | $ - | $ 3,491 | $ 4,213 | $ 1,765 | $ 86,844 | $ 65,300 | $ 21,813 |
| 18 | 0.398 | $ 744 | $ - | $ 3,596 | $ 4,340 | $ 1,728 | $ 91,184 | $ 67,028 | $ 20,047 |
| 19 | 0.378 | $ 766 | $ - | $ 3,704 | $ 4,470 | $ 1,691 | $ 95,654 | $ 68,718 | $ 18,320 |
| 20 | 0.359 | $ 789 | $ 707 | $ 3,815 | $ 5,311 | $ 1,909 | $ 100,964 | $ 70,627 | $ 16,629 |
| 21 | 0.341 | $ 813 | $ - | $ 3,929 | $ 4,742 | $ 1,619 | $ 105,707 | $ 72,246 | $ 14,720 |
| 22 | 0.324 | $ 837 | $ - | $ 4,047 | $ 4,884 | $ 1,585 | $ 110,591 | $ 73,831 | $ 13,101 |
| 23 | 0.308 | $ 862 | $ - | $ 4,169 | $ 5,031 | $ 1,551 | $ 115,622 | $ 75,382 | $ 11,516 |
| 24 | 0.293 | $ 888 | $ - | $ 4,294 | $ 5,182 | $ 1,518 | $ 120,804 | $ 76,899 | $ 9,966 |
| 25 | 0.278 | $ 915 | $ - | $ 4,423 | $ 5,337 | $ 1,485 | $ 126,141 | $ 78,384 | $ 8,448 |
| 26 | 0.264 | $ 942 | $ - | $ 4,555 | $ 5,497 | $ 1,453 | $ 131,638 | $ 79,838 | $ 6,963 |
| 27 | 0.251 | $ 970 | $ - | $ 4,692 | $ 5,662 | $ 1,422 | $ 137,301 | $ 81,260 | $ 5,509 |
| 28 | 0.239 | $ 1,000 | $ - | $ 4,833 | $ 5,832 | $ 1,392 | $ 143,133 | $ 82,652 | $ 4,087 |
| 29 | 0.227 | $ 1,030 | $ - | $ 4,978 | $ 6,007 | $ 1,362 | $ 149,140 | $ 84,014 | $ 2,695 |
| 30 | 0.215 | $ 1,060 | $ - | $ 5,127 | $ 6,187 | $ 1,333 | $ 155,328 | $ 85,347 | $ 1,333 |

**Description: WQBE 04A - Bioswale in ROW**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

4 Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).

8 Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per year, 1 hour per visit).

4 Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Grass seed, gravel & soils spot repairs, grass health supplies at $450/year total.

**Replacement Assumptions:**

Replacement of treatment media, compost, and vegatation will take place every ten years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 04A - Bioswale_ROW | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Bioswale in ROW** | 375 | SF | | $ - |
| 2 | **Bioswale Facility (Length - bottom dimensions)** | 75 | LF | | |
| 3 | **Bioswale Facility (5'W bottom dimensions)** | 5 | LF | | |
| 4 | **Top Dimensions @ 3:1 Side Slopes** | 800 | SF | | |
| 5 | Facility Excavation to Berm and Waste @2.8'D | 61 | CY | $ 79 | $ 4,813 |
| 6 | Mulch Compost (@ 0.3'D) | 9 | CY | $ 86 | $ 764 |
| 7 | Flow Spreader (Inlet, Mid and Outlet) | 3 | EA | $ 1,480 | $ 4,440 |
| 8 | | | | | |
| 9 | **Facility Removals and Restoration:** | | | | |
| 10 | Concrete Curb and Gutter (in curb cut areas only) | 15 | LF | $ 111 | $ 1,665 |
| 11 | Grass Seeding and Restoration | 142 | SY | $ 10 | $ 1,417 |
| 12 | Trees (None noted in Design Basis) | 0 | EA | $ 720 | $ - |
| 13 | | | | | $ - |
| 14 | | | | | |
| 15 | **Additional Costs** | | | | $ - |
| 16 | Removals @ 4% Construction Costs | 4.0% | LS | $ 13,099 | $ 524 |
| 17 | Traffic Control (Heavy) | 0.5 | MO | $ 20,000 | $ 10,000 |
| 18 | TESC @2% Construction Costs | 2% | LS | $ 13,623 | $ 272 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 23,896 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 2,390 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 26,285 |
| | | | | ***Direct: Subtotal Construction Costs (375 SF Area)*** | ***$ 26,285*** |

**Description: WQBE 04A - Bioswale in ROW**

An open, gently sloped, vegetated channel designed for treatment of stormwater. Grass is most common vegetation, but wetland vegetation can be used if soil is saturated.

**Cost Estimating Assumptions:**

Facility design is per KC SWDM Section 6.3.1
Installation is in ROW on the roadside or highway and does not require easements or acquisition.
Pretreatment is not included in the cost model.
Treatment media is not included in the cost model.
0.2 feet of composted media is tilled into the top 6 inches of soil.

The facility treatment area is 200 sf with a 50:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 375 sf area (5' wide by 75' long) was selcted to represent an typical installation. The facility subtotal construction costs were then scaled to represent the selected 200 sf treatment area. A maximum ponding depth of 4" and a 6" minimum freeboard depth are assumed. The longitudinal gradient is less than 6% and check dams are not required.
No underdrain is required
Surface flows enter the swale via curb openings.
Flow spreaders are required at the inlet, mid-swale, and outlet.
It is assumed that the facility fits within the roadside and that pavement removal and resoration is not required.
The excavated material is unsuitable for use as backfill.
Dewatering is not required
Shoring is not required.
No piping is needed to convey flows to or from the facility.
The concrete curb and gutter restoration is assumed only at the swale inlet and outlet areas.
There is sufficient area along the roadside to construct the swales without pavement patching or sidewalk restoration.
Seeded grass restoration is required for the facility area.
Tree plantings are not included in the cost model.
Removals are estimated at 4% of the item construction costs, in conformance with LTCP GSI cost estimates.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located within the ROW and Traffic control is required
A street use permit is required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 04B - Bioswale_On_Public_Property | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Bioswale in On Public Property (200 SF Bottom Area) | 200 | SF | $ 41 | $ 8,200 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 8,200*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 1,230 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 9,430*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 943 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 10,373*** |
| | | | | Construction Sales Tax | $ 1,063 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 11,400*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 1,245 |
| | | | | Construction Management | $ 830 |
| | | | | Permitting & Support | $ 52 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 519 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 2,645*** |
| | | | | Project Contingency | $ 2,107 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 4,800*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 16,200*** |

**Description: WQBE 4B - Bioswale On Public Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 200 | ft2 |
| **Initial Capital Cost** | **$ 16,200** | |
| Capital cost | $ 81 | $/Unit |
| Total Direct O&M/Year | $ 2,176 | |
| Direct O&M cost | $ 10.88 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 707 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 72,500** | **$/unit** |
| **Annual O&M Cost** | **$ 2,600** | **$/year** |
| Annualized Cost | $710 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Grass seed, gravel & soil spot repairs, grass health supplies. | 2023 dollars | $ 450 | $/year |
| | 2023 dollars | $ - | $/year |
| Subtotal | | $450 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash | 4 | hr | |
| Plant Health | 8 | hr | |
| Remediation of erosion | 4 | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 16 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 870 | |
| Labor cost, burdened | O/H 150.0% | $ 2,176 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 21,409 | | $ 103,505 | **$142,528** | **$ 72,547** | | | |
| 0 | 1.000 | **$ 16,200** | | | $16,200 | $ 16,200 | $ 16,200 | $ 16,200 | $ 72,547 |
| 1 | 0.950 | $ 450 | $ - | $ 2,176 | $ 2,626 | $ 2,495 | $ 18,826 | $ 18,695 | $ 56,347 |
| 2 | 0.903 | $ 464 | $ - | $ 2,241 | $ 2,704 | $ 2,441 | $ 21,530 | $ 21,136 | $ 53,853 |
| 3 | 0.858 | $ 477 | $ - | $ 2,308 | $ 2,785 | $ 2,389 | $ 24,315 | $ 23,525 | $ 51,411 |
| 4 | 0.815 | $ 492 | $ - | $ 2,377 | $ 2,869 | $ 2,338 | $ 27,185 | $ 25,863 | $ 49,022 |
| 5 | 0.774 | $ 506 | $ - | $ 2,449 | $ 2,955 | $ 2,288 | $ 30,140 | $ 28,151 | $ 46,684 |
| 6 | 0.736 | $ 522 | $ - | $ 2,522 | $ 3,044 | $ 2,239 | $ 33,183 | $ 30,390 | $ 44,396 |
| 7 | 0.699 | $ 537 | $ - | $ 2,598 | $ 3,135 | $ 2,191 | $ 36,319 | $ 32,582 | $ 42,157 |
| 8 | 0.664 | $ 553 | $ - | $ 2,676 | $ 3,229 | $ 2,144 | $ 39,548 | $ 34,726 | $ 39,966 |
| 9 | 0.631 | $ 570 | $ - | $ 2,756 | $ 3,326 | $ 2,099 | $ 42,874 | $ 36,825 | $ 37,821 |
| 10 | 0.599 | $ 587 | $ 707 | $ 2,839 | $ 4,133 | $ 2,477 | $ 47,006 | $ 39,302 | $ 35,723 |
| 11 | 0.570 | $ 605 | $ - | $ 2,924 | $ 3,529 | $ 2,010 | $ 50,535 | $ 41,312 | $ 33,245 |
| 12 | 0.541 | $ 623 | $ - | $ 3,012 | $ 3,634 | $ 1,967 | $ 54,169 | $ 43,279 | $ 31,235 |
| 13 | 0.514 | $ 642 | $ - | $ 3,102 | $ 3,743 | $ 1,925 | $ 57,913 | $ 45,204 | $ 29,268 |
| 14 | 0.489 | $ 661 | $ - | $ 3,195 | $ 3,856 | $ 1,884 | $ 61,769 | $ 47,087 | $ 27,344 |
| 15 | 0.464 | $ 681 | $ - | $ 3,291 | $ 3,971 | $ 1,843 | $ 65,740 | $ 48,931 | $ 25,460 |
| 16 | 0.441 | $ 701 | $ - | $ 3,390 | $ 4,091 | $ 1,804 | $ 69,831 | $ 50,735 | $ 23,617 |
| 17 | 0.419 | $ 722 | $ - | $ 3,491 | $ 4,213 | $ 1,765 | $ 74,044 | $ 52,500 | $ 21,813 |
| 18 | 0.398 | $ 744 | $ - | $ 3,596 | $ 4,340 | $ 1,728 | $ 78,384 | $ 54,228 | $ 20,047 |
| 19 | 0.378 | $ 766 | $ - | $ 3,704 | $ 4,470 | $ 1,691 | $ 82,854 | $ 55,918 | $ 18,320 |
| 20 | 0.359 | $ 789 | $ 707 | $ 3,815 | $ 5,311 | $ 1,909 | $ 88,164 | $ 57,827 | $ 16,629 |
| 21 | 0.341 | $ 813 | $ - | $ 3,929 | $ 4,742 | $ 1,619 | $ 92,907 | $ 59,446 | $ 14,720 |
| 22 | 0.324 | $ 837 | $ - | $ 4,047 | $ 4,884 | $ 1,585 | $ 97,791 | $ 61,031 | $ 13,101 |
| 23 | 0.308 | $ 862 | $ - | $ 4,169 | $ 5,031 | $ 1,551 | $ 102,822 | $ 62,582 | $ 11,516 |
| 24 | 0.293 | $ 888 | $ - | $ 4,294 | $ 5,182 | $ 1,518 | $ 108,004 | $ 64,099 | $ 9,966 |
| 25 | 0.278 | $ 915 | $ - | $ 4,423 | $ 5,337 | $ 1,485 | $ 113,341 | $ 65,584 | $ 8,448 |
| 26 | 0.264 | $ 942 | $ - | $ 4,555 | $ 5,497 | $ 1,453 | $ 118,838 | $ 67,038 | $ 6,963 |
| 27 | 0.251 | $ 970 | $ - | $ 4,692 | $ 5,662 | $ 1,422 | $ 124,501 | $ 68,460 | $ 5,509 |
| 28 | 0.239 | $ 1,000 | $ - | $ 4,833 | $ 5,832 | $ 1,392 | $ 130,333 | $ 69,852 | $ 4,087 |
| 29 | 0.227 | $ 1,030 | $ - | $ 4,978 | $ 6,007 | $ 1,362 | $ 136,340 | $ 71,214 | $ 2,695 |
| 30 | 0.215 | $ 1,060 | $ - | $ 5,127 | $ 6,187 | $ 1,333 | $ 142,528 | $ 72,547 | $ 1,333 |

**Description: WQBE 4B - Bioswale On Public Property**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be
4 performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4
8 visits per year, 1 hour per visit).

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour
4 per visit).

Grass seed, gravel & soils spot repairs, grass health supplies at $450/year total.

**Replacement Assumptions:**

Replacement of treatment media, compost, and vegatation will take place every ten years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 04B - Bioswale_On_Public_Property | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Bioswale in ROW** | 375 | SF | | $ - |
| 2 | **Bioswale Facility (Length - bottom dimensions)** | 75 | LF | | |
| 3 | **Bioswale Facility (5'W bottom dimensions)** | 5 | LF | | |
| 4 | **Top Dimensions @ 3:1 Side Slopes (11'WX23'L)** | 800 | SF | | |
| 5 | Facility Excavation to Berm and Waste @2.8'D | 61 | CY | $ 79 | $ 4,813 |
| 6 | Mulch Compost (@ 0.3'D) | 9 | CY | $ 86 | $ 764 |
| 7 | Flow Spreader (Inlet, Mid and Outlet) | 3 | EA | $ 1,480 | $ 4,440 |
| 8 | | | | | |
| 9 | **Facility Removals and Restoration:** | | | | |
| 10 | Concrete Curb and Gutter (in curb cut areas only) | 15 | LF | $ 111 | $ 1,665 |
| 11 | Grass Seeding and Restoration | 142 | SY | $ 10 | $ 1,417 |
| 12 | Trees (None noted in Design Basis) | 0 | EA | $ 720 | $ - |
| 13 | | | | | $ - |
| 14 | | | | | |
| 15 | **Additional Costs** | | | | $ - |
| 16 | Removals @ 4% Construction Costs | 4.0% | LS | $ 13,099 | $ 524 |
| 17 | TESC @2% Construction Costs | 2% | LS | $ 13,623 | $ 272 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 13,896 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 1,390 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 15,285 |
| | | | | ***Direct: Subtotal Construction Costs (375 SF Area)*** | ***$ 15,285*** |

**Description: WQBE 4B - Bioswale On Public Property**
An open, gently sloped, vegetated channel designed for treatment of stormwater. Grass is most common vegetation, but wetland vegetation can be used if soil is saturated.

**Cost Estimating Assumptions:**
Facility design is per KC SWDM Section 6.3.1
Installation is in ROW on the roadside or highway and does not require easements or acquisition.
Pretreatment is not included in the cost model.
Treatment media is not included in the cost model.
0.2 feet of composted media is tilled into the top 6 inches of soil.

The facility treatment area is 200 sf with a 50:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 375 sf area (5' wide by 75' long) was selcted to represent an typical installation. The facility subtotal construction costs were then scaled to represent the selected 200 sf treatment area.
A maximum ponding depth of 4" and a 6" minimum freeboard depth are assumed. The longitudinal gradient is less than 6% and check dams are not required.
No underdrain is required
Surface flows enter the swale via curb openings.
Flow spreaders are required at the inlet, mid-swale, and outlet.
It is assumed that the facility fits within the roadside and that pavement removal and resoration is not required.
The excavated material is unsuitable for use as backfill.
Dewatering is not required
Shoring is not required.
No piping is needed to convey flows to or from the facility.
The concrete curb and gutter restoration is assumed only at the swale inlet and outlet areas.
There is sufficient area along the roadside to construct the swales without pavement patching or sidewalk restoration.
Seeded grass restoration is required for the facility area.
Tree plantings are not included in the cost model.
Removals are estimated at 4% of the item construction costs, in conformance with LTCP GSI cost estimates.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and Traffic Control is not required.
A street use permit is not required.

**Planning Basis Assumptions:**
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**
This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 04C - Bioswale_With Property Cost | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Bioswale On Property (200 SF Bottom Area) | 200 | SF | $ 41 | $ 8,200 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 8,200*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 1,230 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 9,430*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 943 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 10,373*** |
| | | | | Construction Sales Tax | $ 1,063 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 11,400*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 1,245 |
| | | | | Construction Management | $ 830 |
| | | | | Permitting & Support | $ 52 |
| 735 | s.f. Land Area | Medium | | Land Purchase/ROW Acquisition | $ 59,116 |
| | s.f. Land Area | None | | Permanent Easements | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 519 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 61,761*** |
| | | | | Project Contingency | $ 10,974 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 72,700*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 84,100*** |

**Description: WQBE 04C - Bioswale_With Property Cost (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 200 | ft2 |
| **Initial Capital Cost** | **$ 84,100** | |
| Capital cost | $ 421 | $/Unit |
| Total Direct O&M/Year | $ 2,176 | |
| Direct O&M cost | $ 10.88 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 707 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 140,400** | **$/unit** |
| **Annual O&M Cost** | **$ 2,600** | **$/year** |
| Annualized Cost | $710 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Grass seed, gravel & soil spot repairs, grass health supplies. | 2023 dollars | $ 450 | $/year |
| | 2023 dollars | $ - | $/year |
| Subtotal | | $450 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash | 4 | hr | |
| Plant Health | 8 | hr | |
| Remediation of erosion | 4 | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 16 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 870 | |
| Labor cost, burdened | O/H 150.0% | $ 2,176 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 21,409 | | $ 103,505 | **$210,428** | **$ 140,447** | | | |
| 0 | 1.000 | **$ 84,100** | | | $84,100 | $ 84,100 | $ 84,100 | $ 84,100 | $ 140,447 |
| 1 | 0.950 | $ 450 | $ - | $ 2,176 | $ 2,626 | $ 2,495 | $ 86,726 | $ 86,595 | $ 56,347 |
| 2 | 0.903 | $ 464 | $ - | $ 2,241 | $ 2,704 | $ 2,441 | $ 89,430 | $ 89,036 | $ 53,853 |
| 3 | 0.858 | $ 477 | $ - | $ 2,308 | $ 2,785 | $ 2,389 | $ 92,215 | $ 91,425 | $ 51,411 |
| 4 | 0.815 | $ 492 | $ - | $ 2,377 | $ 2,869 | $ 2,338 | $ 95,085 | $ 93,763 | $ 49,022 |
| 5 | 0.774 | $ 506 | $ - | $ 2,449 | $ 2,955 | $ 2,288 | $ 98,040 | $ 96,051 | $ 46,684 |
| 6 | 0.736 | $ 522 | $ - | $ 2,522 | $ 3,044 | $ 2,239 | $ 101,083 | $ 98,290 | $ 44,396 |
| 7 | 0.699 | $ 537 | $ - | $ 2,598 | $ 3,135 | $ 2,191 | $ 104,219 | $ 100,482 | $ 42,157 |
| 8 | 0.664 | $ 553 | $ - | $ 2,676 | $ 3,229 | $ 2,144 | $ 107,448 | $ 102,626 | $ 39,966 |
| 9 | 0.631 | $ 570 | $ - | $ 2,756 | $ 3,326 | $ 2,099 | $ 110,774 | $ 104,725 | $ 37,821 |
| 10 | 0.599 | $ 587 | $ 707 | $ 2,839 | $ 4,133 | $ 2,477 | $ 114,906 | $ 107,202 | $ 35,723 |
| 11 | 0.570 | $ 605 | $ - | $ 2,924 | $ 3,529 | $ 2,010 | $ 118,435 | $ 109,212 | $ 33,245 |
| 12 | 0.541 | $ 623 | $ - | $ 3,012 | $ 3,634 | $ 1,967 | $ 122,069 | $ 111,179 | $ 31,235 |
| 13 | 0.514 | $ 642 | $ - | $ 3,102 | $ 3,743 | $ 1,925 | $ 125,813 | $ 113,104 | $ 29,268 |
| 14 | 0.489 | $ 661 | $ - | $ 3,195 | $ 3,856 | $ 1,884 | $ 129,669 | $ 114,987 | $ 27,344 |
| 15 | 0.464 | $ 681 | $ - | $ 3,291 | $ 3,971 | $ 1,843 | $ 133,640 | $ 116,831 | $ 25,460 |
| 16 | 0.441 | $ 701 | $ - | $ 3,390 | $ 4,091 | $ 1,804 | $ 137,731 | $ 118,635 | $ 23,617 |
| 17 | 0.419 | $ 722 | $ - | $ 3,491 | $ 4,213 | $ 1,765 | $ 141,944 | $ 120,400 | $ 21,813 |
| 18 | 0.398 | $ 744 | $ - | $ 3,596 | $ 4,340 | $ 1,728 | $ 146,284 | $ 122,128 | $ 20,047 |
| 19 | 0.378 | $ 766 | $ - | $ 3,704 | $ 4,470 | $ 1,691 | $ 150,754 | $ 123,818 | $ 18,320 |
| 20 | 0.359 | $ 789 | $ 707 | $ 3,815 | $ 5,311 | $ 1,909 | $ 156,064 | $ 125,727 | $ 16,629 |
| 21 | 0.341 | $ 813 | $ - | $ 3,929 | $ 4,742 | $ 1,619 | $ 160,807 | $ 127,346 | $ 14,720 |
| 22 | 0.324 | $ 837 | $ - | $ 4,047 | $ 4,884 | $ 1,585 | $ 165,691 | $ 128,931 | $ 13,101 |
| 23 | 0.308 | $ 862 | $ - | $ 4,169 | $ 5,031 | $ 1,551 | $ 170,722 | $ 130,482 | $ 11,516 |
| 24 | 0.293 | $ 888 | $ - | $ 4,294 | $ 5,182 | $ 1,518 | $ 175,904 | $ 131,999 | $ 9,966 |
| 25 | 0.278 | $ 915 | $ - | $ 4,423 | $ 5,337 | $ 1,485 | $ 181,241 | $ 133,484 | $ 8,448 |
| 26 | 0.264 | $ 942 | $ - | $ 4,555 | $ 5,497 | $ 1,453 | $ 186,738 | $ 134,938 | $ 6,963 |
| 27 | 0.251 | $ 970 | $ - | $ 4,692 | $ 5,662 | $ 1,422 | $ 192,401 | $ 136,360 | $ 5,509 |
| 28 | 0.239 | $ 1,000 | $ - | $ 4,833 | $ 5,832 | $ 1,392 | $ 198,233 | $ 137,752 | $ 4,087 |
| 29 | 0.227 | $ 1,030 | $ - | $ 4,978 | $ 6,007 | $ 1,362 | $ 204,240 | $ 139,114 | $ 2,695 |
| 30 | 0.215 | $ 1,060 | $ - | $ 5,127 | $ 6,187 | $ 1,333 | $ 210,428 | $ 140,447 | $ 1,333 |

**Description: WQBE 04C - Bioswale_With Property Cost**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

4 Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).

8 Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per year, 1 hour per visit).

4 Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Grass seed, gravel & soils spot repairs, grass health supplies at $450/year total.

**Replacement Assumptions:**

Replacement of treatment media, compost, and vegetation will take place every ten years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 04C - Bioswale_With Property Cost | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Bioswale in ROW** | 375 | SF | | $ - |
| 2 | **Bioswale Facility (Length - bottom dimensions)** | 75 | LF | | |
| 3 | **Bioswale Facility (5'W bottom dimensions)** | 5 | LF | | |
| 4 | **Top Dimensions @ 3:1 Side Slopes** | 800 | SF | | |
| 5 | Facility Excavation to Berm and Waste @2.8'D | 61 | CY | $ 79 | $ 4,813 |
| 6 | Mulch Compost (@ 0.3'D) | 9 | CY | $ 86 | $ 764 |
| 7 | Flow Spreader (Inlet, Mid and Outlet) | 3 | EA | $ 1,480 | $ 4,440 |
| 8 | | | | | |
| 9 | **Facility Removals and Restoration:** | | | | |
| 10 | Concrete Curb and Gutter (in curb cut areas only) | 15 | LF | $ 111 | $ 1,665 |
| 11 | Grass Seeding and Restoration | 142 | SY | $ 10 | $ 1,417 |
| 12 | Trees (None noted in Design Basis) | 0 | EA | $ 720 | $ - |
| 13 | | | | | $ - |
| 14 | | | | | |
| 15 | **Additional Costs** | | | | $ - |
| 16 | Removals @ 4% Construction Costs | 4.0% | LS | $ 13,099 | $ 524 |
| 17 | TESC @2% Construction Costs | 2% | LS | $ 13,623 | $ 272 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 13,896 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 1,390 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 15,285 |
| | | | | ***Direct: Subtotal Construction Costs (375 SF Area)*** | ***$ 15,285*** |

**Description: WQBE 04C - Bioswale_With Property Cost**

An open, gently sloped, vegetated channel designed for treatment of stormwater. Grass is most common vegetation, but wetland vegetation can be used if soil is saturated.

**Cost Estimating Assumptions:**

Facility design is per KC SWDM Section 6.3.1
Pretreatment is not included in the cost model.
Treatment media is not included in the cost model.
0.2 feet of composted media is tilled into the top 6 inches of soil.

The facility treatment area is 200 sf with a 50:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 375 sf area (5' wide by 75' long) was selcted to represent an typical installation. The facility subtotal construction costs were then scaled to represent the selected 200 sf treatment area.
A maximum ponding depth of 4" and a 6" minimum freeboard depth are assumed. The longitudinal gradient is less than 6% and check dams are not required.
No underdrain is required
Surface flows enter the swale via curb openings.
Flow spreaders are required at the inlet, mid-swale, and outlet.
It is assumed that the facility fits within the roadside and that pavement removal and resoration is not required.
The excavated material is unsuitable for use as backfill.
Dewatering is not required
Shoring is not required.
No piping is needed to convey flows to or from the facility.
The concrete curb and gutter restoration is assumed only at the swale inlet and outlet areas.
There is sufficient area along the roadside to construct the swales without pavement patching or sidewalk restoration.
Seeded grass restoration is required for the facility area.
Tree plantings are not included in the cost model.
Removals are estimated at 4% of the item construction costs, in conformance with LTCP GSI cost estimates.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and Traffic Control is not required.
A street use permit is **not** required.
The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to Medium.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 05A - Media_Filter_Drain_ROW_Underdrain | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Media Filter Drain (200 SF Bottom Area) - w/Underdrain | 200 | SF | $ 87 | $ 17,400 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 17,400*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 2,610 |
| | | | Street Use Permit (Y/N) | Y | $ 700 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 20,710*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 2,001 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 22,711*** |
| | | | | Construction Sales Tax | $ 2,256 |
| | | | | Outside Agency Construction | $ 348 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 25,300*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 2,725 |
| | | | | Construction Management | $ 1,817 |
| | | | | Permitting & Support | $ 114 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 1,136 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 5,791*** |
| | | | | Project Contingency | $ 4,664 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 10,500*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 35,800*** |

**Description: WQBE 05A - Media_Filter_Drain_ROW_Underdrain (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 200 | ft2 |
| **Initial Capital Cost** | **$ 35,800** | |
| Capital cost | $ 179 | $/Unit |
| Total Direct O&M/Year | $ 2,176 | |
| Direct O&M cost | $ 10.88 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 4,309 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 90,800** | **$/unit** |
| **Annual O&M Cost** | **$ 2,400** | **$/year** |
| Annualized Cost | $360 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Grass seed & gravel for spot repairs | 2023 dollars | $ 225 | $/year |
| | 2023 dollars | | $/year |
| Subtotal | | $ 225 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash | 4 | hr | |
| Grass Health | 8 | hr | |
| Remediation of erosion | 4 | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 16 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 870 | |
| Labor cost, burdened | O/H 150.0% | $ 2,176 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 10,704 | | $ 103,505 | **$158,628** | **$ 90,831** | | | |
| 0 | 1.000 | **$ 35,800** | | | $35,800 | $ 35,800 | $ 35,800 | $ 35,800 | $ 90,831 |
| 1 | 0.950 | $ 225 | $ - | $ 2,176 | $ 2,401 | $ 2,281 | $ 38,201 | $ 38,081 | $ 55,031 |
| 2 | 0.903 | $ 232 | $ - | $ 2,241 | $ 2,473 | $ 2,232 | $ 40,673 | $ 40,313 | $ 52,750 |
| 3 | 0.858 | $ 239 | $ - | $ 2,308 | $ 2,547 | $ 2,184 | $ 43,220 | $ 42,497 | $ 50,518 |
| 4 | 0.815 | $ 246 | $ - | $ 2,377 | $ 2,623 | $ 2,138 | $ 45,843 | $ 44,635 | $ 48,334 |
| 5 | 0.774 | $ 253 | $ - | $ 2,449 | $ 2,702 | $ 2,092 | $ 48,545 | $ 46,727 | $ 46,196 |
| 6 | 0.736 | $ 261 | $ - | $ 2,522 | $ 2,783 | $ 2,047 | $ 51,328 | $ 48,774 | $ 44,104 |
| 7 | 0.699 | $ 269 | $ - | $ 2,598 | $ 2,866 | $ 2,003 | $ 54,195 | $ 50,778 | $ 42,057 |
| 8 | 0.664 | $ 277 | $ - | $ 2,676 | $ 2,952 | $ 1,961 | $ 57,147 | $ 52,738 | $ 40,053 |
| 9 | 0.631 | $ 285 | $ - | $ 2,756 | $ 3,041 | $ 1,919 | $ 60,188 | $ 54,657 | $ 38,093 |
| 10 | 0.599 | $ 294 | $ 4,309 | $ 2,839 | $ 7,442 | $ 4,461 | $ 67,629 | $ 59,118 | $ 36,174 |
| 11 | 0.570 | $ 302 | $ - | $ 2,924 | $ 3,226 | $ 1,838 | $ 70,856 | $ 60,956 | $ 31,713 |
| 12 | 0.541 | $ 311 | $ - | $ 3,012 | $ 3,323 | $ 1,798 | $ 74,179 | $ 62,754 | $ 29,875 |
| 13 | 0.514 | $ 321 | $ - | $ 3,102 | $ 3,423 | $ 1,760 | $ 77,601 | $ 64,514 | $ 28,077 |
| 14 | 0.489 | $ 330 | $ - | $ 3,195 | $ 3,525 | $ 1,722 | $ 81,127 | $ 66,236 | $ 26,317 |
| 15 | 0.464 | $ 340 | $ - | $ 3,291 | $ 3,631 | $ 1,685 | $ 84,758 | $ 67,922 | $ 24,595 |
| 16 | 0.441 | $ 351 | $ - | $ 3,390 | $ 3,740 | $ 1,649 | $ 88,498 | $ 69,571 | $ 22,909 |
| 17 | 0.419 | $ 361 | $ - | $ 3,491 | $ 3,852 | $ 1,614 | $ 92,350 | $ 71,185 | $ 21,260 |
| 18 | 0.398 | $ 372 | $ - | $ 3,596 | $ 3,968 | $ 1,580 | $ 96,318 | $ 72,765 | $ 19,646 |
| 19 | 0.378 | $ 383 | $ - | $ 3,704 | $ 4,087 | $ 1,546 | $ 100,405 | $ 74,311 | $ 18,066 |
| 20 | 0.359 | $ 395 | $ 4,309 | $ 3,815 | $ 8,519 | $ 3,062 | $ 108,924 | $ 77,372 | $ 16,520 |
| 21 | 0.341 | $ 406 | $ - | $ 3,929 | $ 4,336 | $ 1,480 | $ 113,259 | $ 78,853 | $ 13,459 |
| 22 | 0.324 | $ 419 | $ - | $ 4,047 | $ 4,466 | $ 1,449 | $ 117,725 | $ 80,302 | $ 11,978 |
| 23 | 0.308 | $ 431 | $ - | $ 4,169 | $ 4,600 | $ 1,418 | $ 122,325 | $ 81,719 | $ 10,529 |
| 24 | 0.293 | $ 444 | $ - | $ 4,294 | $ 4,738 | $ 1,388 | $ 127,063 | $ 83,107 | $ 9,112 |
| 25 | 0.278 | $ 457 | $ - | $ 4,423 | $ 4,880 | $ 1,358 | $ 131,943 | $ 84,465 | $ 7,724 |
| 26 | 0.264 | $ 471 | $ - | $ 4,555 | $ 5,026 | $ 1,329 | $ 136,969 | $ 85,794 | $ 6,366 |
| 27 | 0.251 | $ 485 | $ - | $ 4,692 | $ 5,177 | $ 1,300 | $ 142,146 | $ 87,094 | $ 5,037 |
| 28 | 0.239 | $ 500 | $ - | $ 4,833 | $ 5,332 | $ 1,273 | $ 147,479 | $ 88,367 | $ 3,737 |
| 29 | 0.227 | $ 515 | $ - | $ 4,978 | $ 5,492 | $ 1,245 | $ 152,971 | $ 89,612 | $ 2,464 |
| 30 | 0.215 | $ 530 | $ - | $ 5,127 | $ 5,657 | $ 1,219 | $ 158,628 | $ 90,831 | $ 1,219 |

**Description: WQBE 05A - Media_Filter_Drain_ROW_Underdrain**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be
4 performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).
Inspection and remediation of grass health (sparse growth, excessive growth, weed growth).
8 Assumed work completed quarterly by a crew of two at 1 hour per visit.
Inspection and remediation of eroded or scoured areas due to flow channelization, or higher flows. Remediation includes filling area with gravel for areas less than 12" wide, and regrading and reseeding for areas larger than 12". Assumed work completed twice annually by a crew of 2 at 1
4 hour per visit. Work to be performed by hand.
Grass seed and gravel for spot repairs at $225/year total.

**Replacement Assumptions:**

Replacement of treatment media, compost, and vegatation will take place every ten years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 05A - Media_Filter_Drain_ROW_Underdrain | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Media Filter Drain (MFD) - Till Soils** | 200 | SF | | $ - |
| 2 | **Facility Length** | 50 | LF | | |
| 3 | **Facility Width** | 4 | LF | | |
| 4 | Shaping and compacting crushed gravel in non-vegetation zone @ 2'W X 50'LX0.5'D | 2 | CY | $ 52 | $ 96 |
| 5 | Seeded Grass Strip @3'W X 50'L | 17 | SY | $ 10 | $ 167 |
| 6 | Excavation to Waste - Grass Strip @ 3'W X 1'D X50'L | 6 | CY | $ 79 | $ 439 |
| 7 | Soil Mix for Grass Strip @ 3'W X 1'D X50'L | 6 | CY | $ 105 | $ 583 |
| 8 | Excavation to Waste MFD @4'WX50'LX1.25' Ave. Depth | 9 | CY | $ 79 | $ 731 |
| 9 | Media Filter Drain Mix (dolomite, gypsum, perlite) | 9 | CY | $ 197 | $ 1,824 |
| 10 | | | | | $ - |
| 11 | **Underdrain Items** | 50 | LF | | $ - |
| 12 | Trench Excavation to Waste | 6 | CY | $ 79 | $ 497 |
| 13 | 8-inch diameter underdrain pipe | 2 | LF | $ 48 | $ 96 |
| 14 | Gravel for underdrain (2'WX1.7'L) | 6 | CY | $ 133 | $ 837 |
| 15 | Geotextile | 41 | SY | $ 4 | |
| 16 | | | | | |
| 17 | **Additional Costs** | | | | $ - |
| 18 | Traffic Control (Heavy) | 0.50 | MO | $ 20,000 | $ 10,000 |
| 19 | Removals @ 4% Construction Costs | 4.0% | LS | $ 5,272 | $ 211 |
| 20 | TESC @2% Construction Costs | 2% | LS | $ 15,482 | $ 310 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 15,792 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 1,579 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 17,371 |
| | | | | ***Direct: Subtotal Construction Costs (200 SF Area)*** | ***$ 17,371*** |

**Description: WQBE 5A - Media Filter Drain - In ROW_Underdrain**

A linear flow-through stormwater treatment device that can be sited along roadway side slopes (conventional design) and medians (dual MFD), borrow ditches, or other linear depressions. Cut-slope applications may also be considered. MFDs have four basic components: a gravel no-vegetation zone, a vegetated filter strip, the MFD mix bed, and an optional gravel-filled underdrain trench or layer of crushed surfacing base course. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.

**Cost Estimating Assumptions:**

Facility design is per Ecology BMP T8.40
Installation is in ROW on the roadside and does not require easements or acquisition
Facility is sited on the roadside and assumes pavement restoration to accommodate the facility width.
A minimum of 12 inches of treatment media with mix of crushed rock, dolomite, gypsum and perlite (see table V-6.4) is used.
Treatment media mixture is assumed to be 75% crushed rock and 25% dolomite, gypsum and perlite (see quantities on table V-6.4 of Ecology manual)
The facility treatment area is 200 sf with a length of 50 linear feet and width of 4 feet
Facilities placed in till soils require an underdrain system, facilities located in outwash soils do not require an underdrain.
A total of 2 LF of 8-inch diameter storm pipe is required to connect to the storm or CSO main.
The excavated material is unsuitable for use as backfill.
A 3' wide grass strip will be installed next to treatment media
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 1% of the construction costs.
The facility is located within the ROW and Traffic control is required
A street use permit is required.
Underdrains are assumed for till soils.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 05B - Media_Filter_Drain_ROW_No_Underdrain | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Media Filter Drain - No Underdrain (200 SF Bottom Area) | 200 | SF | $ 79 | $ 15,800 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 15,800*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 2,370 |
| | | | Street Use Permit (Y/N) | Y | $ 700 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 18,870*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 1,817 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 20,687*** |
| | | | | Construction Sales Tax | $ 2,049 |
| | | | | Outside Agency Construction | $ 316 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 23,100*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 2,482 |
| | | | | Construction Management | $ 1,655 |
| | | | | Permitting & Support | $ 103 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 1,034 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 5,275*** |
| | | | | Project Contingency | $ 4,256 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 9,500*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 32,600*** |

**Description: WQBE 5B - Media Filter Drain - In ROW - No Underdrain (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 200 | ft2 |
| **Initial Capital Cost** | **$ 32,600** | |
| Capital cost | $ 163 | $/Unit |
| Total Direct O&M/Year | $ 2,176 | |
| Direct O&M cost | $ 10.88 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 4,309 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 87,600** | **$/unit** |
| **Annual O&M Cost** | **$ 2,400** | **$/year** |
| Annualized Cost | $360 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Grass seed & gravel for spot repairs | 2023 dollars | $ 225 | $/year |
| | 2023 dollars | | $/year |
| Subtotal | | $ 225 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash | 4 | hr | |
| Plant Health | 8 | hr | |
| Remediation of erosion | 4 | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 16 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 870 | |
| Labor cost, burdened | O/H 150.0% | $ 2,176 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 10,704 | | $ 103,505 | **$155,428** | **$ 87,631** | | | |
| 0 | 1.000 | **$ 32,600** | | | $32,600 | $ 32,600 | $ 32,600 | $ 32,600 | $ 87,631 |
| 1 | 0.950 | $ 225 | $ - | $ 2,176 | $ 2,401 | $ 2,281 | $ 35,001 | $ 34,881 | $ 55,031 |
| 2 | 0.903 | $ 232 | $ - | $ 2,241 | $ 2,473 | $ 2,232 | $ 37,473 | $ 37,113 | $ 52,750 |
| 3 | 0.858 | $ 239 | $ - | $ 2,308 | $ 2,547 | $ 2,184 | $ 40,020 | $ 39,297 | $ 50,518 |
| 4 | 0.815 | $ 246 | $ - | $ 2,377 | $ 2,623 | $ 2,138 | $ 42,643 | $ 41,435 | $ 48,334 |
| 5 | 0.774 | $ 253 | $ - | $ 2,449 | $ 2,702 | $ 2,092 | $ 45,345 | $ 43,527 | $ 46,196 |
| 6 | 0.736 | $ 261 | $ - | $ 2,522 | $ 2,783 | $ 2,047 | $ 48,128 | $ 45,574 | $ 44,104 |
| 7 | 0.699 | $ 269 | $ - | $ 2,598 | $ 2,866 | $ 2,003 | $ 50,995 | $ 47,578 | $ 42,057 |
| 8 | 0.664 | $ 277 | $ - | $ 2,676 | $ 2,952 | $ 1,961 | $ 53,947 | $ 49,538 | $ 40,053 |
| 9 | 0.631 | $ 285 | $ - | $ 2,756 | $ 3,041 | $ 1,919 | $ 56,988 | $ 51,457 | $ 38,093 |
| 10 | 0.599 | $ 294 | $ 4,309 | $ 2,839 | $ 7,442 | $ 4,461 | $ 64,429 | $ 55,918 | $ 36,174 |
| 11 | 0.570 | $ 302 | $ - | $ 2,924 | $ 3,226 | $ 1,838 | $ 67,656 | $ 57,756 | $ 31,713 |
| 12 | 0.541 | $ 311 | $ - | $ 3,012 | $ 3,323 | $ 1,798 | $ 70,979 | $ 59,554 | $ 29,875 |
| 13 | 0.514 | $ 321 | $ - | $ 3,102 | $ 3,423 | $ 1,760 | $ 74,401 | $ 61,314 | $ 28,077 |
| 14 | 0.489 | $ 330 | $ - | $ 3,195 | $ 3,525 | $ 1,722 | $ 77,927 | $ 63,036 | $ 26,317 |
| 15 | 0.464 | $ 340 | $ - | $ 3,291 | $ 3,631 | $ 1,685 | $ 81,558 | $ 64,722 | $ 24,595 |
| 16 | 0.441 | $ 351 | $ - | $ 3,390 | $ 3,740 | $ 1,649 | $ 85,298 | $ 66,371 | $ 22,909 |
| 17 | 0.419 | $ 361 | $ - | $ 3,491 | $ 3,852 | $ 1,614 | $ 89,150 | $ 67,985 | $ 21,260 |
| 18 | 0.398 | $ 372 | $ - | $ 3,596 | $ 3,968 | $ 1,580 | $ 93,118 | $ 69,565 | $ 19,646 |
| 19 | 0.378 | $ 383 | $ - | $ 3,704 | $ 4,087 | $ 1,546 | $ 97,205 | $ 71,111 | $ 18,066 |
| 20 | 0.359 | $ 395 | $ 4,309 | $ 3,815 | $ 8,519 | $ 3,062 | $ 105,724 | $ 74,172 | $ 16,520 |
| 21 | 0.341 | $ 406 | $ - | $ 3,929 | $ 4,336 | $ 1,480 | $ 110,059 | $ 75,653 | $ 13,459 |
| 22 | 0.324 | $ 419 | $ - | $ 4,047 | $ 4,466 | $ 1,449 | $ 114,525 | $ 77,102 | $ 11,978 |
| 23 | 0.308 | $ 431 | $ - | $ 4,169 | $ 4,600 | $ 1,418 | $ 119,125 | $ 78,519 | $ 10,529 |
| 24 | 0.293 | $ 444 | $ - | $ 4,294 | $ 4,738 | $ 1,388 | $ 123,863 | $ 79,907 | $ 9,112 |
| 25 | 0.278 | $ 457 | $ - | $ 4,423 | $ 4,880 | $ 1,358 | $ 128,743 | $ 81,265 | $ 7,724 |
| 26 | 0.264 | $ 471 | $ - | $ 4,555 | $ 5,026 | $ 1,329 | $ 133,769 | $ 82,594 | $ 6,366 |
| 27 | 0.251 | $ 485 | $ - | $ 4,692 | $ 5,177 | $ 1,300 | $ 138,946 | $ 83,894 | $ 5,037 |
| 28 | 0.239 | $ 500 | $ - | $ 4,833 | $ 5,332 | $ 1,273 | $ 144,279 | $ 85,167 | $ 3,737 |
| 29 | 0.227 | $ 515 | $ - | $ 4,978 | $ 5,492 | $ 1,245 | $ 149,771 | $ 86,412 | $ 2,464 |
| 30 | 0.215 | $ 530 | $ - | $ 5,127 | $ 5,657 | $ 1,219 | $ 155,428 | $ 87,631 | $ 1,219 |

**Description: WQBE 5B - Media Filter Drain - In ROW - No Underdrain**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be
4 performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).
Inspection and remediation of grass health (sparse growth, excessive growth, weed growth).
2 Assumed work completed quarterly by a crew of two at 1 hour per visit.
Inspection and remediation of eroded or scoured areas due to flow channelization, or higher flows. Remediation includes filling area with gravel for areas less than 12" wide, and regrading and reseeding for areas larger than 12". Assumed work completed twice annually by a crew of 2 at 1 hour
4 per visit. Work to be performed by hand.
Grass seed and gravel for spot repairs at $225/year total.

**Replacement Assumptions:**

Replacement of treatment media, compost, and vegatation will take place every ten years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 05B - Media_Filter_Drain_ROW_No_Underdrain | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Media Filter Drain (MFD) - Till Soils** | 200 | SF | | $ - |
| 2 | **Facility Length** | 50 | LF | | |
| 3 | **Facility Width** | 4 | LF | | |
| 4 | Shaping and compacting crushed gravel in non-vegetation zone @ 2'W X 50'LX0.5'D | 2 | CY | $ 52 | $ 96 |
| 5 | Seeded Grass Strip @3'W X 50'L | 17 | SY | $ 10 | $ 167 |
| 6 | Excavation to Waste - Grass Strip @ 3'W X 1'D X50'L | 6 | CY | $ 79 | $ 439 |
| 7 | Soil Mix for Grass Strip @ 3'W X 1'D X50'L | 6 | CY | $ 105 | $ 583 |
| 8 | Excavation to Waste MFD @4'WX50'LX1.25' Ave. Depth | 9 | CY | $ 79 | $ 731 |
| 9 | Media Filter Drain Mix (dolomite, gypsum, perlite) | 9 | CY | $ 197 | $ 1,824 |
| 10 | | | | | |
| 11 | **Additional Costs** | | | | $ - |
| 12 | Traffic Control (Heavy) | 0.50 | MO | $ 20,000 | $ 10,000 |
| 13 | Removals @ 4% Construction Costs | 4.0% | LS | $ 3,841 | $ 154 |
| 14 | TESC @2% Construction Costs | 2% | LS | $ 13,994 | $ 280 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 14,274 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 1,427 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 15,702 |
| | | | | ***Direct: Subtotal Construction Costs (200 SF Area)*** | ***$ 15,702*** |

**Description: WQBE 5B - Media Filter Drain - In ROW - No Underdrain**

A linear flow-through stormwater treatment device that can be sited along roadway side slopes (conventional design) and medians (dual MFD), borrow ditches, or other linear depressions. Cut-slope applications may also be considered. MFDs have four basic components: a gravel no-vegetation zone, a vegetated filter strip, the MFD mix bed, and an optional gravel-filled underdrain trench or layer of crushed surfacing base course. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.

**Cost Estimating Assumptions:**

Facility design is per Ecology BMP T8.40
Installation is in ROW on the roadside and does not require easements or acquisition
Facility is sited on the roadside and assumes pavement restoration to accommodate the facility width.
A minimum of 12 inches of treatment media with mix of crushed rock, dolomite, gypsum and perlite (see table V-6.4) is used.
Treatment media mixture is assumed to be 75% crushed rock and 25% dolomite, gypsum and perlite (see quantities on table V-6.4 of Ecology manual)
The facility treatment area is 200 sf with a length of 50 linear feet and width of 4 feet
Facilities placed in till soils require an underdrain system, facilities located in outwash soils do not require an underdrain.
A total of 2 LF of 8-inch diameter storm pipe is required to connect to the storm or CSO main.
The excavated material is unsuitable for use as backfill.
A 3' wide grass strip will be installed next to treatment media
Removals are estimated at 3.5% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 1% of the construction costs.
The facility is located within the ROW and Traffic control is required
A street use permit is required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Jeremy Hollingsworth (HDR)<br>Ryan Oberg (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 16_Cistern_On Property | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Cistern on Property (18 SF @ 5 FT Storage Depth) | 1 | EA | $ 15,454 | $ 15,454 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 15,454*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 2,318 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 17,773*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 1,777 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 19,550*** |
| | | | | Construction Sales Tax | $ 2,004 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 21,600*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 2,346 |
| | | | | Construction Management | $ 1,564 |
| | | | | Permitting & Support | $ 98 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 977 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 4,985*** |
| | | | | Project Contingency | $ 3,988 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 9,000*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 30,600*** |

**Description: WQBE 16_Cistern_On Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | Each |
| **Initial Capital Cost** | **$ 30,600** | |
| Capital cost | $ 30,600 | $/Unit |
| Total Direct O&M/Year | $ 680 | |
| Direct O&M cost | $ 680 | $/Unit |
| Capital Replacement Costs (10 Years) | $ - | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

No capital replacement cost

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 46,100** | **$/unit** |
| **Annual O&M Cost** | **$ 700** | **$/year** |
| Annualized Cost | $80 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Mulch and Media Replacement | 2023 dollars | $ 50 | $/year |
| | 2023 dollars | $ - | $/year |
| Subtotal | | $50 | |

Labor

| | | | |
|---|---|---|---|
| Remove sediment and debris | 2 | hr | |
| Inspection and repair of piping, joints, and concrete | 3 | hr | |
| | | hr | |
| | 0 | hr | |
| **Total hours per year** | 5 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 272 | |
| Labor cost, burdened | O/H 150.0% | $ 680 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 2,379 | | $ 32,345 | **$65,324** | **$ 46,075** | | | |
| 0 | 1.000 | **$ 30,600** | | | $30,600 | $ 30,600 | $ 30,600 | $ 30,600 | $ 46,075 |
| 1 | 0.950 | $50 | $ - | $ 680 | $ 730 | $ 693 | $ 31,330 | $ 31,293 | $ 15,475 |
| 2 | 0.903 | $ 52 | $ - | $ 700 | $ 752 | $ 679 | $ 32,082 | $ 31,972 | $ 14,782 |
| 3 | 0.858 | $ 53 | $ - | $ 721 | $ 774 | $ 664 | $ 32,856 | $ 32,636 | $ 14,103 |
| 4 | 0.815 | $ 55 | $ - | $ 743 | $ 798 | $ 650 | $ 33,654 | $ 33,286 | $ 13,439 |
| 5 | 0.774 | $ 56 | $ - | $ 765 | $ 821 | $ 636 | $ 34,475 | $ 33,922 | $ 12,789 |
| 6 | 0.736 | $ 58 | $ - | $ 788 | $ 846 | $ 622 | $ 35,321 | $ 34,545 | $ 12,153 |
| 7 | 0.699 | $ 60 | $ - | $ 812 | $ 872 | $ 609 | $ 36,193 | $ 35,154 | $ 11,531 |
| 8 | 0.664 | $ 61 | $ - | $ 836 | $ 898 | $ 596 | $ 37,090 | $ 35,750 | $ 10,921 |
| 9 | 0.631 | $ 63 | $ - | $ 861 | $ 925 | $ 583 | $ 38,015 | $ 36,333 | $ 10,325 |
| 10 | 0.599 | $ 65 | $ - | $ 887 | $ 952 | $ 571 | $ 38,967 | $ 36,904 | $ 9,742 |
| 11 | 0.570 | $ 67 | $ - | $ 914 | $ 981 | $ 559 | $ 39,948 | $ 37,463 | $ 9,171 |
| 12 | 0.541 | $ 69 | $ - | $ 941 | $ 1,010 | $ 547 | $ 40,958 | $ 38,010 | $ 8,612 |
| 13 | 0.514 | $ 71 | $ - | $ 969 | $ 1,041 | $ 535 | $ 41,999 | $ 38,545 | $ 8,066 |
| 14 | 0.489 | $ 73 | $ - | $ 998 | $ 1,072 | $ 524 | $ 43,071 | $ 39,068 | $ 7,530 |
| 15 | 0.464 | $ 76 | $ - | $ 1,028 | $ 1,104 | $ 512 | $ 44,175 | $ 39,581 | $ 7,007 |
| 16 | 0.441 | $ 78 | $ - | $ 1,059 | $ 1,137 | $ 501 | $ 45,312 | $ 40,082 | $ 6,494 |
| 17 | 0.419 | $ 80 | $ - | $ 1,091 | $ 1,171 | $ 491 | $ 46,483 | $ 40,573 | $ 5,993 |
| 18 | 0.398 | $ 83 | $ - | $ 1,124 | $ 1,206 | $ 480 | $ 47,690 | $ 41,053 | $ 5,502 |
| 19 | 0.378 | $ 85 | $ - | $ 1,157 | $ 1,243 | $ 470 | $ 48,932 | $ 41,523 | $ 5,022 |
| 20 | 0.359 | $ 88 | $ - | $ 1,192 | $ 1,280 | $ 460 | $ 50,212 | $ 41,983 | $ 4,552 |
| 21 | 0.341 | $ 90 | $ - | $ 1,228 | $ 1,318 | $ 450 | $ 51,530 | $ 42,433 | $ 4,092 |
| 22 | 0.324 | $ 93 | $ - | $ 1,265 | $ 1,358 | $ 440 | $ 52,888 | $ 42,874 | $ 3,642 |
| 23 | 0.308 | $ 96 | $ - | $ 1,303 | $ 1,399 | $ 431 | $ 54,287 | $ 43,305 | $ 3,201 |
| 24 | 0.293 | $ 99 | $ - | $ 1,342 | $ 1,440 | $ 422 | $ 55,727 | $ 43,727 | $ 2,770 |
| 25 | 0.278 | $ 102 | $ - | $ 1,382 | $ 1,484 | $ 413 | $ 57,211 | $ 44,140 | $ 2,348 |
| 26 | 0.264 | $ 105 | $ - | $ 1,424 | $ 1,528 | $ 404 | $ 58,739 | $ 44,544 | $ 1,936 |
| 27 | 0.251 | $ 108 | $ - | $ 1,466 | $ 1,574 | $ 395 | $ 60,313 | $ 44,939 | $ 1,532 |
| 28 | 0.239 | $ 111 | $ - | $ 1,510 | $ 1,621 | $ 387 | $ 61,934 | $ 45,326 | $ 1,136 |
| 29 | 0.227 | $ 114 | $ - | $ 1,556 | $ 1,670 | $ 379 | $ 63,604 | $ 45,705 | $ 749 |
| 30 | 0.215 | $ 118 | $ - | $ 1,602 | $ 1,720 | $ 371 | $ 65,324 | $ 46,075 | $ 371 |

**Description: WQBE 16_Cistern_On Property**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

2 Removal of all sediment and debris from storage area by crew of two, 1-hour of work annually.

Inspection and repair of joints, vault walls, cracks wider than 1/2 inch, crew of two, 3-hour work day
3 once every two years. Annual cost of cement patching mix or joint replacement of $50

**Replacement Assumptions:**

No capital replacement assumed in 30-year life.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Jeremy Hollingsworth (HDR)<br>Ryan Oberg (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 16_Cistern_On Property | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| | **Cistern On Property** | 1 | EA | | $ - |
| | Cistern pad excavation and installation, hand (6'W x 6'L x 8"D) | 0.9 | CY | $ 5,000 | $ 4,467 |
| | Pipe excavation, shallow trench (40'L x 3'D x 1'W) | 4.4 | CY | $ 53 | $ 236 |
| | Cistern pad base rock (4") | 0.4 | CY | $ 52 | $ 23 |
| | Cistern pad reinforced concrete (6") | 0.7 | CY | $ 950 | $ 633 |
| | | | | | $ - |
| | **4" PVC piping** | | | | $ - |
| | Down spout piping | 10 | FT | $ 72 | $ 720 |
| | Discharge piping | 50 | FT | $ 72 | $ 3,600 |
| | 90 degree elbows | 4 | EA | $ 120 | $ 480 |
| | 45 degree elbows | 1 | EA | $ 86 | $ 86 |
| | Tee | 2 | EA | $ 120 | $ 240 |
| | True union ball valve | 1 | EA | $ 580 | $ 580 |
| | Flanges | 2 | EA | $ 100 | $ 200 |
| | Orifice plate gasket | 1 | EA | $ 185 | $ 185 |
| | | | | | $ - |
| | Cistern tank (56"D x 70"H, polyethylene water storage tank) | 1 | EA | $ 2,600 | $ 2,600 |
| | | | | $ - | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | | | $ 14,049 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| General Conditions | | | 0% | 1 | $ - |
| Mobilization/Demobilization | | | 10% | 1.1 | $ 1,405 |
| Overhead & Profit (OHP) | | | 0% | 1 | $ - |
| Insurance | | | 0.0% | 1 | $ - |
| Bonding | | | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | | | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | | | $ 15,454 |
| ***Direct: Subtotal Construction Costs (1 EA)*** | | | | | ***$ 15,454*** |

**Description: WQBE 16_Cistern_On Property**

A shallow, landscaped depression with compost-amended native soils and adapted plants. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas, and to allow stormwater to pass through the amended soil profile.

**Cost Estimating Assumptions:**

Cisterns are installed in accordance with Seattle Stormwater Manual and meet RainWise requirements.
Cistern is based on a vertical polyethylene water storage tank (+660 gallons).
Costs include delivery, which may vary by location.
Base for cistern is 6"H x 6'L x 6'W reinforced concrete pad. Pad is 4" above grade. Aggregate base layer for concrete pad is 6".
Pipe is 4" PVC pipe
Roof downspout is assumed to be 4" PVC pipe, 10' L with one 45 deg elbow.
Discharge and overflow piping is assumed to be 50'L to discharge point, with four 90 degree elbows, and one tee.
Flow control valve is a true union ball valve.
Excavation equals depth of pad and aggregate, size is footprint of concrete pad. Vertical excavation.
Excavation costs based on shallow trench excavation costs.
Discharge connection is to existing lateral, install 6" PVC tee with flange to connect to discharge piping.
No insulation is provided.
It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Updated on: 06/07/24

Updated on 7/21/24

Phase 2 Updated on: 5/6/21

| | | | | | | | PHASE 3 COSTS (2023 dollars) | | | | | | | | PHASE 2 COSTS (2019 Dollars) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item No. | Action | Class | Difficulty | Description | Sub-Action Number | Subcategory | Action Unit | Design Drainage Area | Total Direct Construction Cost | Property acquisition | Total Indirect Non-Construction Costs | Total Project Cost | O&M Costs (Annual) | Life Cycle Cost (NPV) | Action Unit | Total Direct Construction Cost | Property acquisition | Total Indirect Non-Construction Costs | Total Project Cost | O&M Costs (Annual) | Life Cycle Cost (NPV) |
| 6 | Drywell | Class 10 | Low | WQBE_06A_Drywell on Property | 6A | On property without Acquisition | 1 Each | Till 261 SF; Outwash 780 SF | $14,000 | $0 | $5,800 | $19,800 | $1,000 | $41,400 | 1 Each | $11,000 | $0 | $5,000 | $16,000 | $1,800 | $53,000 |
| | | | | WQBE_06B_Drywell with Bioretention Planter on Property | 6B | On property without Acquisition with Bioretention Planter | 1 Each | Till 261 SF; Outwash 780 SF | $30,200 | $0 | $12,600 | $42,800 | $1,500 | $76,000 | 1 Each | $50,000 | $0 | $22,000 | $72,000 | $1,900 | $112,000 |
| 7 | Deep UIC Wells | Class 10 | Low | WQBE_07A_Deep UIC Well On Property | 7A | On property without Acquisition | 1 Each | NA | $40,400 | $0 | $16,800 | $57,200 | $900 | $75,900 | 1 Each | $32,000 | $0 | $14,000 | $46,000 | $2,000 | $86,000 |
| | | | | WQBE_07B_Deep UIC Well in ROW | 7B | In ROW/Highway | 1 Each | NA | $58,000 | $0 | $23,900 | $81,900 | $900 | $100,600 | 1 Each | $46,000 | $0 | $20,000 | $66,000 | $2,000 | $106,000 |
| | | | | WQBE_07C_Deep UIC Well With Property Cost | 7C | On property with Acquisition | 1 Each | NA | $40,400 | $2,011 | $19,100 | $59,500 | $900 | $78,200 | 1 Each | $32,000 | $1,400 | $16,000 | $48,000 | $2,000 | $88,000 |
| | | | | WQBE_07D_Deep UIC Well with Filter in ROW | 7D | In ROW/Highway with High Rate Media Filter | 1 EA/24 SF | 52,164 SF | $158,700 | $0 | $65,400 | $224,100 | $2,400 | $274,000 | 1 Each | $142,000 | $0 | $62,000 | $204,000 | $4,900 | $303,000 |
| | | | | WQBE_07E_Deep UIC Well with Bioretention Planter in ROW | 7E | In ROW/Highway with Bioretention Planter | 1 EA/580 SF | 54,546 SF | $946,600 | $0 | $390,200 | $1,336,800 | $5,900 | $1,466,700 | 1 Each | $762,000 | $0 | $333,000 | $1,095,000 | $6,800 | $1,239,000 |
| | | | | WQBE_07F_Deep UIC Well with Bioretention Planter on Property | 7F | On property without Acquisition | 1 Each/580 SF | 54,546 SF | $811,500 | $0 | $337,600 | $1,149,100 | $5,900 | $1,279,600 | | | | | | | $1,083,000 |
| | | | | WQBE_07G_Deep UIC Well with Filter on Property | 7G | On property without Acquisition | 1 Each/25 SF | 52,164 SF | $141,300 | $0 | $58,800 | $200,100 | $2,400 | $250,000 | 1 Each | $650,000 | $0 | $287,000 | $938,000 | $6,800 | $1,083,000 |
| 8 | Permeable Pavement | Class 10 | Low | WQBE_08A_Pervious Concrete Sidewalk (no sand layer) | 8A | Pervious Conc. Sidewalk (no sand layer) | 200 SF | 200 SF | $11,200 | $0 | $4,600 | $15,800 | $2,300 | $75,700 | 200 SF | $8,000 | $0 | $4,000 | $12,000 | $2,100 | $78,000 |
| | | | | WQBE_08B_Porous Asphalt Driveway (with sand layer) | 8B | Porous Asp. Driveway (with sand layer) | 200 SF | 200 SF | $5,900 | $0 | $2,400 | $8,300 | $2,300 | $63,800 | 200 SF | $4,000 | $0 | $2,000 | $6,000 | $2,200 | $60,000 |
| | | | | WQBE_08C_Permeable Paver Driveway (with sand layer) | 8C | Permeable Paver Driveway (with sand layer) | 200 SF | 200 SF | $7,800 | $0 | $3,200 | $11,000 | $2,300 | $68,400 | 200 SF | $3,000 | $0 | $1,000 | $4,000 | $2,100 | $55,000 |
| | | | | WQBE_08D_Permeable Paver Plaza (no sand layer) | 8D | Permeable Paver Plaza (no sand layer) | 200 SF | 200 SF | $6,700 | $0 | $2,800 | $9,500 | $2,300 | $64,800 | 200 SF | $3,000 | $0 | $1,000 | $4,000 | $2,100 | $54,000 |
| 9 | Depaving | Class 10 | Low | WQBE_9A_Depaving on Property (wheel strips) | 9A | Driveway Depaving w/Wheel Strips | 100 SF | 100 SF | $1,800 | $0 | $800 | $2,600 | $700 | $16,800 | 100 SF | $1,000 | $0 | $1,000 | $2,000 | $600 | $15,000 |
| | | | | WQBE_9B_Depaving on Property (no wheel strips) | 9B | Driveway Depaving without Alt. Surface | 100 SF | 100 SF | $1,400 | $0 | $600 | $2,000 | $700 | $16,200 | 100 SF | $1,000 | $0 | $1,000 | $2,000 | $600 | $15,000 |
| 21 | High Rate Underground Filter System | Class 10 | Low | WQBE_21A_High Rate Underground Filter in Urban ROW PCCP | 21A | Public ROW with PCCP - Urban ROW | 1 Each | 34,956 SF | $147,500 | $0 | $60,800 | $208,300 | $2,500 | $262,000 | 1 Each | $120,000 | $0 | $75,000 | $195,000 | $2,900 | $254,000 |
| | | | | WQBE_21B_High Rate Underground Filter In Highway ROW PCCP | 21B | Public ROW with PCCP - Highway ROW | 1 Each | 34,956 SF | $108,500 | $0 | $44,800 | $153,300 | $2,500 | $207,000 | 1 Each | $89,000 | $0 | $56,000 | $145,000 | $2,900 | $204,000 |
| | | | | WQBE_21C_High Rate Underground Filter In Urban ROW HMA | 21C | Public ROW with HMA - Urban ROW | 1 Each | 34,956 SF | $106,000 | $0 | $43,700 | $149,700 | $2,500 | $203,400 | 1 Each | $86,000 | $0 | $54,000 | $140,000 | $2,900 | $199,000 |
| | | | | WQBE_21D_High Rate Underground Filter In Highway ROW HMA | 21D | Public ROW with HMA - Highway ROW | 1 Each | 34,956 SF | $96,100 | $0 | $39,600 | $135,700 | $2,500 | $189,400 | 1 Each | $79,000 | $0 | $50,000 | $129,000 | $2,900 | $188,000 |
| | | | | WQBE 21E_High Rate Underground Filter On Public Property | 21E | On property without Acquisition | 1 Each | 34,956 SF | $73,300 | $0 | $30,500 | $103,800 | $2,500 | $157,500 | 1 Each | $64,000 | $0 | $42,000 | $106,000 | $2,900 | $165,000 |
| | | | | WQBE 21F_High Rate Underground Filter with Property Cost | 21F | On Property with Acquisition | 1 Each | 34,956 SF | $73,300 | $1,287 | $32,000 | $105,300 | $2,500 | $159,000 | 1 Each | $64,000 | $900 | $43,000 | $107,000 | $2,900 | $166,000 |

| MANDATORY INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |
| Retail Sales Tax Rate | 10.25% | Current Rate within City of Seattle is 10.25%, 10.1% outside of Seattle |
| Allowance for Indeterminates (AFI), Dependenent Upon Project Phase | 15% | Complexity Inputs for AFI (High = 30%; Moderate = 25%; Routine = 20%; Low = 15%) |
| Construction Change Order Allowance | 10% | |
| Project Contingency | 15% | <Override Value due to lack of complexity, controlled location and application with developed design and construction methods. |

| SECONDARY INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |
| Street Use Permit | $ 700 | In ROW only - Arterial @ $700/Unit; Non-Arterial @use $300/unit |
| Outside Agency Construction | 2% | For Projects in ROW Utility coordination assumed to be at 2% construction cost. |

| PROJECT CATEGORY AND INDIRECT PROJECT INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |

**PROPERTY COST**

| Cost Category | $/sf |
|---|---|
| Low | $ 10.10 |
| Medium | $ 80.43 |
| High | $ 284.37 |
| None | $ - |

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Royce Robertson (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_06A_Drywell_on Property | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Drywell on Property (4 Ft Dia. and 6 Ft. Depth) | 1 | EA | $ 10,052 | $ 10,052 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 10,052*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 1,508 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 11,559*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 1,156 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 12,715*** |
| | | | | Construction Sales Tax | $ 1,303 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 14,000*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 1,526 |
| | | | | Construction Management | $ 1,017 |
| | | | | Permitting & Support | $ 64 |
| | s.f. Land Area | None | | Land Purchase/ROW Acquisition | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 636 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 3,242*** |
| | | | | Project Contingency | $ 2,586 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 5,800*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 19,800*** |

**Description: WQBE 06A Drywell on Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | Each |
| **Initial Capital Cost** | **$ 19,800** | |
| Capital cost | $ 19,800 | $/Unit |
| Total Direct O&M/Year | $ 544 | |
| Direct O&M cost | $ 544 | $/Unit |
| Capital Replacement Costs (10 Years) | $ - | $/unit |
| Discount rate (%) | 5.25 | |

Replacement Costs (N/A for drywell)

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 41,400** | **$/unit** |
| **Annual O&M Cost** | **$ 1,000** | **$/year** |
| Annualized Cost | $750 | $/year |

| **Materials, Supplies, Other Costs** | 2023 dollars | | |
|---|---|---|---|
| | | $ - | $/year |
| Annual Costs | 2023 dollars | $ 113 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $473 | |

| Labor | | | |
|---|---|---|---|
| Remove Trash from structure & roots from piping | 4 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| | | hr | |
| **Total hours per year** | 4 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 218 | |
| Labor cost, burdened | O/H 150.0% | $ 544 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 22,503 | | $ 25,876 | **$68,179** | **$ 41,361** | | | |
| 0 | 1.000 | **$ 19,800** | | | $19,800 | $ 19,800 | $ 19,800 | $ 19,800 | $ 41,361 |
| 1 | 0.950 | $473 | $ - | $ 544 | $ 1,017 | $ 966 | $ 20,817 | $ 20,766 | $ 21,561 |
| 2 | 0.903 | $ 487 | $ - | $ 560 | $ 1,047 | $ 946 | $ 21,864 | $ 21,712 | $ 20,595 |
| 3 | 0.858 | $ 502 | $ - | $ 577 | $ 1,079 | $ 925 | $ 22,943 | $ 22,637 | $ 19,649 |
| 4 | 0.815 | $ 517 | $ - | $ 594 | $ 1,111 | $ 906 | $ 24,054 | $ 23,543 | $ 18,724 |
| 5 | 0.774 | $ 532 | $ - | $ 612 | $ 1,145 | $ 886 | $ 25,199 | $ 24,429 | $ 17,818 |
| 6 | 0.736 | $ 548 | $ - | $ 631 | $ 1,179 | $ 867 | $ 26,378 | $ 25,296 | $ 16,932 |
| 7 | 0.699 | $ 565 | $ - | $ 649 | $ 1,214 | $ 849 | $ 27,592 | $ 26,145 | $ 16,065 |
| 8 | 0.664 | $ 582 | $ - | $ 669 | $ 1,251 | $ 831 | $ 28,843 | $ 26,975 | $ 15,216 |
| 9 | 0.631 | $ 599 | $ - | $ 689 | $ 1,288 | $ 813 | $ 30,131 | $ 27,788 | $ 14,386 |
| 10 | 0.599 | $ 617 | $ - | $ 710 | $ 1,327 | $ 795 | $ 31,458 | $ 28,583 | $ 13,573 |
| 11 | 0.570 | $ 636 | $ - | $ 731 | $ 1,367 | $ 778 | $ 32,824 | $ 29,362 | $ 12,778 |
| 12 | 0.541 | $ 655 | $ - | $ 753 | $ 1,408 | $ 762 | $ 34,232 | $ 30,124 | $ 11,999 |
| 13 | 0.514 | $ 674 | $ - | $ 775 | $ 1,450 | $ 745 | $ 35,682 | $ 30,869 | $ 11,237 |
| 14 | 0.489 | $ 695 | $ - | $ 799 | $ 1,493 | $ 730 | $ 37,175 | $ 31,599 | $ 10,492 |
| 15 | 0.464 | $ 715 | $ - | $ 823 | $ 1,538 | $ 714 | $ 38,713 | $ 32,313 | $ 9,762 |
| 16 | 0.441 | $ 737 | $ - | $ 847 | $ 1,584 | $ 699 | $ 40,298 | $ 33,011 | $ 9,048 |
| 17 | 0.419 | $ 759 | $ - | $ 873 | $ 1,632 | $ 684 | $ 41,929 | $ 33,695 | $ 8,350 |
| 18 | 0.398 | $ 782 | $ - | $ 899 | $ 1,681 | $ 669 | $ 43,610 | $ 34,364 | $ 7,666 |
| 19 | 0.378 | $ 805 | $ - | $ 926 | $ 1,731 | $ 655 | $ 45,341 | $ 35,019 | $ 6,997 |
| 20 | 0.359 | $ 829 | $ - | $ 954 | $ 1,783 | $ 641 | $ 47,124 | $ 35,660 | $ 6,342 |
| 21 | 0.341 | $ 854 | $ - | $ 982 | $ 1,837 | $ 627 | $ 48,961 | $ 36,287 | $ 5,701 |
| 22 | 0.324 | $ 880 | $ - | $ 1,012 | $ 1,892 | $ 614 | $ 50,853 | $ 36,901 | $ 5,074 |
| 23 | 0.308 | $ 906 | $ - | $ 1,042 | $ 1,948 | $ 601 | $ 52,801 | $ 37,501 | $ 4,460 |
| 24 | 0.293 | $ 934 | $ - | $ 1,073 | $ 2,007 | $ 588 | $ 54,808 | $ 38,089 | $ 3,860 |
| 25 | 0.278 | $ 962 | $ - | $ 1,106 | $ 2,067 | $ 575 | $ 56,875 | $ 38,664 | $ 3,272 |
| 26 | 0.264 | $ 990 | $ - | $ 1,139 | $ 2,129 | $ 563 | $ 59,005 | $ 39,227 | $ 2,697 |
| 27 | 0.251 | $ 1,020 | $ - | $ 1,173 | $ 2,193 | $ 551 | $ 61,198 | $ 39,778 | $ 2,134 |
| 28 | 0.239 | $ 1,051 | $ - | $ 1,208 | $ 2,259 | $ 539 | $ 63,456 | $ 40,317 | $ 1,583 |
| 29 | 0.227 | $ 1,082 | $ - | $ 1,244 | $ 2,327 | $ 528 | $ 65,783 | $ 40,845 | $ 1,044 |
| 30 | 0.215 | $ 1,115 | $ - | $ 1,282 | $ 2,396 | $ 516 | $ 68,179 | $ 41,361 | $ 516 |

**Description: WQBE 06A Drywell on Property**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.

Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

2 Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two w/vactor truck (2 visits per year, 0.5 hour per visit). Total for equipment $360.

1 Inspection and removal of roots that reduce free movement of water through pipes by a crew of two (1 visits per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) $113 per year.

**Replacement Assumptions:**

No capital replacement costs with this Action.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Royce Robertson (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_06A_Drywell_on Property | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Drywell on Property (4' Diameter)** | 6 | VF | | $ - |
| 2 | **Drywell Footprint Area** | 13 | SF | | $ - |
| 3 | **Top Excavation Area Footprint @ 0.5:1** | 50 | SF | | $ - |
| 4 | Facility Excavation to Backfill and to Waste @ 8' D w0.5:1 slope | 9 | CY | $ 79 | $ 737 |
| 5 | Drywell Washed Drain Rock | 3 | CY | $ 118 | $ 341 |
| 6 | Geotextile - Drywell Filter Fabric (assumed covers entire surface area w/overlap) | 11 | SY | $ 4 | $ 45 |
| 7 | Observation Port | 1 | EA | $ 677 | $ 677 |
| 8 | Grass Seeding and Restoration (disturbed area @ 15'X15') | 25 | SY | $ 10 | $ 250 |
| 9 | | | | $ - | $ - |
| 10 | **Pipe Inlet Items:** | | | $ - | $ - |
| 11 | Catch Basin/Yard Drain | 1 | EA | $ 3,900 | $ 3,900 |
| 12 | 8" PVC pipe from Yard Drain to Drywell | 25 | LF | $ 80 | $ 2,000 |
| 13 | Trench Exc and Backfill (3'W X 3' D) | 8 | CY | $ 79 | $ 658 |
| 14 | Grass Seeding and Restoration (pipe area) | 1 | SY | $ 10 | $ 6 |
| 15 | | | | $ - | $ - |
| 16 | **Additional Costs** | | | $ - | $ - |
| 17 | Removals @4% Construction Costs | 4.0% | LS | $ 8,614 | $ 345 |
| 18 | TESC @2% Construction Costs | 2% | LS | $ 8,959 | $ 179 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 9,138 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 914 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 10,052 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 10,052*** |

**Description: WQBE_06A_Drywell_on Property**
A gravel filled hole that conveys stormwater runoff into the soil matrix. Provides volume and peak flow reduction.

**Cost Estimating Assumptions:**
Facility design is per Seattle SW Manual Section 5.4.3.
It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.
It is assumed that the insitu soils and location will be suitable for drywell installation.
It is assumed that groundwater conditions will be suitable for drywell installation.
Pretreatment is not included in the cost model.
The drywell facility is 4 feet in diameter and 6 feet in depth.
Excavation is by open trench with temporary construction slopes assumed a 0.5:1. Slopes design may vary based on conditions and shall conform to OSHA, L&I and other safety requirements.
There is approximately 2 feet of cover over the drywell.
A catch basin (yard drain) and approximately 25 LF of 8" PVC are included in the cost model.

The excavated material will be suitable for use as backfill. Material not used for backfill will be disposed of in accordance with applicable regulations.
Dewatering is not required
The trenches are shallow and it is assumed that shoring is not required.
Seeded grass restoration is required for areas disturbed during construction.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
A street use permit is not required.

**Planning Basis Assumptions:**
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**
This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Royce Robertson (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 06B Drywell with Bioretention Planter on Property | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Drywell on Property with Bioretention Planter (4 s.f. bottom area) | 1 | EA | $ 21,633 | $ 21,633 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 21,633*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 3,245 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 24,878*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 2,488 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 27,366*** |
| | | | | Construction Sales Tax | $ 2,805 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 30,200*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 3,284 |
| | | | | Construction Management | $ 2,189 |
| | | | | Permitting & Support | $ 137 |
| | s.f. Land Area | None | | Land Purchase/ROW Acquisition | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 1,368 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 6,978*** |
| | | | | Project Contingency | $ 5,577 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 12,600*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 42,800*** |

**Description: WQBE 06B Drywell with Bioretention Planter on Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 42,800** | |
| Capital cost | $ 42,800 | $/Unit |
| Total Direct O&M/Year | $ 952 | |
| Direct O&M cost | $ 952 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 763 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 76,000** | **$/unit** |
| **Annual O&M Cost** | **$ 1,500** | **$/year** |
| Annualized Cost | $920 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| Miscellaneous drainage parts in drywell | 2023 dollars | $ 113 | $/year |
| Remediation of mulch/media and planting & Misc Drainage Parts | 2023 dollars | $ 108 | |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $ 581 | |

Labor

| | | | |
|---|---|---|---|
| Drywell O&M | 3 | hr | |
| Bioretention Planter O&M | 4 | hr | |
| | | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 7 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 381 | |
| Labor cost, burdened | O/H 150.0% | $ 952 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 27,641 | | $ 45,283 | **$117,250** | **$ 76,031** | | | |
| 0 | 1.000 | **$ 42,800** | | | $42,800 | $ 42,800 | $ 42,800 | $ 42,800 | $ 76,031 |
| 1 | 0.950 | $581 | $ - | $ 952 | $ 1,533 | $ 1,456 | $ 44,333 | $ 44,256 | $ 33,231 |
| 2 | 0.903 | $ 598 | $ - | $ 980 | $ 1,579 | $ 1,425 | $ 45,912 | $ 45,682 | $ 31,775 |
| 3 | 0.858 | $ 616 | $ - | $ 1,010 | $ 1,626 | $ 1,395 | $ 47,538 | $ 47,076 | $ 30,350 |
| 4 | 0.815 | $ 635 | $ - | $ 1,040 | $ 1,675 | $ 1,365 | $ 49,213 | $ 48,441 | $ 28,955 |
| 5 | 0.774 | $ 654 | $ - | $ 1,071 | $ 1,725 | $ 1,336 | $ 50,938 | $ 49,777 | $ 27,590 |
| 6 | 0.736 | $ 674 | $ - | $ 1,103 | $ 1,777 | $ 1,307 | $ 52,715 | $ 51,084 | $ 26,254 |
| 7 | 0.699 | $ 694 | $ - | $ 1,137 | $ 1,830 | $ 1,279 | $ 54,545 | $ 52,364 | $ 24,947 |
| 8 | 0.664 | $ 715 | $ - | $ 1,171 | $ 1,885 | $ 1,252 | $ 56,430 | $ 53,615 | $ 23,668 |
| 9 | 0.631 | $ 736 | $ - | $ 1,206 | $ 1,942 | $ 1,225 | $ 58,372 | $ 54,841 | $ 22,416 |
| 10 | 0.599 | $ 758 | $ 763 | $ 1,242 | $ 2,763 | $ 1,656 | $ 61,135 | $ 56,497 | $ 21,191 |
| 11 | 0.570 | $ 781 | $ - | $ 1,279 | $ 2,060 | $ 1,173 | $ 63,195 | $ 57,670 | $ 19,534 |
| 12 | 0.541 | $ 804 | $ - | $ 1,318 | $ 2,122 | $ 1,148 | $ 65,317 | $ 58,818 | $ 18,361 |
| 13 | 0.514 | $ 828 | $ - | $ 1,357 | $ 2,185 | $ 1,124 | $ 67,502 | $ 59,942 | $ 17,213 |
| 14 | 0.489 | $ 853 | $ - | $ 1,398 | $ 2,251 | $ 1,100 | $ 69,753 | $ 61,042 | $ 16,089 |
| 15 | 0.464 | $ 879 | $ - | $ 1,440 | $ 2,319 | $ 1,076 | $ 72,072 | $ 62,118 | $ 14,989 |
| 16 | 0.441 | $ 905 | $ - | $ 1,483 | $ 2,388 | $ 1,053 | $ 74,460 | $ 63,171 | $ 13,913 |
| 17 | 0.419 | $ 932 | $ - | $ 1,527 | $ 2,460 | $ 1,031 | $ 76,919 | $ 64,202 | $ 12,860 |
| 18 | 0.398 | $ 960 | $ - | $ 1,573 | $ 2,534 | $ 1,009 | $ 79,453 | $ 65,210 | $ 11,829 |
| 19 | 0.378 | $ 989 | $ - | $ 1,620 | $ 2,610 | $ 987 | $ 82,063 | $ 66,198 | $ 10,821 |
| 20 | 0.359 | $ 1,019 | $ 763 | $ 1,669 | $ 3,451 | $ 1,240 | $ 85,513 | $ 67,438 | $ 9,834 |
| 21 | 0.341 | $ 1,049 | $ - | $ 1,719 | $ 2,768 | $ 945 | $ 88,282 | $ 68,383 | $ 8,594 |
| 22 | 0.324 | $ 1,081 | $ - | $ 1,771 | $ 2,852 | $ 925 | $ 91,133 | $ 69,308 | $ 7,648 |
| 23 | 0.308 | $ 1,113 | $ - | $ 1,824 | $ 2,937 | $ 905 | $ 94,070 | $ 70,213 | $ 6,723 |
| 24 | 0.293 | $ 1,147 | $ - | $ 1,879 | $ 3,025 | $ 886 | $ 97,095 | $ 71,099 | $ 5,818 |
| 25 | 0.278 | $ 1,181 | $ - | $ 1,935 | $ 3,116 | $ 867 | $ 100,211 | $ 71,966 | $ 4,932 |
| 26 | 0.264 | $ 1,216 | $ - | $ 1,993 | $ 3,209 | $ 848 | $ 103,421 | $ 72,815 | $ 4,065 |
| 27 | 0.251 | $ 1,253 | $ - | $ 2,053 | $ 3,306 | $ 830 | $ 106,726 | $ 73,645 | $ 3,216 |
| 28 | 0.239 | $ 1,291 | $ - | $ 2,114 | $ 3,405 | $ 813 | $ 110,131 | $ 74,458 | $ 2,386 |
| 29 | 0.227 | $ 1,329 | $ - | $ 2,178 | $ 3,507 | $ 795 | $ 113,638 | $ 75,253 | $ 1,573 |
| 30 | 0.215 | $ 1,369 | $ - | $ 2,243 | $ 3,612 | $ 778 | $ 117,250 | $ 76,031 | $ 778 |

**Description: WQBE 06B Drywell with Bioretention Planter on Property**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions (Drywell):**

2 Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two w/vactor truck (2 visits per year, 0.5 hour per visit). Total for equipment $360.

1 Inspection and removal of roots that reduce free movement of water through pipes by a crew of two (1 visits per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) $113 per year.

**O&M Estimating Assumptions (Planter):**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. This task will be executed in the same hours as already set aside for Drywell maintenance.

Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth). This task will be executed in the same hours as already set aside for Drywell maintenance.

4 Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events. This task will be executed in the same hours as already set aside for Drywell maintenance. Annual plant replacement will cost $54. Comprised of (1) small plant replacement at $54/each.

**Replacement Assumptions:**

Replacement of treatment media, compost, and vegatation will take place every ten years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Royce Robertson (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 06B Drywell with Bioretention Planter on Property | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Drywell on Property (4' Diameter)** | 6 | VF | | $ - |
| 2 | **Drywell Footprint Area** | 13 | SF | | $ - |
| 3 | **Top Excavation Area Footprint @ 0.5:1** | 50 | SF | | $ - |
| 4 | Facility Excavation to Backfill and to Waste @ 8' D w0.5:1 slope | 9 | CY | $ 79 | $ 737 |
| 5 | Drywell Washed Drain Rock | 3 | CY | $ 118 | $ 341 |
| 6 | Geotextile - Drywell Filter Fabric (assumed covers entire surface area w/overlap) | 11 | SY | $ 4 | $ 45 |
| 7 | Observation Port | 1 | EA | $ 677 | $ 677 |
| 8 | Grass Seeding and Restoration (disturbed area @ 15'X15') | 25 | SY | $ 10 | $ 250 |
| 9 | | | | $ - | $ - |
| 10 | **Drywell Pipe Inlet Items (Also Bioretention Planter Outlet Pipe):** | | | $ - | $ - |
| 11 | Catch Basin/Yard Drain | 1 | EA | $ 3,900 | $ 3,900 |
| 12 | 8" PVC pipe from Yard Drain to Drywell | 50 | LF | $ 80 | $ 4,000 |
| 13 | Trench Exc and Backfill (3'W X 3' D) | 65 | CY | $ 79 | $ 5,120 |
| 14 | Grass Seeding and Restoration (pipe area) | 1 | SY | $ 10 | $ 6 |
| 15 | | | | $ - | $ - |
| 16 | Bioretention Planter - Property | 4 | SF | $ - | $ - |
| 17 | Bioretention Planter Unit: 2'W X 2'L X 2'D | 2 | LF | $ - | $ - |
| 18 | Curbed, vertical sides - Top Area | 4 | SF | $ - | $ - |
| 19 | **Structural Excavation to Waste (8'W X8'L X 6'D)** | 14 | CY | $ 79 | $ 1,124 |
| 20 | Imported Structural Fill (Bioretention Planter: 2'W X 2'L X 4.7'D) | 1 | CY | $ 44 | $ 31 |
| 21 | Formed Concrete Walls (4" walls: 8'L X 4.7'D) | 0.5 | CY | $ 1,560 | $ 724 |
| 22 | Formed Concrete Base (4" base: 2.6'W X 2.6'L) | 0.1 | CY | $ 590 | $ 49 |
| 23 | Treatment Media (2'W X 2'L X 1.5'D) w/ biochar | 0.2 | CY | $ 270 | $ 60 |
| 24 | Mulch Compost (@ 0.3'D) | 0.04 | CY | $ 86 | $ 4 |
| 25 | Vegetated Entrance | 0.4 | SY | $ 2 | $ 1 |
| 26 | Trench Shoring Facility | 72 | SF | $ 10 | $ 720 |
| 27 | | | | $ - | $ - |
| 28 | **Underdrain Items:** | 2 | LF | $ - | $ - |
| 29 | Underdrain Aggregate (2'W X 2' LX 2.2'D) | 0.3 | CY | $ 133 | $ 43 |
| 30 | Overflow & Drain Pipe 8" Dia. (4' + 2') | 6 | LF | $ 48 | $ 288 |
| 31 | | | | $ - | $ - |
| 32 | **Bioretention Planter Restoration:** | | | $ - | $ - |
| 33 | Landscaping, Planting, and Restoration (10'X10') | 7 | SY | $ 59 | $ 420 |
| 34 | Trees (Not in Design Basis) | 0 | EA | $ 720 | $ - |
| 41 | | | | | |
| 42 | | | | | $ - |
| 43 | **Additional Costs** | | | | $ - |
| 44 | Removals @ 4% Construction Costs | 4.0% | LS | $ 18,539 | $ 742 |
| 45 | TESC @2% Construction Costs | 2.0% | LS | $ 19,281 | $ 386 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 19,667 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 1,967 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 21,633 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 21,633*** |

**Description: WQBE 6B - Drywell with Bioretention Planter on Property**

A shallow, landscaped depression with compost-amended native soils and adapted plants. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas, and to allow stormwater to pass through the amended soil profile. The drywell component conveys stormwater runoff into the soil matrix. Provides volume and peak flow reduction.

**Cost Estimating Assumptions:**

**General:**

Dewatering is not required

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

A street use permit is not required.

**Bioretention Planter:**

Bioretention planter installation is per the Seattle Stormwater Manual, "Non-infiltrating Bioretention" (Volume 3 Section 5.8.2)

Filter fabrics not used between the subgrade and the Bioretention Soil Mix

Bioretention Planter facility is sited in an open space with outlet pipe beneath a parking area

18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.

0.3' of composted media is included.

The bioretention facility treatment area is 4 sf with curbed, vertical sides.

A maximum bioretention ponding depth of 6" and a 12" of freeboard depth are assumed.

Bioretention Planter facilities have a closed bottom and include an underdrain.

A catch basin (yard drain) and a total of 50 LF of 8" storm pipe is required to connect the bioretention planter to the drywell structure.

The bioretention planter excavated material is unsuitable for use as backfill.

Bioretention excavation width of 3 feet is assumed on each side of the box.

The piping is on open property and assumed can be constructed with open cut.

Parking lot restoration is assumed for the bioretention outlet pipe and consists of 4" HMA/4" CSTC.

Concrete curb, gutter, and sidewalk removal and restoration will not be required for the installation.

Landscape restoration is required for the bioretention facility, earth berm and area of disturbance. Assume landscape and restoration area of disturbance @ 10'X10'.

Drywell:

Drywell Facility design is per Seattle SW Manual Section 5.4.3.

It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

It is assumed that the insitu soils and location will be suitable for drywell installation.

It is assumed that groundwater conditions will be suitable for drywell installation.

It is assumed that pretreatment is included in the cost model.

The drywell facility is 4 feet in diameter and 6 feet in depth.

Excavation is by open trench with temporary construction slopes assumed a 0.5:1. Slopes design may vary based on conditions and shall conform to OSHA, L&I and other safety requirements.

There is approximately 2 feet of cover over the drywell.

The drywell catch basin and piping are combined with piping to connect to the biorention planter.

The drywell excavated material will be suitable for use as backfill. Material not used for backfill will be disposed of in accordance with applicable regulations.

Dewatering is not required

The trenches are shallow and it is assumed that shoring is not required.

Seeded grass restoration is required for areas disturbed during construction.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

A street use permit is not required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Royce Robertson (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 07_A - Deep UIC Well_On_Property | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Deep UIC Well Installation (20 VF Depth) - On property | 1 | EA | $ 28,941 | $ 28,941 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 28,941*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 4,341 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 33,282*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 3,328 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 36,610*** |
| | | | | Construction Sales Tax | $ 3,753 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 40,400*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 4,393 |
| | | | | Construction Management | $ 2,929 |
| | | | | Permitting & Support | $ 183 |
| | s.f. Land Area | None | | Land Purchase/ROW Acquisition | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 1,831 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 9,336*** |
| | | | | Project Contingency | $ 7,460 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 16,800*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 57,200*** |

**Description: WQBE 07A - Deep UIC Well_On_Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 57,200** | |
| Capital cost | $ 57,200.00 | $/Unit |
| Total Direct O&M/Year | $ 408 | |
| Direct O&M cost | $ 408 | $/Unit |
| Capital Replacement Costs (10 Years) | $ - | $/unit |
| Discount rate (%) | 5.25 | |

Replacement Costs (N/A for UIC well)

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 75,900** | **$/unit** |
| **Annual O&M Cost** | **$ 900** | **$/year** |
| Annualized Cost | $750 | $/year |

**Materials, Supplies, Other Costs** 2023 dollars

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Annual Costs | 2023 dollars | $ 113 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $473 | |
| Labor | | | |
| Remove Trash from structure & roots from piping | 3 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 3 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 163 | |
| Labor cost, burdened | O/H 150.0% | $ 408 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 22,503 | | $ 19,407 | **$99,110** | **$ 75,878** | | | |
| 0 | 1.000 | **$ 57,200** | | | $57,200 | $ 57,200 | $ 57,200 | $ 57,200 | $ 75,878 |
| 1 | 0.950 | $473 | $ - | $ 408 | $ 881 | $ 837 | $ 58,081 | $ 58,037 | $ 18,678 |
| 2 | 0.903 | $ 487 | $ - | $ 420 | $ 907 | $ 819 | $ 58,988 | $ 58,856 | $ 17,841 |
| 3 | 0.858 | $ 502 | $ - | $ 433 | $ 935 | $ 802 | $ 59,923 | $ 59,658 | $ 17,022 |
| 4 | 0.815 | $ 517 | $ - | $ 446 | $ 963 | $ 784 | $ 60,885 | $ 60,442 | $ 16,220 |
| 5 | 0.774 | $ 532 | $ - | $ 459 | $ 991 | $ 768 | $ 61,877 | $ 61,210 | $ 15,436 |
| 6 | 0.736 | $ 548 | $ - | $ 473 | $ 1,021 | $ 751 | $ 62,898 | $ 61,961 | $ 14,668 |
| 7 | 0.699 | $ 565 | $ - | $ 487 | $ 1,052 | $ 735 | $ 63,950 | $ 62,696 | $ 13,917 |
| 8 | 0.664 | $ 582 | $ - | $ 502 | $ 1,083 | $ 719 | $ 65,033 | $ 63,416 | $ 13,182 |
| 9 | 0.631 | $ 599 | $ - | $ 517 | $ 1,116 | $ 704 | $ 66,149 | $ 64,120 | $ 12,462 |
| 10 | 0.599 | $ 617 | $ - | $ 532 | $ 1,149 | $ 689 | $ 67,299 | $ 64,809 | $ 11,758 |
| 11 | 0.570 | $ 636 | $ - | $ 548 | $ 1,184 | $ 674 | $ 68,483 | $ 65,483 | $ 11,069 |
| 12 | 0.541 | $ 655 | $ - | $ 565 | $ 1,219 | $ 660 | $ 69,702 | $ 66,143 | $ 10,395 |
| 13 | 0.514 | $ 674 | $ - | $ 582 | $ 1,256 | $ 646 | $ 70,958 | $ 66,789 | $ 9,735 |
| 14 | 0.489 | $ 695 | $ - | $ 599 | $ 1,294 | $ 632 | $ 72,252 | $ 67,421 | $ 9,089 |
| 15 | 0.464 | $ 715 | $ - | $ 617 | $ 1,332 | $ 618 | $ 73,584 | $ 68,039 | $ 8,457 |
| 16 | 0.441 | $ 737 | $ - | $ 636 | $ 1,372 | $ 605 | $ 74,957 | $ 68,645 | $ 7,838 |
| 17 | 0.419 | $ 759 | $ - | $ 655 | $ 1,414 | $ 592 | $ 76,370 | $ 69,237 | $ 7,233 |
| 18 | 0.398 | $ 782 | $ - | $ 674 | $ 1,456 | $ 580 | $ 77,826 | $ 69,817 | $ 6,641 |
| 19 | 0.378 | $ 805 | $ - | $ 694 | $ 1,500 | $ 567 | $ 79,326 | $ 70,384 | $ 6,061 |
| 20 | 0.359 | $ 829 | $ - | $ 715 | $ 1,545 | $ 555 | $ 80,871 | $ 70,939 | $ 5,494 |
| 21 | 0.341 | $ 854 | $ - | $ 737 | $ 1,591 | $ 543 | $ 82,462 | $ 71,482 | $ 4,939 |
| 22 | 0.324 | $ 880 | $ - | $ 759 | $ 1,639 | $ 532 | $ 84,101 | $ 72,014 | $ 4,396 |
| 23 | 0.308 | $ 906 | $ - | $ 782 | $ 1,688 | $ 520 | $ 85,789 | $ 72,534 | $ 3,864 |
| 24 | 0.293 | $ 934 | $ - | $ 805 | $ 1,739 | $ 509 | $ 87,527 | $ 73,043 | $ 3,344 |
| 25 | 0.278 | $ 962 | $ - | $ 829 | $ 1,791 | $ 498 | $ 89,318 | $ 73,542 | $ 2,834 |
| 26 | 0.264 | $ 990 | $ - | $ 854 | $ 1,844 | $ 488 | $ 91,162 | $ 74,029 | $ 2,336 |
| 27 | 0.251 | $ 1,020 | $ - | $ 880 | $ 1,900 | $ 477 | $ 93,062 | $ 74,507 | $ 1,848 |
| 28 | 0.239 | $ 1,051 | $ - | $ 906 | $ 1,957 | $ 467 | $ 95,019 | $ 74,974 | $ 1,371 |
| 29 | 0.227 | $ 1,082 | $ - | $ 933 | $ 2,015 | $ 457 | $ 97,034 | $ 75,431 | $ 904 |
| 30 | 0.215 | $ 1,115 | $ - | $ 961 | $ 2,076 | $ 447 | $ 99,110 | $ 75,878 | $ 447 |

**Description: WQBE 07A - Deep UIC Well_On_Property**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two by hand (2 visits per year, 0.5 hour per visit). Combined w/vactor catch basin activity.
2 Total for equipment $360.
Inspection of vegetation and removal of roots that reduce free movement of water through pipes by a crew of
1 two by hand (2 visits per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) $113 per year.

**Replacement Assumptions:**

No capital replacement assumed in 30-year life.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Royce Robertson (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 07_A - Deep UIC Well_On_Property | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **20 FT Deep UIC Well - On Property** | 20 | VF | $ - | $ - |
| 2 | **Well - Borehole Diameter (12")** | 1 | FT | $ - | $ - |
| 3 | **Well - Casing Diameter** | 0.7 | FT | $ - | $ - |
| 4 | Drilling (12" Diameter Borehole) | 20 | VF | $ 135 | $ 2,700 |
| 5 | Well Casing (8-inch Diameter) | 3 | VF | $ 59 | $ 177 |
| 6 | Well Screen | 20 | VF | $ 353 | $ 7,060 |
| 7 | Maintenance Hole, Type 204A | 1 | EA | $ 6,780 | $ 6,780 |
| 8 | Misc Deep Well Costs | 1 | EA | $ 3,710 | $ 3,710 |
| 9 | | | | $ - | $ - |
| 10 | **Facility Removals and Restoration:** | | | $ - | $ - |
| 11 | Clearing and Grubbing | 69 | SY | $ 4 | $ 278 |
| 12 | Landscaping and Restoration (25'WX25'L) | 69 | SY | $ 59 | $ 4,097 |
| 13 | | | | $ - | $ - |
| 14 | **Additional Costs** | | | $ - | $ - |
| 15 | Removals @ 4% Construction Costs | 4.0% | LS | $ 24,802 | $ 992 |
| 16 | TESC @2% Construction Costs | 2% | LS | $ 25,794 | $ 516 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 26,310 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 2,631 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 28,941 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 28,941*** |

**Description: WQBE 07A - Deep UIC Well_On_Property**

Wells that extend below an upper confining layer and discharge into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below.

**Cost Estimating Assumptions:**

Facility design is per 2019 Ecology Stormwater Management Manual.
Assumed depth of facility is 20 feet with a 12" diameter borehole.
All well backfill materials (gravel, bentonite clay, etc.) are assumed to be lumped in the "Misc. Deep Well Costs" bid item.
It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.
Cost is for Deep UIC well only and the cost for an inlet pipe or required pretreatment are not included.
The excavated material is unsuitable for use as backfill.
Landscape restoration is required for the area of disturbance.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on Property and Traffic control is not required.
A street use permit is not required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Royce Robertson (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_07B_Deep UIC Well in_ROW | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Deep UIC Well in ROW (20 VF Depth) | 1 | EA | $ 40,484 | $ 40,484 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 40,484*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 6,073 |
| | | | Street Use Permit (Y/N) | Y | $ 700 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 47,257*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 4,656 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 51,912*** |
| | | | | Construction Sales Tax | $ 5,249 |
| | | | | Outside Agency Construction | $ 810 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 58,000*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 6,229 |
| | | | | Construction Management | $ 4,153 |
| | | | | Permitting & Support | $ 260 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 2,596 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 13,238*** |
| | | | | Project Contingency | $ 10,686 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 23,900*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 81,900*** |

**Description: WQBE 07B - Deep UIC Well in_ROW (2023 Dollars)**

| | | | |
|---|---|---|---|
| Unit | 1 | EA | |
| **Initial Capital Cost** | **$ 81,900** | | |
| Capital cost | $ 81,900.00 | $/Unit | |
| Total Direct O&M/Year | $ 408 | | |
| Direct O&M cost | $ 408 | $/Unit | |
| Capital Replacement Costs (10 Years) | $ - | $/unit | Replacement Costs (N/A for UIC well) |
| Discount rate (%) | 5.25 | | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 100,600** | **$/unit** |
| **Annual O&M Cost** | **$ 900** | **$/year** |
| Annualized Cost | $750 | $/year |

| **Materials, Supplies, Other Costs** | | 2023 dollars | |
|---|---|---|---|
| | | $ - | |
| Annual Costs (misc drainage parts) | 2023 dollars | $ 113 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $473 | |
| Labor | | | |
| Remove Trash from structure & roots from piping | 3 | hr | |
| | | hr | |
| | | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 3 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 163 | |
| Labor cost, burdened | O/H 150.0% | $ 408 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 22,503 | | $ 19,407 | **$123,810** | **$ 100,578** | | | |
| 0 | 1.000 | **$ 81,900** | | | $81,900 | $ 81,900 | $ 81,900 | $ 81,900 | $ 100,578 |
| 1 | 0.950 | $473 | $ - | $ 408 | $ 881 | $ 837 | $ 82,781 | $ 82,737 | $ 18,678 |
| 2 | 0.903 | $ 487 | $ - | $ 420 | $ 907 | $ 819 | $ 83,688 | $ 83,556 | $ 17,841 |
| 3 | 0.858 | $ 502 | $ - | $ 433 | $ 935 | $ 802 | $ 84,623 | $ 84,358 | $ 17,022 |
| 4 | 0.815 | $ 517 | $ - | $ 446 | $ 963 | $ 784 | $ 85,585 | $ 85,142 | $ 16,220 |
| 5 | 0.774 | $ 532 | $ - | $ 459 | $ 991 | $ 768 | $ 86,577 | $ 85,910 | $ 15,436 |
| 6 | 0.736 | $ 548 | $ - | $ 473 | $ 1,021 | $ 751 | $ 87,598 | $ 86,661 | $ 14,668 |
| 7 | 0.699 | $ 565 | $ - | $ 487 | $ 1,052 | $ 735 | $ 88,650 | $ 87,396 | $ 13,917 |
| 8 | 0.664 | $ 582 | $ - | $ 502 | $ 1,083 | $ 719 | $ 89,733 | $ 88,116 | $ 13,182 |
| 9 | 0.631 | $ 599 | $ - | $ 517 | $ 1,116 | $ 704 | $ 90,849 | $ 88,820 | $ 12,462 |
| 10 | 0.599 | $ 617 | $ - | $ 532 | $ 1,149 | $ 689 | $ 91,999 | $ 89,509 | $ 11,758 |
| 11 | 0.570 | $ 636 | $ - | $ 548 | $ 1,184 | $ 674 | $ 93,183 | $ 90,183 | $ 11,069 |
| 12 | 0.541 | $ 655 | $ - | $ 565 | $ 1,219 | $ 660 | $ 94,402 | $ 90,843 | $ 10,395 |
| 13 | 0.514 | $ 674 | $ - | $ 582 | $ 1,256 | $ 646 | $ 95,658 | $ 91,489 | $ 9,735 |
| 14 | 0.489 | $ 695 | $ - | $ 599 | $ 1,294 | $ 632 | $ 96,952 | $ 92,121 | $ 9,089 |
| 15 | 0.464 | $ 715 | $ - | $ 617 | $ 1,332 | $ 618 | $ 98,284 | $ 92,739 | $ 8,457 |
| 16 | 0.441 | $ 737 | $ - | $ 636 | $ 1,372 | $ 605 | $ 99,657 | $ 93,345 | $ 7,838 |
| 17 | 0.419 | $ 759 | $ - | $ 655 | $ 1,414 | $ 592 | $ 101,070 | $ 93,937 | $ 7,233 |
| 18 | 0.398 | $ 782 | $ - | $ 674 | $ 1,456 | $ 580 | $ 102,526 | $ 94,517 | $ 6,641 |
| 19 | 0.378 | $ 805 | $ - | $ 694 | $ 1,500 | $ 567 | $ 104,026 | $ 95,084 | $ 6,061 |
| 20 | 0.359 | $ 829 | $ - | $ 715 | $ 1,545 | $ 555 | $ 105,571 | $ 95,639 | $ 5,494 |
| 21 | 0.341 | $ 854 | $ - | $ 737 | $ 1,591 | $ 543 | $ 107,162 | $ 96,182 | $ 4,939 |
| 22 | 0.324 | $ 880 | $ - | $ 759 | $ 1,639 | $ 532 | $ 108,801 | $ 96,714 | $ 4,396 |
| 23 | 0.308 | $ 906 | $ - | $ 782 | $ 1,688 | $ 520 | $ 110,489 | $ 97,234 | $ 3,864 |
| 24 | 0.293 | $ 934 | $ - | $ 805 | $ 1,739 | $ 509 | $ 112,227 | $ 97,743 | $ 3,344 |
| 25 | 0.278 | $ 962 | $ - | $ 829 | $ 1,791 | $ 498 | $ 114,018 | $ 98,242 | $ 2,834 |
| 26 | 0.264 | $ 990 | $ - | $ 854 | $ 1,844 | $ 488 | $ 115,862 | $ 98,729 | $ 2,336 |
| 27 | 0.251 | $ 1,020 | $ - | $ 880 | $ 1,900 | $ 477 | $ 117,762 | $ 99,207 | $ 1,848 |
| 28 | 0.239 | $ 1,051 | $ - | $ 906 | $ 1,957 | $ 467 | $ 119,719 | $ 99,674 | $ 1,371 |
| 29 | 0.227 | $ 1,082 | $ - | $ 933 | $ 2,015 | $ 457 | $ 121,734 | $ 100,131 | $ 904 |
| 30 | 0.215 | $ 1,115 | $ - | $ 961 | $ 2,076 | $ 447 | $ 123,810 | $ 100,578 | $ 447 |

**Description: WQBE 07B - Deep UIC Well in_ROW**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two by hand (2 visits per year, 0.5 hour per visit). Combined w/vactor catch basin activity.
2 Total for equipment $360.
Inspection of vegetation and removal of roots that reduce free movement of water through pipes by a crew
1 of two by hand (2 visits per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) $113 per year.

**Replacement Assumptions:**

No capital replacement assumed in 30-year life.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Royce Robertson (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_07B_Deep UIC Well in_ROW | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Deep UIC Well - ROW (Urban Roadway)** | 20 | LF | $ - | $ - |
| 2 | **Well - Borehole Diameter** | 12 | FT | $ - | $ - |
| 3 | **Well - Casing Diameter** | 0.7 | FT | $ - | $ - |
| 4 | Drilling (12" Diameter Borehole) | 20 | VF | $ 135 | $ 2,700 |
| 5 | Well Casing (8-inch Diameter) | 3 | VF | $ 59 | $ 177 |
| 6 | Well Screen | 20 | VF | $ 353 | $ 7,060 |
| 7 | Maintenance Hole, Type 204A | 1 | EA | $ 6,780 | $ 6,780 |
| 8 | Misc Deep Well Costs | 1 | EA | $ 3,710 | $ 3,710 |
| 9 | | | | $ - | $ - |
| 10 | **Facility Removals and Restoration:** | | | $ - | $ - |
| 11 | Remove Existing Pavement | 69 | SY | $ 14 | $ 972 |
| 12 | Pavement Patch - Area of Disturbance (6"HMA/6"CSTC) | 69 | SY | $ 110 | $ 7,639 |
| 13 | | | | | $ - |
| 14 | **Additional Costs** | | | $ - | $ - |
| 15 | Removals @ 4% Construction Costs | 4% | LS | $ 29,038 | $ 1,162 |
| 16 | Traffic Control (Heavy) | 0.3 | MO | $ 20,000 | $ 6,000 |
| 17 | TESC @2% Construction Costs | 2% | LS | $ 30,200 | $ 604 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 36,804 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 3,680 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 40,484 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 40,484*** |

**Description: WQBE 07B - Deep UIC Well in_ROW**

Wells that extend below an upper confining layer and discharge into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below.

**Cost Estimating Assumptions:**

Facility design is per 2019 Ecology Stormwater Management Manual.
Assumed depth of facility is 20 feet with a 12" diameter borehole.
All well backfill materials (gravel, bentonite clay, etc.) are assumed to be lumped in the "Misc. Deep Well Costs" bid item
Cost is for Deep UIC well only, any inlet pipe will be accounted for in pretreatment BMP
The excavated material is unsuitable for use as backfill.
Arterial Roadway restoration is assumed for facility footprint and area of disturbance and consists of 6" HMA/6" CSTS
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
Installation is in ROW on the roadside and does not require easements or acquisition
A street use permit is required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Royce Robertson (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR) |
| **Description:** | WQBE_07C_Deep UIC Well With Property Cost | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Deep UIC Well Installation (20 VF Depth) | 1 | EA | $ 28,941 | $ 28,941 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 28,941*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 4,341 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 33,282*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 3,328 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 36,610*** |
| | | | | Construction Sales Tax | $ 3,753 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 40,400*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 4,393 |
| | | | | Construction Management | $ 2,929 |
| | | | | Permitting & Support | $ 183 |
| 25 | s.f. Land Area | Medium | Land Purchase/ROW Acquisition | | $ 2,011 |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 1,831 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 11,346*** |
| | | | | Project Contingency | $ 7,762 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 19,100*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 59,500*** |

**Description: WQBE 07C - Deep UIC Well With Property Cost (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 59,500** | |
| Capital cost | $ 59,500.00 | $/Unit |
| Total Direct O&M/Year | $ 407.93 | |
| Direct O&M cost | $ 407.93 | $/Unit |
| Capital Replacement Costs (10 Years) | $ - | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

Replacement Costs (N/A for UIC well)

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 78,200** | **$/unit** |
| **Annual O&M Cost** | **$ 900** | **$/year** |
| Annualized Cost | $750 | $/year |

| **Materials, Supplies, Other Costs** | 2023 dollars | | |
|---|---|---|---|
| | | $ - | $/year |
| Annual Costs | 2023 dollars | $ 113 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $473 | |
| Labor | | | |
| Remove Trash from structure & roots from piping | 3 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 3 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 163 | |
| Labor cost, burdened | O/H 150.0% | $ 408 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 22,503 | | $ 19,407 | **$101,410** | **$ 78,178** | | | |
| 0 | 1.000 | **$ 59,500** | | | $59,500 | $ 59,500 | $ 59,500 | $ 59,500 | $ 78,178 |
| 1 | 0.950 | $473 | $ - | $ 408 | $ 881 | $ 837 | $ 60,381 | $ 60,337 | $ 18,678 |
| 2 | 0.903 | $ 487 | $ - | $ 420 | $ 907 | $ 819 | $ 61,288 | $ 61,156 | $ 17,841 |
| 3 | 0.858 | $ 502 | $ - | $ 433 | $ 935 | $ 802 | $ 62,223 | $ 61,958 | $ 17,022 |
| 4 | 0.815 | $ 517 | $ - | $ 446 | $ 963 | $ 784 | $ 63,185 | $ 62,742 | $ 16,220 |
| 5 | 0.774 | $ 532 | $ - | $ 459 | $ 991 | $ 768 | $ 64,177 | $ 63,510 | $ 15,436 |
| 6 | 0.736 | $ 548 | $ - | $ 473 | $ 1,021 | $ 751 | $ 65,198 | $ 64,261 | $ 14,668 |
| 7 | 0.699 | $ 565 | $ - | $ 487 | $ 1,052 | $ 735 | $ 66,250 | $ 64,996 | $ 13,917 |
| 8 | 0.664 | $ 582 | $ - | $ 502 | $ 1,083 | $ 719 | $ 67,333 | $ 65,716 | $ 13,182 |
| 9 | 0.631 | $ 599 | $ - | $ 517 | $ 1,116 | $ 704 | $ 68,449 | $ 66,420 | $ 12,462 |
| 10 | 0.599 | $ 617 | $ - | $ 532 | $ 1,149 | $ 689 | $ 69,599 | $ 67,109 | $ 11,758 |
| 11 | 0.570 | $ 636 | $ - | $ 548 | $ 1,184 | $ 674 | $ 70,783 | $ 67,783 | $ 11,069 |
| 12 | 0.541 | $ 655 | $ - | $ 565 | $ 1,219 | $ 660 | $ 72,002 | $ 68,443 | $ 10,395 |
| 13 | 0.514 | $ 674 | $ - | $ 582 | $ 1,256 | $ 646 | $ 73,258 | $ 69,089 | $ 9,735 |
| 14 | 0.489 | $ 695 | $ - | $ 599 | $ 1,294 | $ 632 | $ 74,552 | $ 69,721 | $ 9,089 |
| 15 | 0.464 | $ 715 | $ - | $ 617 | $ 1,332 | $ 618 | $ 75,884 | $ 70,339 | $ 8,457 |
| 16 | 0.441 | $ 737 | $ - | $ 636 | $ 1,372 | $ 605 | $ 77,257 | $ 70,945 | $ 7,838 |
| 17 | 0.419 | $ 759 | $ - | $ 655 | $ 1,414 | $ 592 | $ 78,670 | $ 71,537 | $ 7,233 |
| 18 | 0.398 | $ 782 | $ - | $ 674 | $ 1,456 | $ 580 | $ 80,126 | $ 72,117 | $ 6,641 |
| 19 | 0.378 | $ 805 | $ - | $ 694 | $ 1,500 | $ 567 | $ 81,626 | $ 72,684 | $ 6,061 |
| 20 | 0.359 | $ 829 | $ - | $ 715 | $ 1,545 | $ 555 | $ 83,171 | $ 73,239 | $ 5,494 |
| 21 | 0.341 | $ 854 | $ - | $ 737 | $ 1,591 | $ 543 | $ 84,762 | $ 73,782 | $ 4,939 |
| 22 | 0.324 | $ 880 | $ - | $ 759 | $ 1,639 | $ 532 | $ 86,401 | $ 74,314 | $ 4,396 |
| 23 | 0.308 | $ 906 | $ - | $ 782 | $ 1,688 | $ 520 | $ 88,089 | $ 74,834 | $ 3,864 |
| 24 | 0.293 | $ 934 | $ - | $ 805 | $ 1,739 | $ 509 | $ 89,827 | $ 75,343 | $ 3,344 |
| 25 | 0.278 | $ 962 | $ - | $ 829 | $ 1,791 | $ 498 | $ 91,618 | $ 75,842 | $ 2,834 |
| 26 | 0.264 | $ 990 | $ - | $ 854 | $ 1,844 | $ 488 | $ 93,462 | $ 76,329 | $ 2,336 |
| 27 | 0.251 | $ 1,020 | $ - | $ 880 | $ 1,900 | $ 477 | $ 95,362 | $ 76,807 | $ 1,848 |
| 28 | 0.239 | $ 1,051 | $ - | $ 906 | $ 1,957 | $ 467 | $ 97,319 | $ 77,274 | $ 1,371 |
| 29 | 0.227 | $ 1,082 | $ - | $ 933 | $ 2,015 | $ 457 | $ 99,334 | $ 77,731 | $ 904 |
| 30 | 0.215 | $ 1,115 | $ - | $ 961 | $ 2,076 | $ 447 | $ 101,410 | $ 78,178 | $ 447 |

**Description: WQBE 07C - Deep UIC Well With Property Cost**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two by hand (2 visits per year, 0.5 hour per visit). Combined w/vactor catch basin activity.
2 Total for equipment $360.
Inspection of vegetation and removal of roots that reduce free movement of water through pipes by a crew of
1 two by hand (2 visits per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) $113 per year.

**Replacement Assumptions:**

No capital replacement assumed in 30-year life.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Royce Robertson (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR) |
| **Description:** | WQBE_07C_Deep UIC Well With Property Cost | | | **Version:** | 3 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **20 FT Deep UIC Well - On Property** | 20 | LF | $ - | $ - |
| 2 | **Well - Borehole Diameter (12")** | 1 | FT | $ - | $ - |
| 3 | **Well - Casing Diameter** | 0.7 | FT | $ - | $ - |
| 4 | Drilling (12" Diameter Borehole) | 20 | VF | $ 135 | $ 2,700 |
| 5 | Well Casing (8-inch Diameter) | 3 | VF | $ 59 | $ 177 |
| 6 | Well Screen | 20 | VF | $ 353 | $ 7,060 |
| 7 | Maintenance Hole, Type 204A | 1 | EA | $ 6,780 | $ 6,780 |
| 8 | Misc Deep Well Costs | 1 | EA | $ 3,710 | $ 3,710 |
| 9 | | | | $ - | $ - |
| 10 | **Facility Removals and Restoration:** | | | $ - | $ - |
| 11 | Clearing and Grubbing | 69 | SY | $ 4 | $ 278 |
| 12 | Landscaping and Restoration (25'WX25'L) | 69 | SY | $ 59 | $ 4,097 |
| 13 | | | | $ - | $ - |
| 14 | **Additional Costs** | | | $ - | $ - |
| 15 | Removals @ 4% Construction Costs | 4% | LS | $ 24,802 | $ 992 |
| 16 | TESC @2% Construction Costs | 2% | LS | $ 25,794 | $ 516 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 26,310 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 2,631 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 28,941 |
| ***Direct: Subtotal Construction Costs*** | | | ***$ 28,941*** |

**Description: WQBE 07_C - Deep UIC Well With Property Cost**

Wells that extend below an upper confining layer and discharge into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below.

**Cost Estimating Assumptions:**

Facility design is per 2019 Ecology Stormwater Management Manual.
Assumed depth of facility is 20 feet with a 12" diameter borehole.
All well backfill materials (gravel, bentonite clay, etc.) are assumed to be lumped in the "Misc. Deep Well Costs" bid item
Cost is for Deep UIC well only, any inlet pipe will be accounted for in pretreatment BMP
The excavated material is unsuitable for use as backfill.
Arterial Roadway restoration is assumed for facility footprint and area of disturbance and consists of 6" HMA/6" CSTS
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
Installation is on property and **does** require easements or acquisition
The facility is located on Property and Traffic control is not required.
A street use permit is not required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Royce Robertson (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jeff Price (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_07D_Deep UIC Well with Filter in ROW | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Deep UIC Well (20 VF Depth) with High Rate Underground Filter (24 s.f. bottom area) in ROW | 1 | EA | $ 111,708 | $ 111,708 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 111,708*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 16,756 |
| | | | Street Use Permit (Y/N) | Y | $ 700 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 129,164*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 12,846 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 142,010*** |
| | | | | Construction Sales Tax | $ 14,484 |
| | | | | Outside Agency Construction | $ 2,234 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 158,700*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 17,041 |
| | | | | Construction Management | $ 11,361 |
| | | | | Permitting & Support | $ 710 |
| | s.f. Land Area | None | | Land Purchase/ROW Acquisition | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 7,101 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 36,213*** |
| | | | | Project Contingency | $ 29,237 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 65,400*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 224,100*** |

**Description: WQBE_07D_Deep UIC Well with Filter in ROW (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 224,100** | |
| Capital cost | $ 224,100.00 | $/Unit |
| Total Direct O&M/Year | $ 1,495.73 | |
| Direct O&M cost | $ 1,495.73 | $/Unit |
| Capital Replacement Costs (10 Years) | $ - | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 274,000** | **$/unit** |
| **Annual O&M Cost** | **$ 2,400** | **$/year** |
| Annualized Cost | $1,360 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| Plant & Mulch Replacement | $ - | $ 383 | $/year |
| Misc Drainage parts | $ - | $ 113 | |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $ 856 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash from structure & roots from piping | 3 | hr | |
| Plant Health (Filter) | 4 | hr | |
| Remediation of erosion | 4 | hr | |
| | 0 | hr | |
| **Total hours per year** | 11 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 598 | |
| Labor cost, burdened | O/H 150.0% | $ 1,496 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 40,725 | | $ 71,160 | **$335,984** | **$ 273,963** | | | |
| 0 | 1.000 | **$ 224,100** | | | $224,100 | $ 224,100 | $ 224,100 | $ 224,100 | $ 273,963 |
| 1 | 0.950 | $856 | $ - | $ 1,496 | $ 2,352 | $ 2,234 | $ 226,452 | $ 226,334 | $ 49,863 |
| 2 | 0.903 | $ 882 | $ - | $ 1,541 | $ 2,422 | $ 2,187 | $ 228,874 | $ 228,521 | $ 47,628 |
| 3 | 0.858 | $ 908 | $ - | $ 1,587 | $ 2,495 | $ 2,140 | $ 231,369 | $ 230,661 | $ 45,442 |
| 4 | 0.815 | $ 935 | $ - | $ 1,634 | $ 2,570 | $ 2,094 | $ 233,939 | $ 232,755 | $ 43,302 |
| 5 | 0.774 | $ 963 | $ - | $ 1,683 | $ 2,647 | $ 2,049 | $ 236,586 | $ 234,805 | $ 41,207 |
| 6 | 0.736 | $ 992 | $ - | $ 1,734 | $ 2,726 | $ 2,006 | $ 239,312 | $ 236,810 | $ 39,158 |
| 7 | 0.699 | $ 1,022 | $ - | $ 1,786 | $ 2,808 | $ 1,963 | $ 242,120 | $ 238,773 | $ 37,153 |
| 8 | 0.664 | $ 1,053 | $ - | $ 1,840 | $ 2,892 | $ 1,921 | $ 245,012 | $ 240,694 | $ 35,190 |
| 9 | 0.631 | $ 1,084 | $ - | $ 1,895 | $ 2,979 | $ 1,880 | $ 247,991 | $ 242,573 | $ 33,269 |
| 10 | 0.599 | $ 1,117 | $ - | $ 1,952 | $ 3,068 | $ 1,840 | $ 251,060 | $ 244,413 | $ 31,389 |
| 11 | 0.570 | $ 1,150 | $ - | $ 2,010 | $ 3,161 | $ 1,800 | $ 254,220 | $ 246,213 | $ 29,550 |
| 12 | 0.541 | $ 1,185 | $ - | $ 2,070 | $ 3,255 | $ 1,762 | $ 257,476 | $ 247,975 | $ 27,750 |
| 13 | 0.514 | $ 1,220 | $ - | $ 2,133 | $ 3,353 | $ 1,724 | $ 260,829 | $ 249,699 | $ 25,988 |
| 14 | 0.489 | $ 1,257 | $ - | $ 2,197 | $ 3,454 | $ 1,687 | $ 264,282 | $ 251,386 | $ 24,264 |
| 15 | 0.464 | $ 1,295 | $ - | $ 2,262 | $ 3,557 | $ 1,651 | $ 267,840 | $ 253,037 | $ 22,577 |
| 16 | 0.441 | $ 1,334 | $ - | $ 2,330 | $ 3,664 | $ 1,616 | $ 271,503 | $ 254,653 | $ 20,926 |
| 17 | 0.419 | $ 1,374 | $ - | $ 2,400 | $ 3,774 | $ 1,581 | $ 275,277 | $ 256,234 | $ 19,310 |
| 18 | 0.398 | $ 1,415 | $ - | $ 2,472 | $ 3,887 | $ 1,547 | $ 279,164 | $ 257,781 | $ 17,729 |
| 19 | 0.378 | $ 1,457 | $ - | $ 2,546 | $ 4,004 | $ 1,514 | $ 283,168 | $ 259,296 | $ 16,181 |
| 20 | 0.359 | $ 1,501 | $ - | $ 2,623 | $ 4,124 | $ 1,482 | $ 287,292 | $ 260,778 | $ 14,667 |
| 21 | 0.341 | $ 1,546 | $ - | $ 2,701 | $ 4,247 | $ 1,450 | $ 291,539 | $ 262,228 | $ 13,185 |
| 22 | 0.324 | $ 1,592 | $ - | $ 2,782 | $ 4,375 | $ 1,419 | $ 295,914 | $ 263,648 | $ 11,734 |
| 23 | 0.308 | $ 1,640 | $ - | $ 2,866 | $ 4,506 | $ 1,389 | $ 300,420 | $ 265,037 | $ 10,315 |
| 24 | 0.293 | $ 1,689 | $ - | $ 2,952 | $ 4,641 | $ 1,359 | $ 305,062 | $ 266,396 | $ 8,926 |
| 25 | 0.278 | $ 1,740 | $ - | $ 3,041 | $ 4,781 | $ 1,330 | $ 309,842 | $ 267,726 | $ 7,567 |
| 26 | 0.264 | $ 1,792 | $ - | $ 3,132 | $ 4,924 | $ 1,302 | $ 314,766 | $ 269,028 | $ 6,237 |
| 27 | 0.251 | $ 1,846 | $ - | $ 3,226 | $ 5,072 | $ 1,274 | $ 319,838 | $ 270,302 | $ 4,935 |
| 28 | 0.239 | $ 1,901 | $ - | $ 3,322 | $ 5,224 | $ 1,247 | $ 325,062 | $ 271,549 | $ 3,661 |
| 29 | 0.227 | $ 1,958 | $ - | $ 3,422 | $ 5,381 | $ 1,220 | $ 330,442 | $ 272,769 | $ 2,414 |
| 30 | 0.215 | $ 2,017 | $ - | $ 3,525 | $ 5,542 | $ 1,194 | $ 335,984 | $ 273,963 | $ 1,194 |

**Description: WQBE_07D_Deep UIC Well with Filter in ROW**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions (UIC):**

Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two by hand (2 visits per year, 0.5 hour per visit). Combined w/vactor catch basin
2 activity. Total for equipment $360.
Inspection of vegetation and removal of roots that reduce free movement of water through pipes by a crew
1 of two by hand (2 visits per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) $113 per year.

**O&M Estimating Assumptions (Filter):**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. This task will be executed in the same hours as already set aside for UIC Well maintenance.
Twice a year the 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours. Assumed
4 annual cost of $113 for mulch.

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed
4 biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit).
Annual mulch and plan replacements 5 plants at $54/Plant

**Replacement Assumptions:**

No capital replacement assumed in 30-year life for UIC well or Filter

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Royce Robertson (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jeff Price (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_07D_Deep UIC Well with Filter in ROW | | | **Version:** | ` |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Deep UIC Well - ROW (Urban Roadway)** | 20 | LF | $ - | $ - |
| 2 | **Well - Borehole Diameter** | 12 | IN | $ - | $ - |
| 3 | **Well - Casing Diameter** | 0.7 | FT | $ - | $ - |
| 4 | Drilling (12" Diameter Borehole) | 20 | VF | $ 135 | $ 2,700 |
| 5 | Well Casing (8-inch Diameter) | 3 | VF | $ 59 | $ 177 |
| 6 | Well Screen | 20 | VF | $ 353 | $ 7,060 |
| 7 | Maintenance Hole, Type 204A | 1 | EA | $ 6,780 | $ 6,780 |
| 8 | Misc Deep Well Costs | 1 | EA | $ 3,710 | $ 3,710 |
| 9 | | | | $ - | $ - |
| 10 | **Removal and Restoration UIC Well** | | | $ - | $ - |
| 11 | Remove Existing Pavement | 69 | SY | $ 14 | $ 972 |
| 12 | Pavement Patch - Area of Disturbance (6"HMA/6"CSTC) | 69 | SY | $ 110 | $ 7,639 |
| 13 | | | | $ - | $ - |
| 14 | **High Rate Underground Filter** | | | $ - | $ - |
| 15 | Filterra Unit 4'X6' (complete) | 1 | EA | $ 22,165 | $ 22,165 |
| 16 | Structural Excavation to Waste (10'W X12'L X 5'D) + (50'LX5'WX6'D) | 78 | CY | $ 79 | $ 6,144 |
| 17 | Imported Structural Fill | 73 | CY | $ 44 | $ 3,227 |
| 18 | Crushed Base | 1.0 | CY | $ 64 | $ 64 |
| 19 | Inlet Drain w/Energy Dissipating Rocks | 1 | EA | $ 1,481 | $ 1,481 |
| 20 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 21 | Pipe 8" PSD, DI CL 50 | 50 | LF | $ 160 | $ 8,000 |
| 22 | Trench Box Shoring (Shallow) | 390 | SF | $ 10 | $ 3,900 |
| 23 | | | | $ - | $ - |
| 24 | **Restoration High Rate Underground Filter** | | | $ - | $ - |
| 25 | Pavement Patching HMA 6" HMA/6"CSBC | 36 | SY | $ 110 | $ 3,972 |
| 26 | Concrete Curb and Gutter | 15 | LF | $ 111 | $ 1,665 |
| 27 | Sidewalk 6' Wide | 10 | SY | $ 125 | $ 1,250 |
| 28 | Landscaping, planting, and restoration | 10 | SY | $ 59 | $ 590 |
| 29 | Tree | 1 | EA | $ 720 | $ 720 |
| 30 | | | | | $ - |
| 31 | **Additional Costs** | | | | $ - |
| 32 | Removals @ 4% Construction Costs | 4.0% | LS | $ 86,116 | $ 3,445 |
| 33 | Traffic Control (Heavy) | 0.5 | MO | $ 20,000 | $ 10,000 |
| 34 | TESC @2% Construction Costs | 2% | LS | $ 99,561 | $ 1,991 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 101,552 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 10,155 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 111,708 |
| ***Direct: Subtotal Construction Costs*** | | | ***$ 111,708*** |

**Description: WQBE_07D_Deep UIC Well with Filter in ROW**

A Deep UIC Well is a well that extends below an upper confining layer and discharges into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Cost Estimating Assumptions:**

General

The excavated material is unsuitable for use as backfill.
Arterial Roadway restoration is assumed for facility footprint and area of disturbance and consists of 6" HMA/6" CSTC
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
Installation is in ROW on the roadside and does not require easements or acquisition
The facility is located within the ROW and Traffic control is required. Traffic conditions are assumed to be heavy for the urban setting and light for the rural setting.
A street use permit is required.

Deep UIC Well

Facility design is per 2019 Ecology Stormwater Management Manual.
Assumed depth of facility is 20 feet with a 12" diameter borehole.
All well backfill materials (gravel, bentonite clay, etc.) are assumed to be lumped in the "Misc. Deep Well Costs" bid item

High Rate Underground Filter

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6"thick.
The facility treatment area is 24 sf (4'X6') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.
A total of 50 LF of 8" storm pipe is required to connect to the deep UIC well.
Trench Box shoring is used.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Royce Robertson (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jeff Price (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_07E_Deep UIC Well with Bioretentoin Planter in ROW | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Deep UIC Well with Bioretention Planter in ROW | 1 | EA | $ 668,615 | $ 668,615 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 668,615*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 100,292 |
| | | | Street Use Permit (Y/N) | Y | $ 700 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 769,607*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 76,891 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 846,498*** |
| | | | | Construction Sales Tax | $ 86,694 |
| | | | | Outside Agency Construction | $ 13,372 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 946,600*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 101,580 |
| | | | | Construction Management | $ 67,720 |
| | | | | Permitting & Support | $ 4,232 |
| | s.f. Land Area | None | | Land Purchase/ROW Acquisition | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 42,325 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 215,857*** |
| | | | | Project Contingency | $ 174,369 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 390,200*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 1,336,800*** |

**Description: WQBE_07E_Deep UIC Well with Bioretention Planter in ROW (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 1,336,800** | |
| Capital cost | $ 1,336,800.00 | $/Unit |
| Total Direct O&M/Year | $ 3,127.43 | |
| Direct O&M cost | $ 3,127.43 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 5,030 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 1,466,700** | **$/unit** |
| **Annual O&M Cost** | **$ 5,900** | **$/year** |
| Annualized Cost | $4,400 | $/year |

| **Materials, Supplies, Other Costs** | | 2023 dollars | |
|---|---|---|---|
| Misc drainage parts | $ - | $ 113 | $/year |
| Annual costs (plant/mulch/media replacement, misc drainage parts) | $ - | $ 2,300 | $/year |
| Vactor Truck Equipment + Labor Cost | | $ 360 | $/year |
| Subtotal | | $ 2,773 | |

| Labor | | | | |
|---|---|---|---|---|
| Remove Trash, Inspect and Remove Roots, Remediate Holes and Breaks (UIC) | 3 | hr | | |
| Remove Trash, Sediment, Debris, Inspect Plant Health (bioretention) | 16 | hr | | |
| Remediate Erosion | 4 | hr | | |
| | 0 | hr | | |
| **Total hours per year** | 23 | | | |
| Raw Labor Rate/Hr | | $ 54 | | |
| Raw labor cost | (embedded) | $ 1,251 | | |
| Labor cost, burdened | O/H 150.0% | $ 3,127 | $ | 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | | |
| Life Cycle Period: | 30 | years | | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 131,927 | | $ 148,789 | **$1,627,575** | **$ 1,466,727** | | | |
| 0 | 1.000 | **$ 1,336,800** | | | $1,336,800 | $ 1,336,800 | $ 1,336,800 | $ 1,336,800 | $ 1,466,727 |
| 1 | 0.950 | $2,773 | $ - | $ 3,127 | $ 5,900 | $ 5,606 | $ 1,342,700 | $ 1,342,406 | $ 129,927 |
| 2 | 0.903 | $ 2,856 | $ - | $ 3,221 | $ 6,077 | $ 5,486 | $ 1,348,778 | $ 1,347,892 | $ 124,321 |
| 3 | 0.858 | $ 2,942 | $ - | $ 3,318 | $ 6,260 | $ 5,369 | $ 1,355,038 | $ 1,353,261 | $ 118,835 |
| 4 | 0.815 | $ 3,030 | $ - | $ 3,417 | $ 6,448 | $ 5,254 | $ 1,361,485 | $ 1,358,516 | $ 113,466 |
| 5 | 0.774 | $ 3,121 | $ - | $ 3,520 | $ 6,641 | $ 5,142 | $ 1,368,126 | $ 1,363,657 | $ 108,212 |
| 6 | 0.736 | $ 3,215 | $ - | $ 3,626 | $ 6,840 | $ 5,032 | $ 1,374,966 | $ 1,368,689 | $ 103,070 |
| 7 | 0.699 | $ 3,311 | $ - | $ 3,734 | $ 7,045 | $ 4,924 | $ 1,382,012 | $ 1,373,614 | $ 98,038 |
| 8 | 0.664 | $ 3,410 | $ - | $ 3,846 | $ 7,257 | $ 4,819 | $ 1,389,269 | $ 1,378,433 | $ 93,114 |
| 9 | 0.631 | $ 3,513 | $ - | $ 3,962 | $ 7,474 | $ 4,716 | $ 1,396,743 | $ 1,383,149 | $ 88,294 |
| 10 | 0.599 | $ 3,618 | $ 5,030 | $ 4,081 | $ 12,729 | $ 7,631 | $ 1,409,472 | $ 1,390,780 | $ 83,578 |
| 11 | 0.570 | $ 3,727 | $ - | $ 4,203 | $ 7,930 | $ 4,517 | $ 1,417,401 | $ 1,395,296 | $ 75,948 |
| 12 | 0.541 | $ 3,838 | $ - | $ 4,329 | $ 8,168 | $ 4,420 | $ 1,425,569 | $ 1,399,716 | $ 71,431 |
| 13 | 0.514 | $ 3,954 | $ - | $ 4,459 | $ 8,413 | $ 4,326 | $ 1,433,982 | $ 1,404,042 | $ 67,011 |
| 14 | 0.489 | $ 4,072 | $ - | $ 4,593 | $ 8,665 | $ 4,233 | $ 1,442,647 | $ 1,408,275 | $ 62,685 |
| 15 | 0.464 | $ 4,194 | $ - | $ 4,731 | $ 8,925 | $ 4,143 | $ 1,451,572 | $ 1,412,418 | $ 58,452 |
| 16 | 0.441 | $ 4,320 | $ - | $ 4,872 | $ 9,193 | $ 4,054 | $ 1,460,764 | $ 1,416,472 | $ 54,310 |
| 17 | 0.419 | $ 4,450 | $ - | $ 5,019 | $ 9,468 | $ 3,967 | $ 1,470,233 | $ 1,420,439 | $ 50,256 |
| 18 | 0.398 | $ 4,583 | $ - | $ 5,169 | $ 9,753 | $ 3,883 | $ 1,479,985 | $ 1,424,322 | $ 46,288 |
| 19 | 0.378 | $ 4,721 | $ - | $ 5,324 | $ 10,045 | $ 3,800 | $ 1,490,030 | $ 1,428,121 | $ 42,406 |
| 20 | 0.359 | $ 4,862 | $ 5,030 | $ 5,484 | $ 15,376 | $ 5,526 | $ 1,505,407 | $ 1,433,647 | $ 38,606 |
| 21 | 0.341 | $ 5,008 | $ - | $ 5,648 | $ 10,657 | $ 3,639 | $ 1,516,064 | $ 1,437,286 | $ 33,080 |
| 22 | 0.324 | $ 5,159 | $ - | $ 5,818 | $ 10,977 | $ 3,561 | $ 1,527,040 | $ 1,440,847 | $ 29,441 |
| 23 | 0.308 | $ 5,313 | $ - | $ 5,992 | $ 11,306 | $ 3,485 | $ 1,538,346 | $ 1,444,332 | $ 25,880 |
| 24 | 0.293 | $ 5,473 | $ - | $ 6,172 | $ 11,645 | $ 3,410 | $ 1,549,991 | $ 1,447,742 | $ 22,395 |
| 25 | 0.278 | $ 5,637 | $ - | $ 6,357 | $ 11,994 | $ 3,338 | $ 1,561,985 | $ 1,451,080 | $ 18,985 |
| 26 | 0.264 | $ 5,806 | $ - | $ 6,548 | $ 12,354 | $ 3,266 | $ 1,574,339 | $ 1,454,346 | $ 15,647 |
| 27 | 0.251 | $ 5,980 | $ - | $ 6,745 | $ 12,725 | $ 3,196 | $ 1,587,064 | $ 1,457,542 | $ 12,381 |
| 28 | 0.239 | $ 6,160 | $ - | $ 6,947 | $ 13,107 | $ 3,128 | $ 1,600,171 | $ 1,460,670 | $ 9,185 |
| 29 | 0.227 | $ 6,344 | $ - | $ 7,155 | $ 13,500 | $ 3,061 | $ 1,613,671 | $ 1,463,732 | $ 6,057 |
| 30 | 0.215 | $ 6,535 | $ - | $ 7,370 | $ 13,905 | $ 2,996 | $ 1,627,575 | $ 1,466,727 | $ 2,996 |

**Description: WQBE_07E_Deep UIC Well with Bioretention Planter in ROW**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions (UIC):**

Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two by hand (2 visits per year, 0.5 hour per visit). Combined w/vactor catch basin activity.
2 Total for equipment $360.
Inspection of vegetation and removal of roots that reduce free movement of water through pipes by a crew of
1 two by hand (2 visits per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) $113 per year.

**O&M Estimating Assumptions (Bioretention):**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using
8 hand tools (2 visits per year, 2 hour per visit).

Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth,
8 weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per year, 1 hour per visit).
Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit). Annual
4 mulch/media layer replacement will cost $680.
Annual plant replacement will cost $1620. Comprised of (30) small plant replacements at $54/each.

**Replacement Assumptions:**

Complete rebuild bioretention planter every ten years and consist of complete vegetation replacement along with soils that have been compacted. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Royce Robertson (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jeff Price (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_07E_Deep UIC Well with Bioretentoin Planter in ROW | | | **Version:** | 3 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Deep UIC Well - ROW (Urban Roadway)** | 20 | LF | $ - | $ - |
| 2 | **Well - Borehole Diameter** | 12 | IN | $ - | $ - |
| 3 | **Well - Casing Diameter** | 0.7 | FT | $ - | $ - |
| 4 | Drilling (12" Diameter Borehole) | 20 | VF | $ 135 | $ 2,700 |
| 5 | Well Casing (8-inch Diameter) | 3 | VF | $ 59 | $ 177 |
| 6 | Well Screen | 20 | VF | $ 353 | $ 7,060 |
| 7 | Maintenance Hole, Type 204A | 1 | EA | $ 6,780 | $ 6,780 |
| 8 | Misc Deep Well Costs | 1 | EA | $ 3,710 | $ 3,710 |
| 9 | | | | $ - | $ - |
| 10 | **Deep UIC Well Facility Removals and Restoration:** | | | $ - | $ - |
| 11 | Remove Existing Pavement | 69 | SY | $ 14 | $ 972 |
| 12 | Pavement Patch - Area of Disturbance (6"HMA/6"CSTC) | 69 | SY | $ 110 | $ 7,639 |
| 13 | | | | $ - | $ - |
| 14 | **Bioretention Planter - ROW** | 580 | SF | $ - | $ - |
| 15 | **Bioretention Planter Unit: 6 TOTAL Sized at 5ft x 19ft.** | 114 | LF | $ - | $ - |
| 16 | **Curbed, vertical sides - Top Area** | 580 | SF | $ - | $ - |
| 17 | Structural Excavation to Waste (11'W X25'L X 6'D) x 6 | 367 | CY | $ 79 | $ 28,967 |
| 18 | Imported Structural Fill (Bioretention Planter: 5'W X 19'L X 4.7'D) x 6 | 99 | CY | $ 44 | $ 4,366 |
| 19 | Formed Concrete Walls (2'-6" walls: 48'L X 4.7'D) x 6 | 125 | CY | $ 1,560 | $ 195,520 |
| 20 | Formed Concrete Base (2'-6" base: 10'W X 24'L) x 6 | 133 | CY | $ 590 | $ 78,667 |
| 21 | Treatment Media (5'W X 19'L X 1.5'D) x 6 w/ biochar | 32 | CY | $ 270 | $ 8,550 |
| 22 | Mulch Compost (@ 0.3'D) | 6 | CY | $ 86 | $ 554 |
| 23 | Vegetated Entrance | 63 | SY | $ 2 | $ 127 |
| 24 | Trench Shoring Facility | 1368 | SF | $ 10 | $ 13,680 |
| 25 | | | | $ - | $ - |
| 26 | **Underdrain Items:** | | | $ - | $ - |
| 27 | Underdrain Aggregate (5'W X 19' LX 2.2'D) | 7.7 | CY | $ 133 | $ 1,030 |
| 28 | Overflow & Drain Pipe 8" Dia. (4' + 19') | 115 | LF | $ 48 | $ 5,520 |
| 29 | | | | $ - | $ - |
| 30 | **Bioretention Planter Restoration:** | | | $ - | $ - |
| 31 | Remove Existing Pavement | 183 | SY | $ 14 | $ 2,567 |
| 32 | Pavement Patch - Area of Disturbance (6"HMA/6"CSTC) | 183 | SY | $ 110 | $ 20,167 |
| 33 | Sidewalk 6' Wide | 76 | SY | $ 125 | $ 9,500 |
| 34 | Concrete Curb and Gutter | 114 | LF | $ 111 | $ 12,654 |
| 35 | Landscaping (Planter Only) | 64 | SY | $ 59 | $ 3,802 |
| 36 | Trees (Not in Design Basis) | 0 | EA | $ 720 | $ - |
| 37 | | | | $ - | $ - |
| 38 | **Outlet Pipe** | | | $ - | $ - |
| 39 | Pipe 8" PSD, DI CL 50 | 300 | LF | $ 160 | $ 48,000 |
| 40 | 5' Wide Trench x 7'D to waste | 389 | CY | $ 79 | $ 30,722 |
| 41 | Trench Box Shoring (Shallow) | 4,200 | SF | $ 10 | $ 42,000 |
| 42 | Pavement Patch - Pipe@5'W (6"HMA/6"CSBC) | 167 | SY | $ 110 | $ 18,333 |
| 43 | | | | | $ - |
| 44 | **Additional Costs** | | | | $ - |
| 45 | Removals @ 4% Construction Costs | 4.0% | LS | $ 553,763 | $ 22,151 |
| 46 | Traffic Control (Heavy) | 1 | MO | $ 20,000 | $ 20,000 |
| 47 | TESC @2% Construction Costs | 2% | LS | $ 595,913 | $ 11,918 |
| | | | | | $ - |
| | ***Item Subtotal Construction Costs (Year 2023)*** | | | | $ 607,832 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 60,783 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 668,615 |
| ***Direct: Subtotal Construction Costs*** | | | ***$ 668,615*** |

**Description: WQBE_07E_Deep UIC Well with Bioretention Planter**

A Deep UIC Well is a well that extends below an upper confining layer and discharges into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below. Bioretention Planters include a designed soil mix and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants within a vertical walled container usually constructed from formed concrete, but could include other materials. These designs are often used in ultra-urban settings. For this analysis, the Action is assumed to have an underdrain and closed bottom.

**Cost Estimating Assumptions:**

General

The excavated material is unsuitable for use as backfill.
Arterial Roadway restoration is assumed for facility footprint and area of disturbance and consists of 6" HMA/6" CSTC
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
Installation is in ROW on the roadside and does not require easements or acquisition
The facility is located on Property and Traffic control is not required.
A street use permit is not required.

Deep UIC Well

Facility design is per 2019 Ecology Stormwater Management Manual.
Assumed depth of facility is 20 feet with a 12" diameter borehole.
All well backfill materials (gravel, bentonite clay, etc.) are assumed to be lumped in the "Misc. Deep Well Costs" bid item

Bioretention Planter

Bioretention planter installation is per the Seattle Stormwater Manual, "Non-infiltrating Bioretention" (Volume 3 Section 5.8.2)
Installation is in ROW and does not require easements or acquisition
Filter fabrics not used between the subgrade and the Bioretention Soil Mix
Facility is sited in an open space with outlet pipe beneath a parking area
18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.
0.3' of composted media is included.
The facility treatment area is 580 sf with curbed, vertical sides.
A maximum ponding depth of 6" and a 12" of freeboard depth are assumed.
Facilities have a closed bottom and include an underdrain.
A total of 50 LF of 8" storm pipe is required to connect to the downstream main or structure for each Bioretention Planter.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the box.
Trench Box shoring is used.
Roadway patching and restoration is assumed for the outlet pipe and consists of 6" HMA/6" CSTC
Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.
Restoration is required for the area of disturbance.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Royce Robertson (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jeff Price (HDR)<br>Jess Dexheimer (HDR)<br>Andrew Staples (HDR) |
| **Description:** | WQBE_07F_Deep UIC Well with Bioretention Planter on Property | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Deep UIC Well with Bioretention Planter on Property | 1 | EA | $ 581,860 | $ 581,860 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 581,860*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 87,279 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 669,139*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 66,914 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 736,053*** |
| | | | | Construction Sales Tax | $ 75,445 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 811,500*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 88,326 |
| | | | | Construction Management | $ 58,884 |
| | | | | Permitting & Support | $ 3,680 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 36,803 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 187,693*** |
| | | | | Project Contingency | $ 149,879 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 337,600*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 1,149,100*** |

**Description: WQBE_07F_Deep UIC Well with Bioretention Planter on Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 1,149,100** | |
| Capital cost | $ 1,149,100.00 | $/Unit |
| Total Direct O&M/Year | $ 3,127.43 | |
| Direct O&M cost | $ 3,127.43 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 5,599 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 1,279,600** | **$/unit** |
| **Annual O&M Cost** | **$ 5,900** | **$/year** |
| Annualized Cost | $4,400 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| Misc Drainage parts | $ - | $ 113 | $/year |
| Annual costs (plant/mulch/media replacement, misc drainage parts) | | $ 2,300 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $ 2,773 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash from structure & roots from piping | 3 | hr | |
| Remove trash debris and replace vegetation, sediment removal Bioretention. | 8 | hr | |
| Plant health (bioretention) | 8 | hr | |
| Remediation of erosion | 4 | hr | |
| **Total hours per year** | 23 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 1,251 | |
| Labor cost, burdened | O/H 150.0% | $ 3,127 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 131,927 | | $ 148,789 | **$1,441,012** | **$ 1,279,572** | | | |
| 0 | 1.000 | **$ 1,149,100** | | | $1,149,100 | $ 1,149,100 | $ 1,149,100 | $ 1,149,100 | $ 1,279,572 |
| 1 | 0.950 | $2,773 | $ - | $ 3,127 | $ 5,900 | $ 5,606 | $ 1,155,000 | $ 1,154,706 | $ 130,472 |
| 2 | 0.903 | $ 2,856 | $ - | $ 3,221 | $ 6,077 | $ 5,486 | $ 1,161,078 | $ 1,160,192 | $ 124,866 |
| 3 | 0.858 | $ 2,942 | $ - | $ 3,318 | $ 6,260 | $ 5,369 | $ 1,167,338 | $ 1,165,561 | $ 119,380 |
| 4 | 0.815 | $ 3,030 | $ - | $ 3,417 | $ 6,448 | $ 5,254 | $ 1,173,785 | $ 1,170,816 | $ 114,011 |
| 5 | 0.774 | $ 3,121 | $ - | $ 3,520 | $ 6,641 | $ 5,142 | $ 1,180,426 | $ 1,175,957 | $ 108,757 |
| 6 | 0.736 | $ 3,215 | $ - | $ 3,626 | $ 6,840 | $ 5,032 | $ 1,187,266 | $ 1,180,989 | $ 103,615 |
| 7 | 0.699 | $ 3,311 | $ - | $ 3,734 | $ 7,045 | $ 4,924 | $ 1,194,312 | $ 1,185,914 | $ 98,583 |
| 8 | 0.664 | $ 3,410 | $ - | $ 3,846 | $ 7,257 | $ 4,819 | $ 1,201,569 | $ 1,190,733 | $ 93,659 |
| 9 | 0.631 | $ 3,513 | $ - | $ 3,962 | $ 7,474 | $ 4,716 | $ 1,209,043 | $ 1,195,449 | $ 88,840 |
| 10 | 0.599 | $ 3,618 | $ 5,599 | $ 4,081 | $ 13,297 | $ 7,972 | $ 1,222,340 | $ 1,203,420 | $ 84,123 |
| 11 | 0.570 | $ 3,727 | $ - | $ 4,203 | $ 7,930 | $ 4,517 | $ 1,230,270 | $ 1,207,937 | $ 76,152 |
| 12 | 0.541 | $ 3,838 | $ - | $ 4,329 | $ 8,168 | $ 4,420 | $ 1,238,438 | $ 1,212,357 | $ 71,635 |
| 13 | 0.514 | $ 3,954 | $ - | $ 4,459 | $ 8,413 | $ 4,326 | $ 1,246,850 | $ 1,216,683 | $ 67,215 |
| 14 | 0.489 | $ 4,072 | $ - | $ 4,593 | $ 8,665 | $ 4,233 | $ 1,255,515 | $ 1,220,916 | $ 62,890 |
| 15 | 0.464 | $ 4,194 | $ - | $ 4,731 | $ 8,925 | $ 4,143 | $ 1,264,440 | $ 1,225,058 | $ 58,657 |
| 16 | 0.441 | $ 4,320 | $ - | $ 4,872 | $ 9,193 | $ 4,054 | $ 1,273,633 | $ 1,229,112 | $ 54,514 |
| 17 | 0.419 | $ 4,450 | $ - | $ 5,019 | $ 9,468 | $ 3,967 | $ 1,283,101 | $ 1,233,080 | $ 50,460 |
| 18 | 0.398 | $ 4,583 | $ - | $ 5,169 | $ 9,753 | $ 3,883 | $ 1,292,854 | $ 1,236,962 | $ 46,493 |
| 19 | 0.378 | $ 4,721 | $ - | $ 5,324 | $ 10,045 | $ 3,800 | $ 1,302,899 | $ 1,240,762 | $ 42,610 |
| 20 | 0.359 | $ 4,862 | $ 5,599 | $ 5,484 | $ 15,945 | $ 5,730 | $ 1,318,844 | $ 1,246,492 | $ 38,811 |
| 21 | 0.341 | $ 5,008 | $ - | $ 5,648 | $ 10,657 | $ 3,639 | $ 1,329,501 | $ 1,250,131 | $ 33,080 |
| 22 | 0.324 | $ 5,159 | $ - | $ 5,818 | $ 10,977 | $ 3,561 | $ 1,340,477 | $ 1,253,692 | $ 29,441 |
| 23 | 0.308 | $ 5,313 | $ - | $ 5,992 | $ 11,306 | $ 3,485 | $ 1,351,783 | $ 1,257,177 | $ 25,880 |
| 24 | 0.293 | $ 5,473 | $ - | $ 6,172 | $ 11,645 | $ 3,410 | $ 1,363,428 | $ 1,260,588 | $ 22,395 |
| 25 | 0.278 | $ 5,637 | $ - | $ 6,357 | $ 11,994 | $ 3,338 | $ 1,375,422 | $ 1,263,925 | $ 18,985 |
| 26 | 0.264 | $ 5,806 | $ - | $ 6,548 | $ 12,354 | $ 3,266 | $ 1,387,776 | $ 1,267,191 | $ 15,647 |
| 27 | 0.251 | $ 5,980 | $ - | $ 6,745 | $ 12,725 | $ 3,196 | $ 1,400,501 | $ 1,270,388 | $ 12,381 |
| 28 | 0.239 | $ 6,160 | $ - | $ 6,947 | $ 13,107 | $ 3,128 | $ 1,413,608 | $ 1,273,516 | $ 9,185 |
| 29 | 0.227 | $ 6,344 | $ - | $ 7,155 | $ 13,500 | $ 3,061 | $ 1,427,107 | $ 1,276,577 | $ 6,057 |
| 30 | 0.215 | $ 6,535 | $ - | $ 7,370 | $ 13,905 | $ 2,996 | $ 1,441,012 | $ 1,279,572 | $ 2,996 |

**Description: WQBE_07F_Deep UIC Well with Bioretention Planter on Property**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions (UIC):**

2 Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two by hand (2 visits per year, 0.5 hour per visit). Combined w/vactor catch basin activity. Total for equipment $360.

1 Inspection of vegetation and removal of roots that reduce free movement of water through pipes by a crew of two by hand (2 visits per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) $113 per year.

**O&M Estimating Assumptions (Bioretention):**

8 Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools (2 visits per year, 2 hour per visit).

8 Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per year, 1 hour per visit).

4 Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit). Annual mulch/media layer replacement will cost $680.

Annual plant replacement will cost $1620. Comprised of (30) small plant replacements at $54/each.

**Replacement Assumptions:**

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | |
|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | **Estimator:** | Royce Robertson (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jeff Price (HDR)<br>Jess Dexheimer (HDR)<br>Andrew Staples (HDR) |
| **Description:** | WQBE_07F_Deep UIC Well with Bioretention Planter on Property | **Version:** | 3 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **20 FT Deep UIC Well - On Property** | 20 | LF | $ - | $ - |
| 2 | **Well - Borehole Diameter (12")** | 1 | FT | $ - | $ - |
| 3 | **Well - Casing Diameter** | 0.7 | FT | $ - | $ - |
| 4 | Drilling (12" Diameter Borehole) | 20 | VF | $ 135 | $ 2,700 |
| 5 | Well Casing (8-inch Diameter) | 3 | VF | $ 59 | $ 177 |
| 6 | Well Screen | 20 | VF | $ 353 | $ 7,060 |
| 7 | Maintenance Hole, Type 204A | 1 | EA | $ 6,780 | $ 6,780 |
| 8 | Misc Deep Well Costs | 1 | EA | $ 3,710 | $ 3,710 |
| 9 | | | | $ - | $ - |
| 10 | **Facility Removals and Restoration:** | | | $ - | $ - |
| 11 | Clearing and Grubbing | 69 | SY | $ 4 | $ 278 |
| 12 | Landscaping and Restoration (25'WX25'L) | 69 | SY | $ 59 | $ 4,097 |
| 13 | | | | $ - | $ - |
| 14 | **Bioretention Planter - On Property** | 580 | SF | $ - | $ - |
| 15 | **Bioretention Planter Unit: 6 TOTAL Sized at 5ft x 19ft.** | 114 | LF | $ - | $ - |
| 16 | **Curbed, vertical sides - Top Area** | 580 | SF | $ - | $ - |
| 17 | Structural Excavation to Waste (11'W X25'L X 6'D) x 6 | 367 | CY | $ 79 | $ 28,967 |
| 18 | Imported Structural Fill (Bioretention Planter: 5'W X 19'L X 4.7'D) x 6 | 99 | CY | $ 44 | $ 4,366 |
| 19 | Formed Concrete Walls (2'-6" walls: 48'L X 4.7'D) x 6 | 125 | CY | $ 1,560 | $ 195,520 |
| 20 | Formed Concrete Base (2'-6" base: 10'W X 24'L) x 6 | 133 | CY | $ 590 | $ 78,667 |
| 21 | Treatment Media (5'W X 19'L X 1.5'D) x 6 w/ biochar | 32 | CY | $ 270 | $ 8,550 |
| 22 | Mulch Compost (@ 0.3'D) | 6 | CY | $ 86 | $ 554 |
| 23 | Vegetated Entrance | 63 | SY | $ 10 | $ 633 |
| 24 | Trench Shoring Facility | 1368 | SF | $ 10 | $ 13,680 |
| 25 | | | | $ - | $ - |
| 26 | **Underdrain Items:** | | LF | $ - | $ - |
| 27 | Underdrain Aggregate (5'W X 19' LX 2.2'D) | 7.7 | CY | $ 133 | $ 1,030 |
| 28 | Overflow & Drain Pipe 8" Dia. (4' + 19') | 115 | LF | $ 48 | $ 5,520 |
| 29 | | | | $ - | $ - |
| 30 | **Bioretention Planter Restoration:** | | | $ - | $ - |
| 32 | Landscaping (Planter Only) | 64 | SY | $ 59 | $ 3,802 |
| 33 | Trees (Not in Design Basis) | 0 | EA | $ 720 | $ - |
| 34 | | | | $ - | $ - |
| 35 | **Outlet Pipe** | | | $ - | $ - |
| 36 | Pipe 8" Diameter | 300 | LF | $ 160 | $ 48,000 |
| 37 | 5' Wide Trench x 7'D to waste | 389 | CY | $ 79 | $ 30,722 |
| 38 | Trench Box Shoring (Shallow) | 4,200 | SF | $ 10 | $ 42,000 |
| 39 | Parking Lot Pavement Patch HMA 4" HM/4"CSBC | 167 | SY | $ 71 | $ 11,833 |
| 40 | | | | | $ - |
| 41 | **Additional Costs** | | | | $ - |
| 42 | Removals @ 4% Construction Costs | 4.0% | LS | $ 498,646 | $ 19,946 |
| 43 | TESC @2% Construction Costs | 2% | LS | $ 518,592 | $ 10,372 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 528,964 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 52,896 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 581,860 |
| ***Direct: Subtotal Construction Costs*** | | | ***$ 581,860*** |

**Description: WQBE_07F_Deep UIC Well with Bioretentoin Planter on Property**

A Deep UIC Well is a well that extends below an upper confining layer and discharges into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below. Bioretention Planters include a designed soil mix and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants within a vertical walled container usually constructed from formed concrete, but could include other materials. These designs are often used in ultra-urban settings. For this analysis, the Action is assumed to have an underdrain and closed bottom.

**Cost Estimating Assumptions:**

General

The excavated material is unsuitable for use as backfill.

It is assumed that these facilities are on property and part of a GSI rebate program. Property acquisition and easement costs are not included.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and Traffic control is not required.
A street use permit is not required.

Deep UIC Well

Facility design is per 2019 Ecology Stormwater Management Manual.
Assumed depth of facility is 20 feet with a 12" diameter borehole.
All well backfill materials (gravel, bentonite clay, etc.) are assumed to be lumped in the "Misc. Deep Well Costs" bid item

Bioretention Planter

Bioretention planter installation is per the Seattle Stormwater Manual, "Non-infiltrating Bioretention" (Volume 3 Section 5.8.2)
Filter fabrics not used between the subgrade and the Bioretention Soil Mix
Facility is sited in an open space with outlet pipe beneath a parking area
18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.
0.3' of composted media is included.
The facility treatment area is 580 sf with curbed, vertical sides.
A maximum ponding depth of 6" and a 12" of freeboard depth are assumed.
Facilities have a closed bottom and include an underdrain.
A total of 50 LF of 8" storm pipe is required to connect to the downstream main or structure for each Bioretention Planter.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the box.
Trench Box shoring is used.
Parking lot restoration is assumed for the outlet pipe and consists of 4" HMA/4" CSTC.
No concrete curb, gutter, and sidewalk removal or restoration will be required for the installation.
Restoration is required for the area of disturbance.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Jess Dexheimber (HDR)<br>Tatiana Skadorwa (HDR)<br>Cindy Kinzer (HDR) |
| **Description:** | WQBE_07G_Deep UIC Well with High Rate Filter on Property | | | **Version:** | 1 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Deep UIC Well (20 VF Depth) with High Rate Underground Filter (24 s.f. bottom area) on Property | 1 | EA | $ 101,297 | $ 101,297 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 101,297*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 15,195 |
| | | | | Street Use Permit (Y/N) N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 116,491*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 11,649 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 128,141*** |
| | | | | Construction Sales Tax | $ 13,134 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 141,300*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 15,377 |
| | | | | Construction Management | $ 10,251 |
| | | | | Permitting & Support | $ 641 |
| | s.f. Land Area | None | | Land Purchase/ROW Acquisition | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 6,407 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 32,676*** |
| | | | | Project Contingency | $ 26,096 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 58,800*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 200,100*** |

**Description: WQBE_07G_Deep UIC Well with High Rate Filter on Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 200,100** | |
| Capital cost | $ 200,100.00 | $/Unit |
| Total Direct O&M/Year | $ 1,495.73 | |
| Direct O&M cost | $ 1,495.73 | $/Unit |
| Capital Replacement Costs (10 Years) | $ - | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 250,000** | **$/unit** |
| **Annual O&M Cost** | **$ 2,400** | **$/year** |
| Annualized Cost | $1,360 | $/year |

| **Materials, Supplies, Other Costs** | | 2023 dollars | |
|---|---|---|---|
| Misc drainage parts | $ - | $ 383 | $/year |
| Annual costs (plant/mulch/media replacement, misc drainage parts) | $ - | $ 113 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |

| | | | |
|---|---|---|---|
| Subtotal | | $ 856 | |
| Labor | | | |
| Remove Trash, Inspect and Remove Roots, Remediate Holes and Breaks (UIC) | 3 | hr | |
| Plant Health (Filter) | 4 | hr | |
| Remediation of erosion | 4 | hr | |
| | 0 | hr | |
| **Total hours per year** | 11 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 598 | |
| Labor cost, burdened | O/H 150.0% | $ 1,496 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 40,725 | | $ 71,160 | **$311,984** | **$ 249,963** | | | |
| 0 | 1.000 | **$ 200,100** | | | $200,100 | $ 200,100 | $ 200,100 | $ 200,100 | $ 249,963 |
| 1 | 0.950 | $856 | $ - | $ 1,496 | $ 2,352 | $ 2,234 | $ 202,452 | $ 202,334 | $ 49,863 |
| 2 | 0.903 | $ 882 | $ - | $ 1,541 | $ 2,422 | $ 2,187 | $ 204,874 | $ 204,521 | $ 47,628 |
| 3 | 0.858 | $ 908 | $ - | $ 1,587 | $ 2,495 | $ 2,140 | $ 207,369 | $ 206,661 | $ 45,442 |
| 4 | 0.815 | $ 935 | $ - | $ 1,634 | $ 2,570 | $ 2,094 | $ 209,939 | $ 208,755 | $ 43,302 |
| 5 | 0.774 | $ 963 | $ - | $ 1,683 | $ 2,647 | $ 2,049 | $ 212,586 | $ 210,805 | $ 41,207 |
| 6 | 0.736 | $ 992 | $ - | $ 1,734 | $ 2,726 | $ 2,006 | $ 215,312 | $ 212,810 | $ 39,158 |
| 7 | 0.699 | $ 1,022 | $ - | $ 1,786 | $ 2,808 | $ 1,963 | $ 218,120 | $ 214,773 | $ 37,153 |
| 8 | 0.664 | $ 1,053 | $ - | $ 1,840 | $ 2,892 | $ 1,921 | $ 221,012 | $ 216,694 | $ 35,190 |
| 9 | 0.631 | $ 1,084 | $ - | $ 1,895 | $ 2,979 | $ 1,880 | $ 223,991 | $ 218,573 | $ 33,269 |
| 10 | 0.599 | $ 1,117 | $ - | $ 1,952 | $ 3,068 | $ 1,840 | $ 227,060 | $ 220,413 | $ 31,389 |
| 11 | 0.570 | $ 1,150 | $ - | $ 2,010 | $ 3,161 | $ 1,800 | $ 230,220 | $ 222,213 | $ 29,550 |
| 12 | 0.541 | $ 1,185 | $ - | $ 2,070 | $ 3,255 | $ 1,762 | $ 233,476 | $ 223,975 | $ 27,750 |
| 13 | 0.514 | $ 1,220 | $ - | $ 2,133 | $ 3,353 | $ 1,724 | $ 236,829 | $ 225,699 | $ 25,988 |
| 14 | 0.489 | $ 1,257 | $ - | $ 2,197 | $ 3,454 | $ 1,687 | $ 240,282 | $ 227,386 | $ 24,264 |
| 15 | 0.464 | $ 1,295 | $ - | $ 2,262 | $ 3,557 | $ 1,651 | $ 243,840 | $ 229,037 | $ 22,577 |
| 16 | 0.441 | $ 1,334 | $ - | $ 2,330 | $ 3,664 | $ 1,616 | $ 247,503 | $ 230,653 | $ 20,926 |
| 17 | 0.419 | $ 1,374 | $ - | $ 2,400 | $ 3,774 | $ 1,581 | $ 251,277 | $ 232,234 | $ 19,310 |
| 18 | 0.398 | $ 1,415 | $ - | $ 2,472 | $ 3,887 | $ 1,547 | $ 255,164 | $ 233,781 | $ 17,729 |
| 19 | 0.378 | $ 1,457 | $ - | $ 2,546 | $ 4,004 | $ 1,514 | $ 259,168 | $ 235,296 | $ 16,181 |
| 20 | 0.359 | $ 1,501 | $ - | $ 2,623 | $ 4,124 | $ 1,482 | $ 263,292 | $ 236,778 | $ 14,667 |
| 21 | 0.341 | $ 1,546 | $ - | $ 2,701 | $ 4,247 | $ 1,450 | $ 267,539 | $ 238,228 | $ 13,185 |
| 22 | 0.324 | $ 1,592 | $ - | $ 2,782 | $ 4,375 | $ 1,419 | $ 271,914 | $ 239,648 | $ 11,734 |
| 23 | 0.308 | $ 1,640 | $ - | $ 2,866 | $ 4,506 | $ 1,389 | $ 276,420 | $ 241,037 | $ 10,315 |
| 24 | 0.293 | $ 1,689 | $ - | $ 2,952 | $ 4,641 | $ 1,359 | $ 281,062 | $ 242,396 | $ 8,926 |
| 25 | 0.278 | $ 1,740 | $ - | $ 3,041 | $ 4,781 | $ 1,330 | $ 285,842 | $ 243,726 | $ 7,567 |
| 26 | 0.264 | $ 1,792 | $ - | $ 3,132 | $ 4,924 | $ 1,302 | $ 290,766 | $ 245,028 | $ 6,237 |
| 27 | 0.251 | $ 1,846 | $ - | $ 3,226 | $ 5,072 | $ 1,274 | $ 295,838 | $ 246,302 | $ 4,935 |
| 28 | 0.239 | $ 1,901 | $ - | $ 3,322 | $ 5,224 | $ 1,247 | $ 301,062 | $ 247,549 | $ 3,661 |
| 29 | 0.227 | $ 1,958 | $ - | $ 3,422 | $ 5,381 | $ 1,220 | $ 306,442 | $ 248,769 | $ 2,414 |
| 30 | 0.215 | $ 2,017 | $ - | $ 3,525 | $ 5,542 | $ 1,194 | $ 311,984 | $ 249,963 | $ 1,194 |

**Description: WQBE_07G_Deep UIC Well with High Rate Filter on Property**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions (UIC):**

Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two by hand (2 visits per year, 0.5 hour per visit). Combined w/vactor catch basin activity.
2 Total for equipment $360.
Inspection of vegetation and removal of roots that reduce free movement of water through pipes by a crew of
1 two by hand (2 visits per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) $113 per year.

**O&M Estimating Assumptions (Filter):**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. This task will be executed in the same hours as already set aside for UIC Well maintenance.
Twice a year the 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours. Assumed annual
4 cost of $113 for mulch.

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually
4 and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit).
Annual mulch and plant replacements 5 plants at $54/Plant

**Replacement Assumptions:**

No capital replacement assumed in 30-year life for UIC well or Filter

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County Water Quality Benefits Evaluation - WO12 | | | **Estimator:** | Jess Dexheimber (HDR)<br>Tatiana Skadorwa (HDR)<br>Cindy Kinzer (HDR) |
| **Description:** | King County, WA | | | **Version:** | 1 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Deep UIC Well - ROW (Urban Roadway)** | 20 | LF | $ - | $ - |
| 2 | **Well - Borehole Diameter** | 12 | IN | $ - | $ - |
| 3 | **Well - Casing Diameter** | 0.7 | FT | $ - | $ - |
| 4 | Drilling (12" Diameter Borehole) | 20 | VF | $ 135 | $ 2,700 |
| 5 | Well Casing (8-inch Diameter) | 3 | VF | $ 59 | $ 177 |
| 6 | Well Screen | 20 | VF | $ 353 | $ 7,060 |
| 7 | Maintenance Hole, Type 204A | 1 | EA | $ 6,780 | $ 6,780 |
| 8 | Misc Deep Well Costs | 1 | EA | $ 3,710 | $ 3,710 |
| 9 | | | | $ - | $ - |
| 10 | **Deep UIC Well Facility Removals and Restoration:** | | | $ - | $ - |
| 11 | Clearing and Grubbing | 69 | SY | $ 4 | $ 278 |
| 12 | Grass seeding and Restoration | 69 | SY | $ 10 | $ 683 |
| 13 | | | | $ - | $ - |
| 14 | **High Rate Underground Filter** | | | $ - | $ - |
| 15 | *High Rate Underground Filter Length* | *6* | *FT* | | $ - |
| 16 | *High Rate Underground Filter Width* | *4* | *FT* | $ - | $ - |
| 17 | Filterra Unit 4'X6' (complete) | 1 | EA | $ 22,165 | $ 22,165 |
| 18 | Structural Excavation to Waste (10'W X12'L X 5'D) + (50'LX5'WX6'D) | 78 | CY | $ 79 | $ 6,144 |
| 19 | Imported Structural Fill | 73 | CY | $ 44 | $ 3,227 |
| 20 | Crushed Base | 1 | CY | $ 64 | $ 64 |
| 21 | Inlet Drain w/Energy Dissipating Rocks | 1 | EA | $ 1,481 | $ 1,481 |
| 22 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 23 | Pipe 8" dia. | 50 | LF | $ 80 | $ 4,000 |
| 24 | Trench Box Shoring (Shallow) | 390 | SF | $ 10 | $ 3,900 |
| 25 | | | | $ - | $ - |
| 26 | **Restoration High Rate Underground Filter** | | | $ - | $ - |
| 27 | Landscaping, planting, and restoration | 10 | SY | $ 59 | $ 590 |
| 28 | Tree | 1 | EA | $ 720 | $ 720 |
| 29 | | | | | |
| 30 | | | | | $ - |
| 31 | **Additional Costs** | | | | $ - |
| 32 | Removals @ 4% Construction Costs | 4.0% | LS | $ 67,579 | $ 2,703 |
| 33 | Traffic Control (Heavy) | 1 | MO | $ 20,000 | $ 20,000 |
| 34 | TESC @2% Construction Costs | 2% | LS | $ 90,282 | $ 1,806 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 92,088 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 9,209 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 101,297 |
| ***Direct: Subtotal Construction Costs*** | | | ***$ 101,297*** |

**Description: WQBE_07G_Deep UIC Well with High Rate Filter on Property**

A Deep UIC Well is a well that extends below an upper confining layer and discharges into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Cost Estimating Assumptions:**

<u>General</u>
The excavated material is unsuitable for use as backfill.
Restoration is seeded grass with mulch
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
Installation is on property and does not require easements or acquisition
A street use permit is not required.

<u>Deep UIC Well</u>
Facility design is per 2019 Ecology Stormwater Management Manual.
Assumed depth of facility is 20 feet with a 12" diameter borehole.
All well backfill materials (gravel, bentonite clay, etc.) are assumed to be lumped in the "Misc. Deep Well Costs" bid item

<u>High Rate Underground Filter</u>
Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6"thick.
The facility treatment area is 24 sf (4'X6') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
An excavation width of 3 feet is assumed on each side of the precast box.
Facility is sited on the property.
A total of 50 LF of 8" storm pipe is required to connect to the deep UIC well.
Trench Box shoring is used.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.

**Planning Basis Assumptions:**
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A <u>**Low**</u> indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A <u>**15%**</u> Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**
This estimate is classified as a <u>**Class 10**</u> ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of <u>**-50% to +100%**</u>, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Meaghan McGinn (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_08A_Pervious Concrete Sidewalk_no sand layer | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Pervious Concrete Sidewalk - No Treatment Sand Layer (200 SF Area) | 200 | SF | $ 40 | $ 8,000 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 8,000*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 1,200 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 9,200*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 920 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 10,120*** |
| | | | | Construction Sales Tax | $ 1,037 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 11,200*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 1,214 |
| | | | | Construction Management | $ 810 |
| | | | | Permitting & Support | $ 51 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 506 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 2,581*** |
| | | | | Project Contingency | $ 2,067 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 4,600*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 15,800*** |

**Description: WQBE_08A - Pervious Concrete Sidewalk (no sand layer) (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 200 | ft2 |
| **Initial Capital Cost** | **$ 15,800** | |
| Capital cost | $ 79.00 | $/Unit |
| Total Direct O&M/Year | $ 1,631.70 | |
| Direct O&M cost | $ 8.16 | $/Unit |
| Capital Replacement Costs | $ 795 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

Replace 10% of total each year.

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 75,700** | **$/unit** |
| **Annual O&M Cost** | **$ 2,300** | **$/year** |
| Annualized Cost | $1,000 | $/year |

| **Materials, Supplies, Other Costs** | | 2023 Costs | |
|---|---|---|---|
| Miscellaneous Drainage Parts | $ - | $ 113 | $/year |
| Equipment Rental- Regenerative Air Sweeper | | $ 518 | $/year |
| | | $ - | $/year |
| Subtotal | | $ 631 | |
| Labor | | | |
| Removal of Soil, Mulch, or Sediment | 4 | hr | |
| Remediation of Cracks and Trip Hazards | 8 | hr | |
| Activity | 0 | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 12 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 653 | |
| Labor cost, burdened | O/H 150.0% | $ 1,632 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 30,020 | | $ 77,629 | **$147,290** | **$ 75,651** | | | |
| 0 | 1.000 | **$ 15,800** | | | $15,800 | $ 15,800 | $ 15,800 | $ 15,800 | $ 75,651 |
| 1 | 0.950 | $631 | $ 795 | $ 1,632 | $ 3,057 | $ 2,905 | $ 18,857 | $ 18,705 | $ 59,851 |
| 2 | 0.903 | $ 650 | $ 795 | $ 1,681 | $ 3,125 | $ 2,821 | $ 21,983 | $ 21,526 | $ 56,946 |
| 3 | 0.858 | $ 669 | $ 795 | $ 1,731 | $ 3,195 | $ 2,741 | $ 25,178 | $ 24,267 | $ 54,125 |
| 4 | 0.815 | $ 690 | $ 795 | $ 1,783 | $ 3,267 | $ 2,662 | $ 28,445 | $ 26,929 | $ 51,384 |
| 5 | 0.774 | $ 710 | $ 795 | $ 1,836 | $ 3,341 | $ 2,587 | $ 31,786 | $ 29,516 | $ 48,722 |
| 6 | 0.736 | $ 732 | $ 795 | $ 1,892 | $ 3,418 | $ 2,514 | $ 35,204 | $ 32,031 | $ 46,135 |
| 7 | 0.699 | $ 753 | $ 795 | $ 1,948 | $ 3,496 | $ 2,444 | $ 38,701 | $ 34,474 | $ 43,620 |
| 8 | 0.664 | $ 776 | $ 795 | $ 2,007 | $ 3,578 | $ 2,376 | $ 42,278 | $ 36,850 | $ 41,177 |
| 9 | 0.631 | $ 799 | $ 795 | $ 2,067 | $ 3,661 | $ 2,310 | $ 45,939 | $ 39,160 | $ 38,801 |
| 10 | 0.599 | $ 823 | $ 795 | $ 2,129 | $ 3,747 | $ 2,246 | $ 49,686 | $ 41,406 | $ 36,491 |
| 11 | 0.570 | $ 848 | $ 795 | $ 2,193 | $ 3,836 | $ 2,185 | $ 53,522 | $ 43,591 | $ 34,245 |
| 12 | 0.541 | $ 873 | $ 795 | $ 2,259 | $ 3,927 | $ 2,125 | $ 57,449 | $ 45,716 | $ 32,060 |
| 13 | 0.514 | $ 900 | $ 795 | $ 2,326 | $ 4,021 | $ 2,067 | $ 61,470 | $ 47,784 | $ 29,935 |
| 14 | 0.489 | $ 927 | $ 795 | $ 2,396 | $ 4,118 | $ 2,012 | $ 65,587 | $ 49,795 | $ 27,867 |
| 15 | 0.464 | $ 954 | $ 795 | $ 2,468 | $ 4,217 | $ 1,957 | $ 69,804 | $ 51,753 | $ 25,856 |
| 16 | 0.441 | $ 983 | $ 795 | $ 2,542 | $ 4,320 | $ 1,905 | $ 74,124 | $ 53,658 | $ 23,898 |
| 17 | 0.419 | $ 1,013 | $ 795 | $ 2,618 | $ 4,426 | $ 1,854 | $ 78,550 | $ 55,512 | $ 21,993 |
| 18 | 0.398 | $ 1,043 | $ 795 | $ 2,697 | $ 4,535 | $ 1,805 | $ 83,084 | $ 57,317 | $ 20,139 |
| 19 | 0.378 | $ 1,074 | $ 795 | $ 2,778 | $ 4,647 | $ 1,758 | $ 87,731 | $ 59,075 | $ 18,334 |
| 20 | 0.359 | $ 1,106 | $ 795 | $ 2,861 | $ 4,762 | $ 1,712 | $ 92,494 | $ 60,787 | $ 16,576 |
| 21 | 0.341 | $ 1,140 | $ 795 | $ 2,947 | $ 4,881 | $ 1,667 | $ 97,375 | $ 62,453 | $ 14,864 |
| 22 | 0.324 | $ 1,174 | $ 795 | $ 3,035 | $ 5,004 | $ 1,623 | $ 102,379 | $ 64,077 | $ 13,198 |
| 23 | 0.308 | $ 1,209 | $ 795 | $ 3,127 | $ 5,130 | $ 1,581 | $ 107,509 | $ 65,658 | $ 11,574 |
| 24 | 0.293 | $ 1,245 | $ 795 | $ 3,220 | $ 5,260 | $ 1,541 | $ 112,770 | $ 67,199 | $ 9,993 |
| 25 | 0.278 | $ 1,283 | $ 795 | $ 3,317 | $ 5,394 | $ 1,501 | $ 118,164 | $ 68,700 | $ 8,452 |
| 26 | 0.264 | $ 1,321 | $ 795 | $ 3,416 | $ 5,532 | $ 1,463 | $ 123,696 | $ 70,162 | $ 6,951 |
| 27 | 0.251 | $ 1,361 | $ 795 | $ 3,519 | $ 5,674 | $ 1,425 | $ 129,371 | $ 71,588 | $ 5,489 |
| 28 | 0.239 | $ 1,402 | $ 795 | $ 3,624 | $ 5,821 | $ 1,389 | $ 135,191 | $ 72,977 | $ 4,063 |
| 29 | 0.227 | $ 1,444 | $ 795 | $ 3,733 | $ 5,972 | $ 1,354 | $ 141,163 | $ 74,331 | $ 2,674 |
| 30 | 0.215 | $ 1,487 | $ 795 | $ 3,845 | $ 6,127 | $ 1,320 | $ 147,290 | $ 75,651 | $ 1,320 |

**Description: WQBE_08A - Pervious Concrete Sidewalk (no sand layer)**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

4 Removal of soil, mulch or sediment on paving twice a year with a crew of two using a regenerative air sweeper at 1 hour per visit (4 hours per year total). Air sweeper rental costs at $518 annual total.

8 Remediation of small cracks, trip hazards, or small areas of concrete spalling and raveling by filling with patching mixes annually with a crew of 2 at 4 hours per visit. Assumed $113 annually for cement patching mix.

**Replacement Assumptions:**

Remediation of major cracks, trip hazards, or large areas of concrete spalling and raveling by cutting and replacing. Assume annual replacement of 10% of the total pavement area (20 square feet). Work would include sawcutting pavement, and excavating out and replacing the pavement and subbase. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Meaghan McGinn (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_08A_Pervious Concrete Sidewalk_no sand layer | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Pervious Concrete Sidewalk (no sand layer)** | **200** | **SF** | $ - | $ - |
| 2 | Excavation Incl. Haul (to waste) | 9 | CY | $ 79 | $ 683 |
| 3 | Pervious Concrete Sidewalk - 5" Thick | 22 | SY | $ 267 | $ 5,933 |
| 4 | Permeable Ballast Base Course, incl. haul - 3" Thick | 2 | CY | $ 105 | $ 194 |
| 5 | | | | | $ - |
| 6 | **Additional Costs** | | | | $ - |
| 7 | Removals @ 4% Construction Costs | 4.0% | LS | $ 6,810 | $ 272 |
| 8 | TESC @ 2% Construction Costs | 2% | LS | $ 7,083 | $ 142 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 7,225 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 722 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 7,947 |
| | | | | ***Direct: Subtotal Construction Costs (200 SF Area)*** | ***$ 7,947*** |

**Description: WQBE_08A - Pervious Concrete Sidewalk (no sand layer)**
Pervious concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material intended to allow passage of water through pavement.

**Cost Assumptions**
Permeable Pavement installation is per the King Co. SW Design Manual Appendix C, Section C.2.7.

It is assumed that the soils and drainage conditions are suitable for permeable pavement installation.

It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

The permeable pavement section consists of 5-inches of porous concrete pavement and 3-inches of aggregate subbase. It is assumed to be non-PGIS and no treatment sand layer is provided.

The installation is assumed to be for residential and commercial installations and are not located within a vehicular traffic area.
The facility is 200 s.f. with a 1:1 Length:Width ratio.

It was assumed that there is less than 3-inches of grade loss across the facility, and that check dams - per Seattle SW Manual would not be required.
Concrete curb and gutter removal and restoration is not required for the installation.
Landscape restoration is not included
Removals are estimated at 4% of the item construction costs, in conformance with LTCP.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and traffic control will not be required.
The facility is located outside of the ROW and a street use permit is not required.

**Planning Basis Assumptions:**
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**
This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Meaghan McGinn (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_08B_Porous Asphalt Driveway (with sand layer) | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Porous Asphalt Driveway with Treatment Sand Layer (200 SF) | 200 | SF | $ 21 | $ 4,200 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 4,200*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 630 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 4,830*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 483 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 5,313*** |
| | | | | Construction Sales Tax | $ 545 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 5,900*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 638 |
| | | | | Construction Management | $ 425 |
| | | | | Permitting & Support | $ 27 |
| | s.f. Land Area | None | | Land Purchase/ROW Acquisition | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 266 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,355*** |
| | | | | Project Contingency | $ 1,088 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 2,400*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 8,300*** |

**Description: WQBE_08B - Porous Asphalt Driveway (with sand layer) (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 200 | ft2 |
| **Initial Capital Cost** | **$ 8,300** | |
| Capital cost | $ 41.50 | $/Unit |
| Total Direct O&M/Year | $ 1,631.70 | |
| Direct O&M cost | $ 8.16 | $/Unit |
| Capital Replacement Costs | $ 423 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

Replace 10% of total each year.

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 63,800** | **$/unit** |
| **Annual O&M Cost** | **$ 2,300** | **$/year** |
| Annualized Cost | $1,090 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| Miscellaneous Drainage Parts | $ - | $ 169 | $/year |
| Equipment Rental- Regenerative Air Sweeper | | $ 518 | |
| | | $ - | $/year |
| Subtotal | | $ 687 | |

Labor

| | | | |
|---|---|---|---|
| Removal of Soil, Mulch, or Sediment | 4 | hr | |
| Remediation of Cracks and Trip Hazards | 8 | hr | |
| Activity | 0 | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 12 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 653 | |
| Labor cost, burdened | O/H 150.0% | $ 1,632 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 32,684 | | $ 77,629 | **$131,314** | **$ 63,789** | | | |
| 0 | 1.000 | **$ 8,300** | | | $8,300 | $ 8,300 | $ 8,300 | $ 8,300 | $ 63,789 |
| 1 | 0.950 | $687 | $ 423 | $ 1,632 | $ 2,742 | $ 2,605 | $ 11,042 | $ 10,905 | $ 55,489 |
| 2 | 0.903 | $ 708 | $ 423 | $ 1,681 | $ 2,812 | $ 2,538 | $ 13,854 | $ 13,443 | $ 52,884 |
| 3 | 0.858 | $ 729 | $ 423 | $ 1,731 | $ 2,883 | $ 2,473 | $ 16,737 | $ 15,916 | $ 50,346 |
| 4 | 0.815 | $ 751 | $ 423 | $ 1,783 | $ 2,957 | $ 2,410 | $ 19,694 | $ 18,326 | $ 47,873 |
| 5 | 0.774 | $ 773 | $ 423 | $ 1,836 | $ 3,033 | $ 2,348 | $ 22,727 | $ 20,675 | $ 45,463 |
| 6 | 0.736 | $ 796 | $ 423 | $ 1,892 | $ 3,111 | $ 2,289 | $ 25,839 | $ 22,963 | $ 43,115 |
| 7 | 0.699 | $ 820 | $ 423 | $ 1,948 | $ 3,192 | $ 2,231 | $ 29,031 | $ 25,195 | $ 40,826 |
| 8 | 0.664 | $ 845 | $ 423 | $ 2,007 | $ 3,275 | $ 2,175 | $ 32,306 | $ 27,369 | $ 38,595 |
| 9 | 0.631 | $ 870 | $ 423 | $ 2,067 | $ 3,361 | $ 2,120 | $ 35,666 | $ 29,490 | $ 36,420 |
| 10 | 0.599 | $ 896 | $ 423 | $ 2,129 | $ 3,449 | $ 2,067 | $ 39,115 | $ 31,557 | $ 34,299 |
| 11 | 0.570 | $ 923 | $ 423 | $ 2,193 | $ 3,540 | $ 2,016 | $ 42,655 | $ 33,573 | $ 32,232 |
| 12 | 0.541 | $ 951 | $ 423 | $ 2,259 | $ 3,633 | $ 1,966 | $ 46,288 | $ 35,539 | $ 30,216 |
| 13 | 0.514 | $ 979 | $ 423 | $ 2,326 | $ 3,729 | $ 1,918 | $ 50,017 | $ 37,457 | $ 28,250 |
| 14 | 0.489 | $ 1,009 | $ 423 | $ 2,396 | $ 3,828 | $ 1,870 | $ 53,845 | $ 39,327 | $ 26,332 |
| 15 | 0.464 | $ 1,039 | $ 423 | $ 2,468 | $ 3,931 | $ 1,824 | $ 57,776 | $ 41,152 | $ 24,462 |
| 16 | 0.441 | $ 1,070 | $ 423 | $ 2,542 | $ 4,036 | $ 1,780 | $ 61,812 | $ 42,932 | $ 22,638 |
| 17 | 0.419 | $ 1,102 | $ 423 | $ 2,618 | $ 4,144 | $ 1,736 | $ 65,956 | $ 44,668 | $ 20,858 |
| 18 | 0.398 | $ 1,136 | $ 423 | $ 2,697 | $ 4,256 | $ 1,694 | $ 70,212 | $ 46,362 | $ 19,121 |
| 19 | 0.378 | $ 1,170 | $ 423 | $ 2,778 | $ 4,371 | $ 1,653 | $ 74,583 | $ 48,016 | $ 17,427 |
| 20 | 0.359 | $ 1,205 | $ 423 | $ 2,861 | $ 4,489 | $ 1,613 | $ 79,072 | $ 49,629 | $ 15,774 |
| 21 | 0.341 | $ 1,241 | $ 423 | $ 2,947 | $ 4,611 | $ 1,575 | $ 83,683 | $ 51,203 | $ 14,160 |
| 22 | 0.324 | $ 1,278 | $ 423 | $ 3,035 | $ 4,737 | $ 1,537 | $ 88,420 | $ 52,740 | $ 12,586 |
| 23 | 0.308 | $ 1,316 | $ 423 | $ 3,127 | $ 4,866 | $ 1,500 | $ 93,286 | $ 54,240 | $ 11,049 |
| 24 | 0.293 | $ 1,356 | $ 423 | $ 3,220 | $ 5,000 | $ 1,464 | $ 98,286 | $ 55,704 | $ 9,549 |
| 25 | 0.278 | $ 1,397 | $ 423 | $ 3,317 | $ 5,137 | $ 1,429 | $ 103,422 | $ 57,134 | $ 8,085 |
| 26 | 0.264 | $ 1,438 | $ 423 | $ 3,416 | $ 5,278 | $ 1,395 | $ 108,701 | $ 58,529 | $ 6,656 |
| 27 | 0.251 | $ 1,482 | $ 423 | $ 3,519 | $ 5,424 | $ 1,362 | $ 114,125 | $ 59,892 | $ 5,260 |
| 28 | 0.239 | $ 1,526 | $ 423 | $ 3,624 | $ 5,574 | $ 1,330 | $ 119,698 | $ 61,222 | $ 3,898 |
| 29 | 0.227 | $ 1,572 | $ 423 | $ 3,733 | $ 5,728 | $ 1,299 | $ 125,427 | $ 62,521 | $ 2,567 |
| 30 | 0.215 | $ 1,619 | $ 423 | $ 3,845 | $ 5,888 | $ 1,268 | $ 131,314 | $ 63,789 | $ 1,268 |

**Description: WQBE_08B - Porous Asphalt Driveway (with sand layer)**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

4 Removal of soil, mulch or sediment on paving twice a year with a crew of two using a regenerative air sweeper at 1 hour per visit (4 hours per year total). Air sweeper rental costs at $518 annual total.

8 Remediation of small cracks, trip hazards, or small areas of concrete spalling and raveling by filling with patching mixes. In this case, with pavers, it was assumed small repairs such as cracked pavers and minor localized settling and high spots would be repaired annually with a crew of 2 at 4 hours per visit. Assumed $113 annually for replacement pavers and $56 for sand leveling course; at this level of repair, the base course was assumed to not need repairs.

**Replacement Assumptions:**

Remediation of major cracks, trip hazards, or large areas of concrete spalling and raveling by cutting and replacing. Assume annual replacement of 10% of the total pavement area (20 square feet). Work would include sawcutting pavement, and excavating out and replacing the pavement and subbase. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Meaghan McGinn (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_08B_Porous Asphalt Driveway (with sand layer) | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| | **Porous Asphalt Driveway (with sand layer) - On Property** | **200** | **SF** | $ - | $ - |
| | Roadway Excavation Incl. Haul (to waste) | 9 | CY | $ 79 | $ 683 |
| | Permeable Pavement HMA Cl. 1/2" PG 70-22ER - 5" Thick (small quantity) | 5.7 | TN | $ 360 | $ 2,040 |
| | Permeable Ballast Base Course, incl. haul - 3" Thick | 2 | CY | $ 105 | $ 194 |
| | Sand (Water Quality Treatment Course) - 6" Thick | 4 | CY | $ 168 | $ 622 |
| | Geotextile | 22 | SY | $ 4 | $ 89 |
| | | | | | $ - |
| | **Additional Costs** | | | | $ - |
| | | | | $ - | $ - |
| | Removals @ 4% Construction Costs | 4.0% | LS | $ 3,628 | $ 145 |
| | TESC @ 2% Construction Costs | 2% | LS | $ 3,773 | $ 75 |
| | | | | | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | | | $ 3,849 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| General Conditions | | | 0% | 1 | $ - |
| Mobilization/Demobilization | | | 10% | 1.1 | $ 385 |
| Overhead & Profit (OHP) | | | 0% | 1 | $ - |
| Insurance | | | 0.0% | 1 | $ - |
| Bonding | | | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | | | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | | | $ 4,234 |
| ***Direct: Subtotal Construction Costs (200 SF Area)*** | | | | | ***$ 4,234*** |

**Description: WQBE_08B - Porous Asphalt Driveway (with sand layer)**

Pervious concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material intended to allow passage of water through pavement.

**Cost Assumptions**

Permeable Pavement installation is per the King Co. SW Design Manual Appendix C, Section C.2.7.

It is assumed that the soils and drainage conditions are suitable for permeable pavement installation.
It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

The permeable pavement section consists of 5-inches of permeable asphalt pavement, 3-inches of aggregate subbase, 6-inches of sand (treatment course), and a subgrade geotextile.

Permeable Pavement is Porous Hot Mix Asphalt Cl. 1/2 PG 70-22 ER
The installation is assume to be for residential and commercial installation and does not include industrial or heavily trafficked areas.
The facility is 200 s.f. with a 1:1 Length:Width ratio.

It was assumed that there is less than 3-inches of grade loss across the facility, and that check dams (per Seattle SW Manual) would not be required.
Dewatering is not required.
Concrete curb, gutter, and sidewalk removal and restoration is not required for the installation.
Landscape restoration is not included
Removals are estimated at 4% of the item construction costs, in conformance with LTCP.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and traffic control will not be required.
The facility is located outside of the ROW and a street use permit is not required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%: Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Meaghan McGinn (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_08C_Permeable Paver Driveway (with sand layer) | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Permeable Paver Driveway with sand layer (200 SF Area) | 200 | SF | $ 28 | $ 5,600 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 5,600*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 840 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 6,440*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 644 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 7,084*** |
| | | | | Construction Sales Tax | $ 726 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 7,800*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 850 |
| | | | | Construction Management | $ 567 |
| | | | | Permitting & Support | $ 35 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 354 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,806*** |
| | | | | Project Contingency | $ 1,441 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 3,200*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 11,000*** |

**Description: WQBE_08C - Permeable Paver Driveway (with sand layer) (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 200 | ft2 |
| **Initial Capital Cost** | **$ 11,000** | |
| Capital cost | $ 55.00 | $/Unit |
| Total Direct O&M/Year | $ 1,631.70 | |
| Direct O&M cost | $ 8.16 | $/Unit |
| Capital Replacement Costs | $ 554 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

Replace 10% of total each year.

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 68,400** | **$/unit** |
| **Annual O&M Cost** | **$ 2,300** | **$/year** |
| Annualized Cost | $1,090 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| Miscellaneous Drainage Parts | $ - | $ 169 | $/year |
| Equipment Rental- Regenerative Air Sweeper | | $ 518 | |
| | | $ - | $/year |
| Subtotal | | $ 687 | |

Labor

| | | | |
|---|---|---|---|
| Removal of soil, mulch and sediment | 4 | hr | |
| Remediate small cracks and trip hazards | 8 | hr | |
| Activity | 0 | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 12 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 653 | |
| Labor cost, burdened | O/H 150.0% | $ 1,632 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 32,684 | | $ 77,629 | **$137,948** | **$ 68,449** | | | |
| 0 | 1.000 | **$ 11,000** | | | $11,000 | $ 11,000 | $ 11,000 | $ 11,000 | $ 68,449 |
| 1 | 0.950 | $687 | $ 554 | $ 1,632 | $ 2,873 | $ 2,730 | $ 13,873 | $ 13,730 | $ 57,449 |
| 2 | 0.903 | $ 708 | $ 554 | $ 1,681 | $ 2,943 | $ 2,656 | $ 16,816 | $ 16,386 | $ 54,719 |
| 3 | 0.858 | $ 729 | $ 554 | $ 1,731 | $ 3,014 | $ 2,585 | $ 19,830 | $ 18,972 | $ 52,062 |
| 4 | 0.815 | $ 751 | $ 554 | $ 1,783 | $ 3,088 | $ 2,517 | $ 22,919 | $ 21,488 | $ 49,477 |
| 5 | 0.774 | $ 773 | $ 554 | $ 1,836 | $ 3,164 | $ 2,450 | $ 26,083 | $ 23,938 | $ 46,960 |
| 6 | 0.736 | $ 796 | $ 554 | $ 1,892 | $ 3,242 | $ 2,385 | $ 29,325 | $ 26,324 | $ 44,510 |
| 7 | 0.699 | $ 820 | $ 554 | $ 1,948 | $ 3,323 | $ 2,323 | $ 32,648 | $ 28,646 | $ 42,125 |
| 8 | 0.664 | $ 845 | $ 554 | $ 2,007 | $ 3,406 | $ 2,262 | $ 36,055 | $ 30,908 | $ 39,802 |
| 9 | 0.631 | $ 870 | $ 554 | $ 2,067 | $ 3,492 | $ 2,203 | $ 39,546 | $ 33,111 | $ 37,540 |
| 10 | 0.599 | $ 896 | $ 554 | $ 2,129 | $ 3,580 | $ 2,146 | $ 43,126 | $ 35,258 | $ 35,337 |
| 11 | 0.570 | $ 923 | $ 554 | $ 2,193 | $ 3,671 | $ 2,091 | $ 46,797 | $ 37,348 | $ 33,191 |
| 12 | 0.541 | $ 951 | $ 554 | $ 2,259 | $ 3,764 | $ 2,037 | $ 50,561 | $ 39,385 | $ 31,100 |
| 13 | 0.514 | $ 979 | $ 554 | $ 2,326 | $ 3,860 | $ 1,985 | $ 54,421 | $ 41,370 | $ 29,063 |
| 14 | 0.489 | $ 1,009 | $ 554 | $ 2,396 | $ 3,960 | $ 1,934 | $ 58,381 | $ 43,305 | $ 27,078 |
| 15 | 0.464 | $ 1,039 | $ 554 | $ 2,468 | $ 4,062 | $ 1,885 | $ 62,443 | $ 45,190 | $ 25,144 |
| 16 | 0.441 | $ 1,070 | $ 554 | $ 2,542 | $ 4,167 | $ 1,838 | $ 66,610 | $ 47,028 | $ 23,259 |
| 17 | 0.419 | $ 1,102 | $ 554 | $ 2,618 | $ 4,275 | $ 1,791 | $ 70,885 | $ 48,819 | $ 21,421 |
| 18 | 0.398 | $ 1,136 | $ 554 | $ 2,697 | $ 4,387 | $ 1,746 | $ 75,272 | $ 50,565 | $ 19,630 |
| 19 | 0.378 | $ 1,170 | $ 554 | $ 2,778 | $ 4,502 | $ 1,703 | $ 79,774 | $ 52,268 | $ 17,883 |
| 20 | 0.359 | $ 1,205 | $ 554 | $ 2,861 | $ 4,620 | $ 1,660 | $ 84,394 | $ 53,929 | $ 16,180 |
| 21 | 0.341 | $ 1,241 | $ 554 | $ 2,947 | $ 4,742 | $ 1,619 | $ 89,136 | $ 55,548 | $ 14,520 |
| 22 | 0.324 | $ 1,278 | $ 554 | $ 3,035 | $ 4,868 | $ 1,579 | $ 94,004 | $ 57,127 | $ 12,900 |
| 23 | 0.308 | $ 1,316 | $ 554 | $ 3,127 | $ 4,997 | $ 1,540 | $ 99,002 | $ 58,668 | $ 11,321 |
| 24 | 0.293 | $ 1,356 | $ 554 | $ 3,220 | $ 5,131 | $ 1,503 | $ 104,132 | $ 60,170 | $ 9,781 |
| 25 | 0.278 | $ 1,397 | $ 554 | $ 3,317 | $ 5,268 | $ 1,466 | $ 109,400 | $ 61,636 | $ 8,278 |
| 26 | 0.264 | $ 1,438 | $ 554 | $ 3,416 | $ 5,409 | $ 1,430 | $ 114,810 | $ 63,066 | $ 6,812 |
| 27 | 0.251 | $ 1,482 | $ 554 | $ 3,519 | $ 5,555 | $ 1,395 | $ 120,364 | $ 64,462 | $ 5,382 |
| 28 | 0.239 | $ 1,526 | $ 554 | $ 3,624 | $ 5,705 | $ 1,362 | $ 126,069 | $ 65,823 | $ 3,987 |
| 29 | 0.227 | $ 1,572 | $ 554 | $ 3,733 | $ 5,860 | $ 1,329 | $ 131,929 | $ 67,152 | $ 2,625 |
| 30 | 0.215 | $ 1,619 | $ 554 | $ 3,845 | $ 6,019 | $ 1,297 | $ 137,948 | $ 68,449 | $ 1,297 |

**Description: WQBE_08C - Permeable Paver Driveway (with sand layer)**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

4 Removal of soil, mulch or sediment on paving twice a year with a crew of two using a regenerative air sweeper at 1 hour per visit (4 hours per year total). Air sweeper rental costs at $518 annual total.

8 Remediation of small cracks, trip hazards, or small areas of concrete spalling and raveling by filling with patching mixes annually with a crew of 2 at 4 hours per visit. Assumed $113 annually for replacement cement patching mix and $56 for sand leveling course.

**Replacement Assumptions:**

Full replacement of 10% of the pavers every year.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Meaghan McGinn (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_08C_Permeable Paver Driveway (with sand layer) | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Permeable Paver Driveway (with sand layer)** | **200** | **SF** | $ - | $ - |
| 2 | Driveway Excavation Incl. Haul (to waste) | 9 | CY | $ 79 | $ 683 |
| 3 | Permeable Concrete Paver 8" Thick | 200 | SF | $ 16 | $ 3,200 |
| 4 | Sand (Leveling Course) - 1" Thick | 1 | CY | $ 85 | $ 52 |
| 5 | Permeable Ballast Base Course, incl. haul - 3" Thick | 2 | CY | $ 105 | $ 194 |
| 6 | Sand (Water Quality Treatment Course) - 6" Thick | 4 | CY | $ 168 | $ 622 |
| 7 | | | | | $ - |
| 8 | **Additional Costs** | | | | $ - |
| 9 | Removals @ 4% Construction Costs | 4.0% | LS | $ 4,752 | $ 190 |
| 10 | TESC @ 2% Construction Costs | 2% | LS | $ 4,942 | $ 99 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 5,041 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 504 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 5,545 |
| | | | | ***Direct: Subtotal Construction Costs (200 SF Area)*** | ***$ 5,545*** |

**Description: WQBE_08C - Permeable Paver Driveway (with sand layer)**

Pervious concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material intended to allow passage of water through pavement.

**Cost Assumptions**

Permeable Pavement installation is per the King Co. SW Design Manual Appendix C, Section C.2.7.

It is assumed that the soils and drainage conditions are suitable for permeable paver installation.
It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

The permeable pavement section consists of 8-inches pavers with 0.1' of leveling and filler sand, 3-inches of aggregate subbase, 6-inches of sand.
Permeable Concrete Pavers 8-inch thick and standard widths are used.
The installation is assume to be for residential and commercial installation and does not include industrial or heavily trafficked areas.
The permeable paver area is 200 s.f. with a 1:1 Length:Width ratio.
It is assumed that there is less than 3-inches of grade loss across the facility, and that check dams - per Seattle SW Manual is not required.
Concrete curb, gutter, and sidewalk removal and restoration is not required for the installation.
Landscape restoration is not included
Removals are estimated at 4% of the item construction costs, in conformance with LTCP.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and traffic control will not be required.
The facility is located outside of the ROW and a street use permit is not required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Meaghan McGinn (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_08D_Permeable Paver Plaza (no sand layer) | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Permeable Paver Plaza no sand layer - 8-inch thick (200 SF Area) | 200 | SF | $ 24 | $ 4,800 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 4,800*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 720 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 5,520*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 552 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 6,072*** |
| | | | | Construction Sales Tax | $ 622 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 6,700*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 729 |
| | | | | Construction Management | $ 486 |
| | | | | Permitting & Support | $ 30 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 304 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,548*** |
| | | | | Project Contingency | $ 1,237 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 2,800*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 9,500*** |

**Description: WQBE_08D_Permeable Paver Plaza (no sand layer) (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 200 | ft2 |
| **Initial Capital Cost** | **$ 9,500** | |
| Capital cost | $ 47.50 | $/Unit |
| Total Direct O&M/Year | $ 1,631.70 | |
| Direct O&M cost | $ 8.16 | $/Unit |
| Capital Replacement Costs | $ 488 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

Replace 10% of total each year.

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 64,800** | **$/unit** |
| **Annual O&M Cost** | **$ 2,300** | **$/year** |
| Annualized Cost | $1,000 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| Miscellaneous Drainage Parts | $ - | $ 113 | $/year |
| Equipment Rental- Regenerative Air Sweeper | | $ 518 | |
| | | $ - | $/year |
| Subtotal | | $ 631 | |

Labor

| | | | |
|---|---|---|---|
| Removal of Soil, Mulch, or Sediment | 4 | hr | |
| Remediation of Cracks and Trip Hazards | 8 | hr | |
| Remediation of erosion | 0 | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 12 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 653 | |
| Labor cost, burdened | O/H 150.0% | $ 1,632 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 30,020 | | $ 77,629 | **$131,785** | **$ 64,766** | | | |
| 0 | 1.000 | **$ 9,500** | | | $9,500 | $ 9,500 | $ 9,500 | $ 9,500 | $ 64,766 |
| 1 | 0.950 | $631 | $ 488 | $ 1,632 | $ 2,751 | $ 2,613 | $ 12,251 | $ 12,113 | $ 55,266 |
| 2 | 0.903 | $ 650 | $ 488 | $ 1,681 | $ 2,818 | $ 2,544 | $ 15,069 | $ 14,658 | $ 52,652 |
| 3 | 0.858 | $ 669 | $ 488 | $ 1,731 | $ 2,888 | $ 2,477 | $ 17,957 | $ 17,135 | $ 50,108 |
| 4 | 0.815 | $ 690 | $ 488 | $ 1,783 | $ 2,960 | $ 2,412 | $ 20,918 | $ 19,547 | $ 47,631 |
| 5 | 0.774 | $ 710 | $ 488 | $ 1,836 | $ 3,035 | $ 2,350 | $ 23,952 | $ 21,897 | $ 45,218 |
| 6 | 0.736 | $ 732 | $ 488 | $ 1,892 | $ 3,111 | $ 2,289 | $ 27,063 | $ 24,185 | $ 42,869 |
| 7 | 0.699 | $ 753 | $ 488 | $ 1,948 | $ 3,190 | $ 2,229 | $ 30,253 | $ 26,415 | $ 40,580 |
| 8 | 0.664 | $ 776 | $ 488 | $ 2,007 | $ 3,271 | $ 2,172 | $ 33,524 | $ 28,587 | $ 38,351 |
| 9 | 0.631 | $ 799 | $ 488 | $ 2,067 | $ 3,354 | $ 2,116 | $ 36,878 | $ 30,703 | $ 36,179 |
| 10 | 0.599 | $ 823 | $ 488 | $ 2,129 | $ 3,440 | $ 2,062 | $ 40,318 | $ 32,766 | $ 34,062 |
| 11 | 0.570 | $ 848 | $ 488 | $ 2,193 | $ 3,529 | $ 2,010 | $ 43,847 | $ 34,775 | $ 32,000 |
| 12 | 0.541 | $ 873 | $ 488 | $ 2,259 | $ 3,620 | $ 1,959 | $ 47,467 | $ 36,735 | $ 29,990 |
| 13 | 0.514 | $ 900 | $ 488 | $ 2,326 | $ 3,714 | $ 1,910 | $ 51,181 | $ 38,644 | $ 28,031 |
| 14 | 0.489 | $ 927 | $ 488 | $ 2,396 | $ 3,811 | $ 1,862 | $ 54,991 | $ 40,506 | $ 26,121 |
| 15 | 0.464 | $ 954 | $ 488 | $ 2,468 | $ 3,910 | $ 1,815 | $ 58,902 | $ 42,321 | $ 24,260 |
| 16 | 0.441 | $ 983 | $ 488 | $ 2,542 | $ 4,013 | $ 1,770 | $ 62,915 | $ 44,091 | $ 22,445 |
| 17 | 0.419 | $ 1,013 | $ 488 | $ 2,618 | $ 4,119 | $ 1,726 | $ 67,034 | $ 45,816 | $ 20,675 |
| 18 | 0.398 | $ 1,043 | $ 488 | $ 2,697 | $ 4,228 | $ 1,683 | $ 71,261 | $ 47,500 | $ 18,949 |
| 19 | 0.378 | $ 1,074 | $ 488 | $ 2,778 | $ 4,340 | $ 1,642 | $ 75,601 | $ 49,141 | $ 17,266 |
| 20 | 0.359 | $ 1,106 | $ 488 | $ 2,861 | $ 4,456 | $ 1,601 | $ 80,057 | $ 50,742 | $ 15,624 |
| 21 | 0.341 | $ 1,140 | $ 488 | $ 2,947 | $ 4,575 | $ 1,562 | $ 84,631 | $ 52,304 | $ 14,023 |
| 22 | 0.324 | $ 1,174 | $ 488 | $ 3,035 | $ 4,697 | $ 1,524 | $ 89,328 | $ 53,828 | $ 12,461 |
| 23 | 0.308 | $ 1,209 | $ 488 | $ 3,127 | $ 4,823 | $ 1,487 | $ 94,152 | $ 55,315 | $ 10,937 |
| 24 | 0.293 | $ 1,245 | $ 488 | $ 3,220 | $ 4,953 | $ 1,451 | $ 99,105 | $ 56,766 | $ 9,451 |
| 25 | 0.278 | $ 1,283 | $ 488 | $ 3,317 | $ 5,087 | $ 1,416 | $ 104,193 | $ 58,181 | $ 8,000 |
| 26 | 0.264 | $ 1,321 | $ 488 | $ 3,416 | $ 5,225 | $ 1,381 | $ 109,418 | $ 59,563 | $ 6,584 |
| 27 | 0.251 | $ 1,361 | $ 488 | $ 3,519 | $ 5,368 | $ 1,348 | $ 114,786 | $ 60,911 | $ 5,203 |
| 28 | 0.239 | $ 1,402 | $ 488 | $ 3,624 | $ 5,514 | $ 1,316 | $ 120,300 | $ 62,227 | $ 3,854 |
| 29 | 0.227 | $ 1,444 | $ 488 | $ 3,733 | $ 5,665 | $ 1,285 | $ 125,965 | $ 63,512 | $ 2,538 |
| 30 | 0.215 | $ 1,487 | $ 488 | $ 3,845 | $ 5,820 | $ 1,254 | $ 131,785 | $ 64,766 | $ 1,254 |

**Description: WQBE_08D_Permeable Paver Plaza (no sand layer)**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

4 Removal of soil, mulch or sediment on paving twice a year with a crew of two using a regenerative air sweeper at 1 hour per visit (4 hours per year total). Air sweeper rental costs at $518 annual total.

8 Remediation of small cracks, trip hazards, or small areas of concrete spalling and raveling by filling with patching mixes annually with a crew of 2 at 4 hours per visit. Assumed $113 annually for cement patching mix.

**Replacement Assumptions:**

Full replacement of 10% of the pavers every year.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Meaghan McGinn (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_08D_Permeable Paver Plaza (no sand layer) | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Permeable Paver Plaza (no sand layer)** | **200** | **SF** | $ - | $ - |
| 2 | Driveway Excavation Incl. Haul (to waste) | 9 | CY | $ 79 | $ 683 |
| 3 | Permeable Concrete Paver 8" Thick | 200 | SF | $ 16 | $ 3,200 |
| 4 | Sand (Seating & Leveling Course) - 1" Thick | 1 | CY | $ 168 | $ 104 |
| 5 | Permeable Ballast Base Course, incl. haul - 3" Thick | 2 | CY | $ 105 | $ 194 |
| 6 | | | | | $ - |
| 7 | **Additional Costs** | | | | $ - |
| 8 | Removals @ 4% Construction Costs | 4.0% | LS | $ 4,181 | $ 167 |
| 9 | TESC @ 2% Construction Costs | 2% | LS | $ 4,348 | $ 87 |
| | | | | | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | | | $ 4,435 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| General Conditions | | | 0% | 1 | $ - |
| Mobilization/Demobilization | | | 10% | 1.1 | $ 444 |
| Overhead & Profit (OHP) | | | 0% | 1 | $ - |
| Insurance | | | 0.0% | 1 | $ - |
| Bonding | | | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | | | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | | | $ 4,879 |
| ***Direct: Subtotal Construction Costs (200 SF Area)*** | | | | | ***$ 4,879*** |

**Description: WQBE_08D - Permeable Paver Plaza (no sand layer)**

Pervious concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material intended to allow passage of water through pavement.

**Cost Assumptions**

Permeable Pavement installation is per the King Co. SW Design Manual Appendix C, Section C.2.7.

It is assumed that the soils and drainage conditions are suitable for permeable paver installation.

It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

The permeable pavement section consists of 8-inches pavers with 0.1' of leveling and filler sand, 3-inches of aggregate subbase, 6-inches of sand.

Permeable Concrete Pavers 8-inch thick and standard widths are used.

The installation is assume to be for residential and commercial installation and does not include industrial or heavily trafficked areas.

The permeable paver area is 200 s.f. with a 1:1 Length:Width ratio.

It is assumed that there is less than 3-inches of grade loss across the facility, and that check dams - per Seattle SW Manual is not required.
Concrete curb, gutter, and sidewalk removal and restoration is not required for the installation.
Landscape restoration is not included
Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and traffic control will not be required.
The facility is located outside of the ROW and a street use permit is not required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 09A_Removal of Impervious Surfaces on Property (wheel strips) | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Removal of Impervious Surfaces - On Property (Wheel Strips) | 100 | SF | $ 13 | $ 1,300 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 1,300*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 195 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 1,495*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 150 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 1,645*** |
| | | | | Construction Sales Tax | $ 169 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 1,800*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 197 |
| | | | | Construction Management | $ 132 |
| | | | | Permitting & Support | $ 8 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 82 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 419*** |
| | | | | Project Contingency | $ 333 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 800*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 2,600*** |

**Description: WQBE 9A_Removal of Impervious Surfaces on Property (wheel strips) (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 100 | ft2 |
| **Initial Capital Cost** | **$ 2,600** | |
| Capital cost | $ 26.00 | $/Unit |
| Total Direct O&M/Year | $ 543.90 | |
| Direct O&M cost | $ 5.44 | $/Unit |
| Capital Replacement Costs (10 years) | $ 244 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 16,800** | **$/unit** |
| **Annual O&M Cost** | **$ 700** | **$/year** |
| Annualized Cost | $180 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Tilling and seeding | 2023 Costs | $ 113 | $/year |
| | | $ - | $/year |
| Subtotal | | $ 113 | |
| Labor | | | |
| Tilling and Overseeding | 4 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| **Total hours per year** | 4 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 218 | |
| Labor cost, burdened | O/H 150.0% | $ 544 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 5,376 | | $ 25,876 | **$34,340** | **$ 16,762** | | | |
| 0 | 1.000 | **$ 2,600** | | | $2,600 | $ 2,600 | $ 2,600 | $ 2,600 | $ 16,762 |
| 1 | 0.950 | $113 | $ - | $ 544 | $ 657 | $ 624 | $ 3,257 | $ 3,224 | $ 14,162 |
| 2 | 0.903 | $ 116 | $ - | $ 560 | $ 677 | $ 611 | $ 3,934 | $ 3,835 | $ 13,538 |
| 3 | 0.858 | $ 120 | $ - | $ 577 | $ 697 | $ 598 | $ 4,630 | $ 4,433 | $ 12,927 |
| 4 | 0.815 | $ 123 | $ - | $ 594 | $ 718 | $ 585 | $ 5,348 | $ 5,018 | $ 12,329 |
| 5 | 0.774 | $ 127 | $ - | $ 612 | $ 739 | $ 572 | $ 6,088 | $ 5,590 | $ 11,744 |
| 6 | 0.736 | $ 131 | $ - | $ 631 | $ 762 | $ 560 | $ 6,849 | $ 6,150 | $ 11,172 |
| 7 | 0.699 | $ 135 | $ - | $ 649 | $ 784 | $ 548 | $ 7,633 | $ 6,699 | $ 10,611 |
| 8 | 0.664 | $ 139 | $ - | $ 669 | $ 808 | $ 537 | $ 8,441 | $ 7,235 | $ 10,063 |
| 9 | 0.631 | $ 143 | $ - | $ 689 | $ 832 | $ 525 | $ 9,274 | $ 7,760 | $ 9,527 |
| 10 | 0.599 | $ 147 | $ 244 | $ 710 | $ 1,101 | $ 660 | $ 10,374 | $ 8,420 | $ 9,002 |
| 11 | 0.570 | $ 152 | $ - | $ 731 | $ 883 | $ 503 | $ 11,257 | $ 8,923 | $ 8,342 |
| 12 | 0.541 | $ 156 | $ - | $ 753 | $ 909 | $ 492 | $ 12,167 | $ 9,415 | $ 7,839 |
| 13 | 0.514 | $ 161 | $ - | $ 775 | $ 937 | $ 482 | $ 13,103 | $ 9,897 | $ 7,347 |
| 14 | 0.489 | $ 166 | $ - | $ 799 | $ 965 | $ 471 | $ 14,068 | $ 10,368 | $ 6,865 |
| 15 | 0.464 | $ 171 | $ - | $ 823 | $ 994 | $ 461 | $ 15,061 | $ 10,829 | $ 6,394 |
| 16 | 0.441 | $ 176 | $ - | $ 847 | $ 1,023 | $ 451 | $ 16,085 | $ 11,280 | $ 5,933 |
| 17 | 0.419 | $ 181 | $ - | $ 873 | $ 1,054 | $ 442 | $ 17,139 | $ 11,722 | $ 5,481 |
| 18 | 0.398 | $ 187 | $ - | $ 899 | $ 1,086 | $ 432 | $ 18,225 | $ 12,154 | $ 5,040 |
| 19 | 0.378 | $ 192 | $ - | $ 926 | $ 1,118 | $ 423 | $ 19,343 | $ 12,577 | $ 4,607 |
| 20 | 0.359 | $ 198 | $ 244 | $ 954 | $ 1,396 | $ 502 | $ 20,739 | $ 13,079 | $ 4,184 |
| 21 | 0.341 | $ 204 | $ - | $ 982 | $ 1,186 | $ 405 | $ 21,925 | $ 13,484 | $ 3,683 |
| 22 | 0.324 | $ 210 | $ - | $ 1,012 | $ 1,222 | $ 396 | $ 23,147 | $ 13,880 | $ 3,278 |
| 23 | 0.308 | $ 217 | $ - | $ 1,042 | $ 1,259 | $ 388 | $ 24,406 | $ 14,268 | $ 2,881 |
| 24 | 0.293 | $ 223 | $ - | $ 1,073 | $ 1,296 | $ 380 | $ 25,702 | $ 14,648 | $ 2,493 |
| 25 | 0.278 | $ 230 | $ - | $ 1,106 | $ 1,335 | $ 372 | $ 27,038 | $ 15,020 | $ 2,114 |
| 26 | 0.264 | $ 237 | $ - | $ 1,139 | $ 1,375 | $ 364 | $ 28,413 | $ 15,383 | $ 1,742 |
| 27 | 0.251 | $ 244 | $ - | $ 1,173 | $ 1,417 | $ 356 | $ 29,830 | $ 15,739 | $ 1,378 |
| 28 | 0.239 | $ 251 | $ - | $ 1,208 | $ 1,459 | $ 348 | $ 31,289 | $ 16,087 | $ 1,023 |
| 29 | 0.227 | $ 259 | $ - | $ 1,244 | $ 1,503 | $ 341 | $ 32,792 | $ 16,428 | $ 674 |
| 30 | 0.215 | $ 266 | $ - | $ 1,282 | $ 1,548 | $ 334 | $ 34,340 | $ 16,762 | $ 334 |

**Description: WQBE 9A_Removal of Impervious Surfaces on Property (wheel strips)**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Tilling and overseeding as needed by crew of two (two visits per year, 1 hour per visit). Assume annual cost of
4 grass seed mix is $113.

**Replacement Assumptions:**

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 09A_Removal of Impervious Surfaces on Property (wheel strips) | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Removal of Impervious Surfaces** | **100** | **SF** | $ - | $ - |
| 2 | Remove Existing Pavement | 11 | SY | $ 14 | $ 156 |
| 3 | Unsuitable Roadway Foundation Excavation Incl. Haul @18" D | 6 | CY | $ 79 | $ 439 |
| 4 | | | | $ - | $ - |
| 5 | **Wheel Strips (2 strips @ 2'W X 10'L X 0.5' Thick** | **40** | **SF** | $ - | $ - |
| 6 | Concrete Wheel Strips | 1 | CY | $ 182 | $ 135 |
| 7 | Subgrade Preparation and Compaction | 4 | SY | $ 22 | $ 98 |
| 8 | Sand Subbase Layer (2 Strips @ 3'WX10'L) | 1 | CY | $ 85 | $ 94 |
| 9 | | | | $ - | $ - |
| 10 | **Restoration** | | | $ - | $ - |
| 11 | Mulch Compost @ 4"D | 1 | CY | $ 86 | $ 106 |
| 12 | Disking or Tilling Soil | 11 | SY | $ 4 | $ 44 |
| 13 | Grass Seeding and Restoration | 7 | SY | $ 10 | $ 67 |
| 14 | Trees (None listed in design description) | 0 | EA | $ 720 | $ - |
| 15 | | | | | $ - |
| 16 | **Additional Costs** | | | | $ - |
| 17 | Removals @ 4% Construction Costs | 4.0% | LS | $ 1,139 | $ 46 |
| 18 | TESC @ 2% Construction Costs | 2% | LS | $ 1,184 | $ 24 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 1,208 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 121 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 1,329 |
| | | | | ***Direct: Subtotal Construction Costs (100 SF Area)*** | ***$ 1,329*** |

**Description: WQBE 09A_Removal of Impervious Surfaces on Property (wheel strips)**
Remove impervious surface down to bare soil. Area is amended with soil and planted with grass. To allow continued site use, area is retrofitted with an alternative treatment (e.g., wheel strip driveways) per KCSWDM, "Reduced Impervious Surface Credit".

**Cost Estimating Assumptions:**
Pavement removal per the King Co. SW Design Manual Appendix C, Section C.2.9.
It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.
The pavement removal footprint = 100 sq. ft. with a 1:1 length to width ratio.
The cost model assumes a residential driveway type application. The driveway is assumed to be 10 feet wide by 10 feet long.
No removals are assumed beyond the existing pavement and base foundation sections.
Concrete curb, gutter, and sidewalk removal and restoration is not required for the installation.

Existing impervious surface and any underlying base course (e.g., crushed rock, gravel, etc.) must be completely removed from the conversion area(s).
Assumed underlying soils are scarified to a depth of 18 inches.
Concrete wheel strips are installed at 2 feet wide by 10 feet long by 6-inches deep.
A 3 feet wide by 10 feet long area beneath the wheel strips will be prepared and compacted prior to installation. A 6 inch sand base will be installed to support the concrete wheel strips.
A minimum of 4 inches of compost are added and mixed into the remaining exposed soils.
All exposed disturbed areas will be seeded with a grass mixture.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
Tree plantings are not included with this design.
Removals are estimated at 4% of the item construction costs.
The facility is located on property and traffic control will not be required.
The facility is located outside of the ROW and a street use permit is not required.

**Planning Basis Assumptions:**
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**
This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 9B_Removal of Impervious Surfaces_On Property (no wheel strips) | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Removal of Impervious Surfaces - On Property (no wheel strips) | 100 | SF | $ 10 | $ 1,000 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 1,000*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 150 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 1,150*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 115 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 1,265*** |
| | | | | Construction Sales Tax | $ 130 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 1,400*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 152 |
| | | | | Construction Management | $ 101 |
| | | | | Permitting & Support | $ 6 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 63 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 323*** |
| | | | | Project Contingency | $ 258 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 600*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 2,000*** |

**Description: WQBE 9B_Removal of Impervious Surfaces_Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 100 | ft2 |
| **Initial Capital Cost** | **$ 2,000** | |
| Capital cost | $ 20.00 | $/Unit |
| Total Direct O&M/Year | $ 543.90 | |
| Direct O&M cost | $ 5.44 | $/Unit |
| Capital Replacement Costs (10 years) | $ 294 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 16,200** | **$/unit** |
| **Annual O&M Cost** | **$ 700** | **$/year** |
| Annualized Cost | $180 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Tilling and seeding | 2023 Costs | $ 113 | $/year |
| | | $ - | $/year |
| Subtotal | | $ 113 | |

Labor

| | | | |
|---|---|---|---|
| Tilling and Overseeding | 4 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| **Total hours per year** | 4 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 218 | |
| Labor cost, burdened | O/H 150.0% | $ 544 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 5,376 | | $ 25,876 | **$33,840** | **$ 16,210** | | | |
| 0 | 1.000 | **$ 2,000** | | | $2,000 | $ 2,000 | $ 2,000 | $ 2,000 | $ 16,210 |
| 1 | 0.950 | $113 | $ - | $ 544 | $ 657 | $ 624 | $ 2,657 | $ 2,624 | $ 14,210 |
| 2 | 0.903 | $ 116 | $ - | $ 560 | $ 677 | $ 611 | $ 3,334 | $ 3,235 | $ 13,585 |
| 3 | 0.858 | $ 120 | $ - | $ 577 | $ 697 | $ 598 | $ 4,030 | $ 3,833 | $ 12,975 |
| 4 | 0.815 | $ 123 | $ - | $ 594 | $ 718 | $ 585 | $ 4,748 | $ 4,418 | $ 12,377 |
| 5 | 0.774 | $ 127 | $ - | $ 612 | $ 739 | $ 572 | $ 5,488 | $ 4,990 | $ 11,792 |
| 6 | 0.736 | $ 131 | $ - | $ 631 | $ 762 | $ 560 | $ 6,249 | $ 5,550 | $ 11,219 |
| 7 | 0.699 | $ 135 | $ - | $ 649 | $ 784 | $ 548 | $ 7,033 | $ 6,099 | $ 10,659 |
| 8 | 0.664 | $ 139 | $ - | $ 669 | $ 808 | $ 537 | $ 7,841 | $ 6,635 | $ 10,111 |
| 9 | 0.631 | $ 143 | $ - | $ 689 | $ 832 | $ 525 | $ 8,674 | $ 7,160 | $ 9,575 |
| 10 | 0.599 | $ 147 | $ 294 | $ 710 | $ 1,151 | $ 690 | $ 9,824 | $ 7,850 | $ 9,049 |
| 11 | 0.570 | $ 152 | $ - | $ 731 | $ 883 | $ 503 | $ 10,707 | $ 8,353 | $ 8,360 |
| 12 | 0.541 | $ 156 | $ - | $ 753 | $ 909 | $ 492 | $ 11,616 | $ 8,845 | $ 7,857 |
| 13 | 0.514 | $ 161 | $ - | $ 775 | $ 937 | $ 482 | $ 12,553 | $ 9,326 | $ 7,365 |
| 14 | 0.489 | $ 166 | $ - | $ 799 | $ 965 | $ 471 | $ 13,518 | $ 9,798 | $ 6,883 |
| 15 | 0.464 | $ 171 | $ - | $ 823 | $ 994 | $ 461 | $ 14,511 | $ 10,259 | $ 6,412 |
| 16 | 0.441 | $ 176 | $ - | $ 847 | $ 1,023 | $ 451 | $ 15,535 | $ 10,710 | $ 5,951 |
| 17 | 0.419 | $ 181 | $ - | $ 873 | $ 1,054 | $ 442 | $ 16,589 | $ 11,152 | $ 5,499 |
| 18 | 0.398 | $ 187 | $ - | $ 899 | $ 1,086 | $ 432 | $ 17,675 | $ 11,584 | $ 5,058 |
| 19 | 0.378 | $ 192 | $ - | $ 926 | $ 1,118 | $ 423 | $ 18,793 | $ 12,007 | $ 4,625 |
| 20 | 0.359 | $ 198 | $ 294 | $ 954 | $ 1,446 | $ 520 | $ 20,238 | $ 12,527 | $ 4,202 |
| 21 | 0.341 | $ 204 | $ - | $ 982 | $ 1,186 | $ 405 | $ 21,425 | $ 12,932 | $ 3,683 |
| 22 | 0.324 | $ 210 | $ - | $ 1,012 | $ 1,222 | $ 396 | $ 22,647 | $ 13,328 | $ 3,278 |
| 23 | 0.308 | $ 217 | $ - | $ 1,042 | $ 1,259 | $ 388 | $ 23,906 | $ 13,716 | $ 2,881 |
| 24 | 0.293 | $ 223 | $ - | $ 1,073 | $ 1,296 | $ 380 | $ 25,202 | $ 14,096 | $ 2,493 |
| 25 | 0.278 | $ 230 | $ - | $ 1,106 | $ 1,335 | $ 372 | $ 26,537 | $ 14,468 | $ 2,114 |
| 26 | 0.264 | $ 237 | $ - | $ 1,139 | $ 1,375 | $ 364 | $ 27,913 | $ 14,831 | $ 1,742 |
| 27 | 0.251 | $ 244 | $ - | $ 1,173 | $ 1,417 | $ 356 | $ 29,329 | $ 15,187 | $ 1,378 |
| 28 | 0.239 | $ 251 | $ - | $ 1,208 | $ 1,459 | $ 348 | $ 30,789 | $ 15,535 | $ 1,023 |
| 29 | 0.227 | $ 259 | $ - | $ 1,244 | $ 1,503 | $ 341 | $ 32,292 | $ 15,876 | $ 674 |
| 30 | 0.215 | $ 266 | $ - | $ 1,282 | $ 1,548 | $ 334 | $ 33,840 | $ 16,210 | $ 334 |

**Description: WQBE 9B_Removal of Impervious Surfaces_Property**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Tilling and overseeding as needed by crew of two (two visits per year, 1 hour per visit). Assume annual cost of
4 grass seed mix is $113.

**Replacement Assumptions:**

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 9B_Removal of Impervious Surfaces_On Property (no wheel strips) | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Removal of Impervious Surfaces** | **100** | **SF** | $ - | $ - |
| 2 | Remove Existing Pavement | 11 | SY | $ 14 | $ 156 |
| 3 | Unsuitable Roadway Foundation Excavation Incl. Haul @18" D | 6 | CY | $ 79 | $ 439 |
| 4 | | | | $ - | $ - |
| 5 | **Restoration** | | | $ - | $ - |
| 6 | Mulch Compost @ 4"D | 1 | CY | $ 86 | $ 106 |
| 7 | Disking or Tilling Soil | 11 | SY | $ 4 | $ 44 |
| 8 | Grass Seeding and Restoration | 11 | SY | $ 10 | $ 111 |
| 9 | Trees (None listed in design description) | 0 | EA | $ 720 | $ - |
| 10 | | | | | $ - |
| 11 | **Additional Costs** | | | | $ - |
| 12 | Removals @4% Construction Costs | 4% | LS | $ 856 | $ 34 |
| 13 | TESC @ 2% Construction Costs | 2% | LS | $ 890 | $ 18 |
| | | | | | $ - |
| | ***Item Subtotal Construction Costs (Year 2023)*** | | | | $ 908 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | General Conditions | | 0% | 1 | $ - |
| | Mobilization/Demobilization | | 10% | 1.1 | $ 91 |
| | Overhead & Profit (OHP) | | 0% | 1 | $ - |
| | Insurance | | 0.0% | 1 | $ - |
| | Bonding | | 0.0% | 1 | $ - |
| | Escalation Multiplier from ENR-CCI | | 0% | 1.0000 | $ - |
| | ***Item Subtotal Construction Costs (Year 2023)*** | | | | $ 999 |
| | ***Direct: Subtotal Construction Costs (100 SF Area)*** | | | | ***$ 999*** |

**Description: WQBE 9B_Removal of Impervious Surfaces_On Property (no wheel strips)**
Remove impervious surface down to bare soil. Area is amended with soil and planted with grass.

**Cost Estimating Assumptions:**
Pavement removal per the King Co. SW Design Manual Appendix C, Section C.2.9.
It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.
The pavement removal footprint = 100 sq. ft. with a 1:1 length to width ratio.
The cost model assumes a residential driveway type application. The driveway is assumed to be 10 feet wide by 10 feet long.
No removals are assumed beyond the existing pavement and base foundation sections.
Concrete curb, gutter, and sidewalk removal and restoration is not required for the installation.

Existing impervious surface and any underlying base course (e.g., crushed rock, gravel, etc.) must be completely removed from the conversion area(s).
Assumed underlying soils are scarified to a depth of 18 inches.
A minimum of 4 inches of compost are added and mixed into the remaining exposed soils.
All exposed disturbed areas will be seeded with a grass mixture.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
Tree plantings are not included with this design.
Removals are estimated at 4% of the item construction costs.
The facility is located on property and traffic control will not be required.
The facility is located outside of the ROW and a street use permit is not required.

**Planning Basis Assumptions:**
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**
This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 21A_High Rate Underground Filter in Urban ROW PCCP | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | High Rate Underground Filter (16 s.f. bottom area) | 1 | EA | $ 103,737 | $ 103,737 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 103,737*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 15,561 |
| | | | Street Use Permit (Y/N) | Y | $ 700 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 119,998*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 11,930 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 131,928*** |
| | | | | Construction Sales Tax | $ 13,451 |
| | | | | Outside Agency Construction | $ 2,075 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 147,500*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 15,831 |
| | | | | Construction Management | $ 10,554 |
| | | | | Permitting & Support | $ 660 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 6,596 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 33,642*** |
| | | | | Project Contingency | $ 27,171 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 60,800*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 208,300*** |

**Description: WQBE 21A_High Rate Underground Filter in Urban ROW PCCP (2023 Dollars)**

| | | | |
|---|---|---|---|
| Unit | 1 | EA | |
| **Initial Capital Cost** | **$ 208,300** | | |
| Capital cost | $ 208,300.00 | $/Unit | |
| Total Direct O&M/Year | $ 1,903.65 | | |
| Direct O&M cost | $ 1,903.65 | $/Unit | |
| Capital Replacement Costs (10 Years) | $ - | $/unit | No replacement costs |
| Discount rate (%) | 5.25 | $/Unit | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 262,000** | **$/unit** |
| **Annual O&M Cost** | **$ 2,500** | **$/year** |
| Annualized Cost | $1,000 | $/year |

**Materials, Supplies, Other Costs**

| | | | | |
|---|---|---|---|---|
| Mulch Replacement | $ - | $ 113 | $/year | |
| Plant Material | $ - | $ 270 | $/year | |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year | |
| Subtotal | | $ 630 | | |
| Labor | | | | |
| Remove Trash | 6 | hr | | |
| Plant Health | 4 | hr | | |
| Mulch Replacement | 4 | hr | | |
| Activity | 0 | hr | | |
| **Total hours per year** | 14 | | | |
| Raw Labor Rate/Hr | | $ 54 | | |
| Raw labor cost | (embedded) | $ 761 | | |
| Labor cost, burdened | O/H 150.0% | $ 1,904 | $ | 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | | |
| Life Cycle Period: | 30 | years | | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 29,973 | | $ 90,567 | **$328,839** | **$ 262,020** | | | |
| 0 | 1.000 | **$ 208,300** | | | $208,300 | $ 208,300 | $ 208,300 | $ 208,300 | $ 262,020 |
| 1 | 0.950 | $630 | $ - | $ 1,904 | $ 2,534 | $ 2,407 | $ 210,834 | $ 210,707 | $ 53,720 |
| 2 | 0.903 | $ 649 | $ - | $ 1,961 | $ 2,610 | $ 2,356 | $ 213,443 | $ 213,063 | $ 51,313 |
| 3 | 0.858 | $ 668 | $ - | $ 2,020 | $ 2,688 | $ 2,305 | $ 216,131 | $ 215,369 | $ 48,957 |
| 4 | 0.815 | $ 688 | $ - | $ 2,080 | $ 2,769 | $ 2,256 | $ 218,900 | $ 217,625 | $ 46,651 |
| 5 | 0.774 | $ 709 | $ - | $ 2,143 | $ 2,852 | $ 2,208 | $ 221,751 | $ 219,833 | $ 44,395 |
| 6 | 0.736 | $ 730 | $ - | $ 2,207 | $ 2,937 | $ 2,161 | $ 224,689 | $ 221,993 | $ 42,187 |
| 7 | 0.699 | $ 752 | $ - | $ 2,273 | $ 3,025 | $ 2,115 | $ 227,714 | $ 224,108 | $ 40,027 |
| 8 | 0.664 | $ 775 | $ - | $ 2,341 | $ 3,116 | $ 2,069 | $ 230,830 | $ 226,177 | $ 37,912 |
| 9 | 0.631 | $ 798 | $ - | $ 2,411 | $ 3,210 | $ 2,025 | $ 234,040 | $ 228,202 | $ 35,843 |
| 10 | 0.599 | $ 822 | $ - | $ 2,484 | $ 3,306 | $ 1,982 | $ 237,345 | $ 230,184 | $ 33,818 |
| 11 | 0.570 | $ 847 | $ - | $ 2,558 | $ 3,405 | $ 1,939 | $ 240,750 | $ 232,124 | $ 31,836 |
| 12 | 0.541 | $ 872 | $ - | $ 2,635 | $ 3,507 | $ 1,898 | $ 244,258 | $ 234,022 | $ 29,896 |
| 13 | 0.514 | $ 898 | $ - | $ 2,714 | $ 3,612 | $ 1,857 | $ 247,870 | $ 235,879 | $ 27,998 |
| 14 | 0.489 | $ 925 | $ - | $ 2,796 | $ 3,721 | $ 1,818 | $ 251,591 | $ 237,697 | $ 26,141 |
| 15 | 0.464 | $ 953 | $ - | $ 2,879 | $ 3,832 | $ 1,779 | $ 255,423 | $ 239,475 | $ 24,323 |
| 16 | 0.441 | $ 982 | $ - | $ 2,966 | $ 3,947 | $ 1,741 | $ 259,370 | $ 241,216 | $ 22,544 |
| 17 | 0.419 | $ 1,011 | $ - | $ 3,055 | $ 4,066 | $ 1,704 | $ 263,436 | $ 242,920 | $ 20,804 |
| 18 | 0.398 | $ 1,041 | $ - | $ 3,146 | $ 4,188 | $ 1,667 | $ 267,624 | $ 244,587 | $ 19,100 |
| 19 | 0.378 | $ 1,073 | $ - | $ 3,241 | $ 4,313 | $ 1,632 | $ 271,937 | $ 246,219 | $ 17,433 |
| 20 | 0.359 | $ 1,105 | $ - | $ 3,338 | $ 4,443 | $ 1,597 | $ 276,380 | $ 247,815 | $ 15,801 |
| 21 | 0.341 | $ 1,138 | $ - | $ 3,438 | $ 4,576 | $ 1,563 | $ 280,956 | $ 249,378 | $ 14,205 |
| 22 | 0.324 | $ 1,172 | $ - | $ 3,541 | $ 4,713 | $ 1,529 | $ 285,670 | $ 250,907 | $ 12,642 |
| 23 | 0.308 | $ 1,207 | $ - | $ 3,648 | $ 4,855 | $ 1,496 | $ 290,524 | $ 252,403 | $ 11,113 |
| 24 | 0.293 | $ 1,243 | $ - | $ 3,757 | $ 5,000 | $ 1,464 | $ 295,525 | $ 253,868 | $ 9,617 |
| 25 | 0.278 | $ 1,281 | $ - | $ 3,870 | $ 5,150 | $ 1,433 | $ 300,675 | $ 255,301 | $ 8,152 |
| 26 | 0.264 | $ 1,319 | $ - | $ 3,986 | $ 5,305 | $ 1,402 | $ 305,980 | $ 256,703 | $ 6,719 |
| 27 | 0.251 | $ 1,359 | $ - | $ 4,105 | $ 5,464 | $ 1,373 | $ 311,444 | $ 258,076 | $ 5,317 |
| 28 | 0.239 | $ 1,399 | $ - | $ 4,229 | $ 5,628 | $ 1,343 | $ 317,072 | $ 259,419 | $ 3,944 |
| 29 | 0.227 | $ 1,441 | $ - | $ 4,355 | $ 5,797 | $ 1,314 | $ 322,869 | $ 260,734 | $ 2,601 |
| 30 | 0.215 | $ 1,485 | $ - | $ 4,486 | $ 5,971 | $ 1,286 | $ 328,839 | $ 262,020 | $ 1,286 |

**Description: WQBE 21A_High Rate Underground Filter in Urban ROW PCCP**

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

6 Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year.

4 Biannually the 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours. Assumed annual cost of $113 for mulch.

4 Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 1 hour per visit. Total of 4 man hours.

Annual mulch and plan replacements 5 plants at $54/Plant

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Replacement Assumptions:**

No capital replacement assumed in 30-year life.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 21A_High Rate Underground Filter in Urban ROW PCCP | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Treatment BMP** | | | $ - | $ - |
| 2 | Filterra Unit 4'X4' (complete) | 1 | EA | $ 19,680 | $ 19,680 |
| 3 | Structural Excavation to Waste (10'W X10'L X 5'D) + (50'LX5'WX6'D) | 74 | CY | $ 79 | $ 5,852 |
| 4 | Imported Structural Fill | 71 | CY | $ 44 | $ 3,129 |
| 5 | Crushed Base | 1 | CY | $ 64 | $ 64 |
| 6 | Inlet Drain w/Energy Dissipating Rocks | 1 | EA | $ 1,481 | $ 1,481 |
| 7 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 8 | Pipe 8" PSD, DI CL 50 | 50 | LF | $ 160 | $ 8,000 |
| 9 | Trench Box Shoring (Shallow) | 390 | SF | $ 10 | $ 3,900 |
| 10 | **Restoration** | | | $ - | $ - |
| 11 | Road Restoration (patching) 10" PCCP/6" CSTC | 48 | SY | $ 405 | $ 19,440 |
| 12 | Concrete Curb and Gutter | 15 | LF | $ 111 | $ 1,665 |
| 13 | Sidewalk 6' Wide | 10 | SY | $ 125 | $ 1,250 |
| 14 | Landscaping, planting, and restoration | 10 | SY | $ 59 | $ 590 |
| 15 | Street Tree | 1 | EA | $ 720 | $ 720 |
| 16 | **Additional Costs** | | | | $ - |
| 17 | Removals @ 4% Construction Costs | 4.0% | LS | $ 69,671 | $ 2,787 |
| 18 | Traffic Control (Heavy) | 1 | MO | $ 20,000 | $ 20,000 |
| 19 | TESC @2% Construction Costs | 2% | LS | $ 92,458 | $ 1,849 |
| | | | | | $ - |
| | ***Item Subtotal Construction Costs (Year 2023)*** | | | | $ 94,307 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | General Conditions | 0% | | 1 | $ - |
| | Mobilization/Demobilization | 10% | | 1.1 | $ 9,431 |
| | Overhead & Profit (OHP) | 0% | | 1 | $ - |
| | Insurance | 0.0% | | 1 | $ - |
| | Bonding | 0.0% | | 1 | $ - |
| | Escalation Multiplier from ENR-CCI | 0% | | 1.0000 | $ - |
| | ***Item Subtotal Construction Costs (Year 2023)*** | | | | $ 103,737 |
| | ***Direct: Subtotal Construction Costs*** | | | | ***$ 103,737*** |

**Description: WQBE 21A_High Rate Underground Filter in Urban ROW PCCP**

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Cost Estimating Assumptions:**

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6"thick.
The facility treatment area is 16 sf (4'X4') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
Installation is within a roadside right-of-way and does not require easements or acquisition
An excavation width of 3 feet is assumed on each side of the precast box.
The excavated material is unsuitable for use as backfill.
Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.
A total of 50 LF of 8" storm pipe is required to connect to a downstream main or facility.
Trench box shoring is used.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
Urban roadway restoration is assumed consisting of 10" PCCP/6"CSTC. Full panel replacement is required.
Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.
Removals are estimated at 4% of the item construction costs, in conformance with LTCP University GSI cost estimates.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located within the ROW and Traffic control is required. Traffic conditions are assumed to be heavy for the urban setting and light for the rural setting.
A street use permit is required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.
It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 21B_High Rate Underground Filter In Highway ROW PCCP | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | High Rate Underground Filter (16 s.f.) | 1 | EA | $ 76,234 | $ 76,234 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 76,234*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 11,435 |
| | | | Street Use Permit (Y/N) | Y | $ 700 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 88,369*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 8,767 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 97,136*** |
| | | | | Construction Sales Tax | $ 9,885 |
| | | | | Outside Agency Construction | $ 1,525 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 108,500*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 11,656 |
| | | | | Construction Management | $ 7,771 |
| | | | | Permitting & Support | $ 486 |
| | s.f. Land Area | None | | Land Purchase/ROW Acquisition | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 4,857 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 24,770*** |
| | | | | Project Contingency | $ 19,990 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 44,800*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 153,300*** |

**Description: WQBE 21B_High Rate Underground Filter In Highway ROW PCCP (2023 Dollars)**

| | | | |
|---|---|---|---|
| Unit | 1 | EA | |
| **Initial Capital Cost** | **$ 153,300** | | |
| Capital cost | $ 153,300.00 | $/Unit | |
| Total Direct O&M/Year | $ 1,903.65 | | |
| Direct O&M cost | $ 1,903.65 | $/Unit | |
| Capital Replacement Costs (10 Years) | $ - | $/unit | No replacement costs |
| Discount rate (%) | 5.25 | $/Unit | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 207,000** | **$/unit** |
| **Annual O&M Cost** | **$ 2,500** | **$/year** |
| Annualized Cost | $1,000 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| Mulch Replacement | $ - | $ 113 | $/year |
| Plant Material | $ - | $ 270 | $/year |
| Vacuum Truck Equipment + Labor | 2023 dollars | $ 360 | $/year |
| Subtotal | | $ 630 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash | 6 | hr | |
| Plant Health | 4 | hr | |
| Mulch Replacement | 4 | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 14 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 761 | |
| Labor cost, burdened | O/H 150.0% | $ 1,904 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 29,973 | | $ 90,567 | **$273,839** | **$ 207,020** | | | |
| 0 | 1.000 | **$ 153,300** | | | $153,300 | $ 153,300 | $ 153,300 | $ 153,300 | $ 207,020 |
| 1 | 0.950 | $630 | $ - | $ 1,904 | $ 2,534 | $ 2,407 | $ 155,834 | $ 155,707 | $ 53,720 |
| 2 | 0.903 | $ 649 | $ - | $ 1,961 | $ 2,610 | $ 2,356 | $ 158,443 | $ 158,063 | $ 51,313 |
| 3 | 0.858 | $ 668 | $ - | $ 2,020 | $ 2,688 | $ 2,305 | $ 161,131 | $ 160,369 | $ 48,957 |
| 4 | 0.815 | $ 688 | $ - | $ 2,080 | $ 2,769 | $ 2,256 | $ 163,900 | $ 162,625 | $ 46,651 |
| 5 | 0.774 | $ 709 | $ - | $ 2,143 | $ 2,852 | $ 2,208 | $ 166,751 | $ 164,833 | $ 44,395 |
| 6 | 0.736 | $ 730 | $ - | $ 2,207 | $ 2,937 | $ 2,161 | $ 169,689 | $ 166,993 | $ 42,187 |
| 7 | 0.699 | $ 752 | $ - | $ 2,273 | $ 3,025 | $ 2,115 | $ 172,714 | $ 169,108 | $ 40,027 |
| 8 | 0.664 | $ 775 | $ - | $ 2,341 | $ 3,116 | $ 2,069 | $ 175,830 | $ 171,177 | $ 37,912 |
| 9 | 0.631 | $ 798 | $ - | $ 2,411 | $ 3,210 | $ 2,025 | $ 179,040 | $ 173,202 | $ 35,843 |
| 10 | 0.599 | $ 822 | $ - | $ 2,484 | $ 3,306 | $ 1,982 | $ 182,345 | $ 175,184 | $ 33,818 |
| 11 | 0.570 | $ 847 | $ - | $ 2,558 | $ 3,405 | $ 1,939 | $ 185,750 | $ 177,124 | $ 31,836 |
| 12 | 0.541 | $ 872 | $ - | $ 2,635 | $ 3,507 | $ 1,898 | $ 189,258 | $ 179,022 | $ 29,896 |
| 13 | 0.514 | $ 898 | $ - | $ 2,714 | $ 3,612 | $ 1,857 | $ 192,870 | $ 180,879 | $ 27,998 |
| 14 | 0.489 | $ 925 | $ - | $ 2,796 | $ 3,721 | $ 1,818 | $ 196,591 | $ 182,697 | $ 26,141 |
| 15 | 0.464 | $ 953 | $ - | $ 2,879 | $ 3,832 | $ 1,779 | $ 200,423 | $ 184,475 | $ 24,323 |
| 16 | 0.441 | $ 982 | $ - | $ 2,966 | $ 3,947 | $ 1,741 | $ 204,370 | $ 186,216 | $ 22,544 |
| 17 | 0.419 | $ 1,011 | $ - | $ 3,055 | $ 4,066 | $ 1,704 | $ 208,436 | $ 187,920 | $ 20,804 |
| 18 | 0.398 | $ 1,041 | $ - | $ 3,146 | $ 4,188 | $ 1,667 | $ 212,624 | $ 189,587 | $ 19,100 |
| 19 | 0.378 | $ 1,073 | $ - | $ 3,241 | $ 4,313 | $ 1,632 | $ 216,937 | $ 191,219 | $ 17,433 |
| 20 | 0.359 | $ 1,105 | $ - | $ 3,338 | $ 4,443 | $ 1,597 | $ 221,380 | $ 192,815 | $ 15,801 |
| 21 | 0.341 | $ 1,138 | $ - | $ 3,438 | $ 4,576 | $ 1,563 | $ 225,956 | $ 194,378 | $ 14,205 |
| 22 | 0.324 | $ 1,172 | $ - | $ 3,541 | $ 4,713 | $ 1,529 | $ 230,670 | $ 195,907 | $ 12,642 |
| 23 | 0.308 | $ 1,207 | $ - | $ 3,648 | $ 4,855 | $ 1,496 | $ 235,524 | $ 197,403 | $ 11,113 |
| 24 | 0.293 | $ 1,243 | $ - | $ 3,757 | $ 5,000 | $ 1,464 | $ 240,525 | $ 198,868 | $ 9,617 |
| 25 | 0.278 | $ 1,281 | $ - | $ 3,870 | $ 5,150 | $ 1,433 | $ 245,675 | $ 200,301 | $ 8,152 |
| 26 | 0.264 | $ 1,319 | $ - | $ 3,986 | $ 5,305 | $ 1,402 | $ 250,980 | $ 201,703 | $ 6,719 |
| 27 | 0.251 | $ 1,359 | $ - | $ 4,105 | $ 5,464 | $ 1,373 | $ 256,444 | $ 203,076 | $ 5,317 |
| 28 | 0.239 | $ 1,399 | $ - | $ 4,229 | $ 5,628 | $ 1,343 | $ 262,072 | $ 204,419 | $ 3,944 |
| 29 | 0.227 | $ 1,441 | $ - | $ 4,355 | $ 5,797 | $ 1,314 | $ 267,869 | $ 205,734 | $ 2,601 |
| 30 | 0.215 | $ 1,485 | $ - | $ 4,486 | $ 5,971 | $ 1,286 | $ 273,839 | $ 207,020 | $ 1,286 |

**Description: WQBE 21B_High Rate Underground Filter In Highway ROW PCCP**
An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings.

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

6 Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year.

4 Biannually the 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours. Assumed annual cost of $113 for mulch.

4 Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 1 hour per visit. Total of 4 man hours.

Annual mulch and plan replacements 5 plants at $54/Plant

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Replacement Assumptions:**

No capital replacement assumed in 30-year life.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 21B_High Rate Underground Filter In Highway ROW PCCP | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Treatment BMP** | | | | $ - |
| 2 | Filterra Unit 4'X4' (complete) | 1 | EA | $ 19,680 | $ 19,680 |
| 3 | Structural Excavation to Waste (10'W X10'L X 5'D) + (50'LX5'WX6'D) | 74 | CY | $ 79 | $ 5,852 |
| 4 | Imported Structural Fill | 71 | CY | $ 44 | $ 3,129 |
| 5 | Crushed Base | 1 | CY | $ 64 | $ 64 |
| 6 | Inlets with energy dissipating rocks | 1 | EA | $ 1,481 | $ 1,481 |
| 7 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 8 | Pipe 8" PSD, DI CL 50 | 50 | LF | $ 160 | $ 8,000 |
| 9 | Trench Box Shoring (Shallow) | 390 | SF | $ 10 | $ 3,900 |
| 10 | **Restoration** | | | $ - | $ - |
| 11 | Road Restoration (Patching) 6" PCCP/6" CSTC | 48 | SY | $ 110 | $ 5,280 |
| 12 | Concrete Curb and Gutter | 15 | LF | $ 111 | $ 1,665 |
| 13 | Sidewalk 5' Wide | 8 | SY | $ 125 | $ 1,042 |
| 14 | Landscaping, planting, and restoration | 10 | SY | $ 59 | $ 590 |
| 15 | Street Tree | 1 | EA | $ 720 | $ 720 |
| 16 | **Additional Costs** | | | | $ - |
| 17 | Removals @ 4% Construction Costs | 4.0% | LS | $ 55,302 | $ 2,212 |
| 18 | Traffic Control (Light) | 1 | MO | $ 10,430 | $ 10,430 |
| 19 | TESC @2% Construction Costs | 2% | LS | $ 67,945 | $ 1,359 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 69,303 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 6,930 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 76,234 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 76,234*** |

**Description: WQBE 21B_High Rate Underground Filter In Highway ROW PCCP**

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings.

**Cost Estimating Assumptions:**

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6"thick.
The facility treatment area is 16 sf (4'X4') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
Installation is within a roadside right-of-way and does not require easements or acquisition
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
The excavated material is unsuitable for use as backfill.
Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.
A total of 50 LF of 8" storm pipe is required to connect to a downstream main or facility.
Trench Box shoring is used.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
Rural roadway restoration is assumed consisting of 6" PCCP/6"CSTC. Full panel replacement is required.
Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.
Removals are estimated at 4% of the item construction costs, in conformance with LTCP University GSI cost estimates.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located within the ROW and Traffic control is required. Traffic conditions are assumed to be heavy for the urban setting and light for the rural setting.
A street use permit is required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.
It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 21C_High Rate Underground Filter In Urban ROW HMA | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | High Rate Underground Filter (16 s.f.) | 1 | EA | $ 74,468 | $ 74,468 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 74,468*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 11,170 |
| | | | Street Use Permit (Y/N) | Y | $ 700 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 86,339*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 8,564 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 94,902*** |
| | | | | Construction Sales Tax | $ 9,656 |
| | | | | Outside Agency Construction | $ 1,489 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 106,000*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 11,388 |
| | | | | Construction Management | $ 7,592 |
| | | | | Permitting & Support | $ 475 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 4,745 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 24,200*** |
| | | | | Project Contingency | $ 19,530 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 43,700*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 149,700*** |

**Description: WQBE 21C_High Rate Underground Filter In Urban ROW HMA (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 149,700** | |
| Capital cost | $ 149,700.00 | $/Unit |
| Total Direct O&M/Year | $ 1,903.65 | |
| Direct O&M cost | $ 1,903.65 | $/Unit |
| Capital Replacement Costs (10 Years) | $ - | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

No replacement costs

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 203,400** | **$/unit** |
| **Annual O&M Cost** | **$ 2,500** | **$/year** |
| Annualized Cost | $1,000 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| Mulch Replacement | $ - | $ 113 | $/year |
| Plant Material | $ - | $ 270 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $ 630 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash | 6 | hr | |
| Plant Health | 4 | hr | |
| Mulch Replacement | 4 | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 14 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 761 | |
| Labor cost, burdened | O/H 150.0% | $ 1,904 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 29,973 | | $ 90,567 | **$270,239** | **$ 203,420** | | | |
| 0 | 1.000 | **$ 149,700** | | | $149,700 | $ 149,700 | $ 149,700 | $ 149,700 | $ 203,420 |
| 1 | 0.950 | $630 | $ - | $ 1,904 | $ 2,534 | $ 2,407 | $ 152,234 | $ 152,107 | $ 53,720 |
| 2 | 0.903 | $ 649 | $ - | $ 1,961 | $ 2,610 | $ 2,356 | $ 154,843 | $ 154,463 | $ 51,313 |
| 3 | 0.858 | $ 668 | $ - | $ 2,020 | $ 2,688 | $ 2,305 | $ 157,531 | $ 156,769 | $ 48,957 |
| 4 | 0.815 | $ 688 | $ - | $ 2,080 | $ 2,769 | $ 2,256 | $ 160,300 | $ 159,025 | $ 46,651 |
| 5 | 0.774 | $ 709 | $ - | $ 2,143 | $ 2,852 | $ 2,208 | $ 163,151 | $ 161,233 | $ 44,395 |
| 6 | 0.736 | $ 730 | $ - | $ 2,207 | $ 2,937 | $ 2,161 | $ 166,089 | $ 163,393 | $ 42,187 |
| 7 | 0.699 | $ 752 | $ - | $ 2,273 | $ 3,025 | $ 2,115 | $ 169,114 | $ 165,508 | $ 40,027 |
| 8 | 0.664 | $ 775 | $ - | $ 2,341 | $ 3,116 | $ 2,069 | $ 172,230 | $ 167,577 | $ 37,912 |
| 9 | 0.631 | $ 798 | $ - | $ 2,411 | $ 3,210 | $ 2,025 | $ 175,440 | $ 169,602 | $ 35,843 |
| 10 | 0.599 | $ 822 | $ - | $ 2,484 | $ 3,306 | $ 1,982 | $ 178,745 | $ 171,584 | $ 33,818 |
| 11 | 0.570 | $ 847 | $ - | $ 2,558 | $ 3,405 | $ 1,939 | $ 182,150 | $ 173,524 | $ 31,836 |
| 12 | 0.541 | $ 872 | $ - | $ 2,635 | $ 3,507 | $ 1,898 | $ 185,658 | $ 175,422 | $ 29,896 |
| 13 | 0.514 | $ 898 | $ - | $ 2,714 | $ 3,612 | $ 1,857 | $ 189,270 | $ 177,279 | $ 27,998 |
| 14 | 0.489 | $ 925 | $ - | $ 2,796 | $ 3,721 | $ 1,818 | $ 192,991 | $ 179,097 | $ 26,141 |
| 15 | 0.464 | $ 953 | $ - | $ 2,879 | $ 3,832 | $ 1,779 | $ 196,823 | $ 180,875 | $ 24,323 |
| 16 | 0.441 | $ 982 | $ - | $ 2,966 | $ 3,947 | $ 1,741 | $ 200,770 | $ 182,616 | $ 22,544 |
| 17 | 0.419 | $ 1,011 | $ - | $ 3,055 | $ 4,066 | $ 1,704 | $ 204,836 | $ 184,320 | $ 20,804 |
| 18 | 0.398 | $ 1,041 | $ - | $ 3,146 | $ 4,188 | $ 1,667 | $ 209,024 | $ 185,987 | $ 19,100 |
| 19 | 0.378 | $ 1,073 | $ - | $ 3,241 | $ 4,313 | $ 1,632 | $ 213,337 | $ 187,619 | $ 17,433 |
| 20 | 0.359 | $ 1,105 | $ - | $ 3,338 | $ 4,443 | $ 1,597 | $ 217,780 | $ 189,215 | $ 15,801 |
| 21 | 0.341 | $ 1,138 | $ - | $ 3,438 | $ 4,576 | $ 1,563 | $ 222,356 | $ 190,778 | $ 14,205 |
| 22 | 0.324 | $ 1,172 | $ - | $ 3,541 | $ 4,713 | $ 1,529 | $ 227,070 | $ 192,307 | $ 12,642 |
| 23 | 0.308 | $ 1,207 | $ - | $ 3,648 | $ 4,855 | $ 1,496 | $ 231,924 | $ 193,803 | $ 11,113 |
| 24 | 0.293 | $ 1,243 | $ - | $ 3,757 | $ 5,000 | $ 1,464 | $ 236,925 | $ 195,268 | $ 9,617 |
| 25 | 0.278 | $ 1,281 | $ - | $ 3,870 | $ 5,150 | $ 1,433 | $ 242,075 | $ 196,701 | $ 8,152 |
| 26 | 0.264 | $ 1,319 | $ - | $ 3,986 | $ 5,305 | $ 1,402 | $ 247,380 | $ 198,103 | $ 6,719 |
| 27 | 0.251 | $ 1,359 | $ - | $ 4,105 | $ 5,464 | $ 1,373 | $ 252,844 | $ 199,476 | $ 5,317 |
| 28 | 0.239 | $ 1,399 | $ - | $ 4,229 | $ 5,628 | $ 1,343 | $ 258,472 | $ 200,819 | $ 3,944 |
| 29 | 0.227 | $ 1,441 | $ - | $ 4,355 | $ 5,797 | $ 1,314 | $ 264,269 | $ 202,134 | $ 2,601 |
| 30 | 0.215 | $ 1,485 | $ - | $ 4,486 | $ 5,971 | $ 1,286 | $ 270,239 | $ 203,420 | $ 1,286 |

**Description: WQBE 21C_High Rate Underground Filter In Urban ROW HMA**
An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Life-Cycle Cost Model Input Assumptions:**
Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm
6 event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year.
Biannually the 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours. Assumed
4 annual cost of $113 for mulch.
Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 1 hour per visit. Total of 4
4 man hours.
Annual mulch and plan replacements 5 plants at $54/Plant
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Replacement Assumptions:**
No capital replacement assumed in 30-year life.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 21C_High Rate Underground Filter In Urban ROW HMA | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Treatment BMP** | | | $ - | $ - |
| 2 | Filterra Unit 4'X4' (complete) | 1 | EA | $ 19,680 | $ 19,680 |
| 3 | Structural Excavation to Waste (10'W X10'L X 5'D) + (50'LX5'WX6'D) | 74 | CY | $ 79 | $ 5,852 |
| 4 | Imported Structural Fill | 71 | CY | $ 44 | $ 3,129 |
| 5 | Crushed Base | 1 | CY | $ 64 | $ 64 |
| 6 | Inlets with energy dissipating rocks | 1 | EA | $ 1,481 | $ 1,481 |
| 7 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 8 | Pipe 8" PSD, DI CL 50 | 50 | LF | $ 160 | $ 8,000 |
| 9 | Trench Box Shoring (Shallow) | 390 | SF | $ 10 | $ 3,900 |
| 10 | **Restoration** | | | $ - | $ - |
| 11 | Pavement Patching HMA 6" HMA/6"CSBC | 36 | SY | $ 110 | $ 3,972 |
| 12 | Concrete Curb and Gutter | 15 | LF | $ 111 | $ 1,665 |
| 13 | Sidewalk 6' Wide | 10 | SY | $ 125 | $ 1,250 |
| 14 | Landscaping, planting, and restoration | 10 | SY | $ 59 | $ 590 |
| 15 | Street Tree | 1 | EA | $ 720 | $ 720 |
| 16 | **Additional Costs** | | | | $ - |
| 17 | Removals @ 4% Construction Costs | 4.0% | LS | $ 54,203 | $ 2,168 |
| 18 | Traffic Control (Heavy) | 0.5 | MO | $ 20,000 | $ 10,000 |
| 19 | TESC @2% Construction Costs | 2% | LS | $ 66,371 | $ 1,327 |
| | | | | | $ - |
| | ***Item Subtotal Construction Costs (Year 2023)*** | | | | $ 67,699 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | General Conditions | | 0% | 1 | $ - |
| | Mobilization/Demobilization | | 10% | 1.1 | $ 6,770 |
| | Overhead & Profit (OHP) | | 0% | 1 | $ - |
| | Insurance | | 0.0% | 1 | $ - |
| | Bonding | | 0.0% | 1 | $ - |
| | Escalation Multiplier from ENR-CCI | | 0% | 1.0000 | $ - |
| | ***Item Subtotal Construction Costs (Year 2023)*** | | | | $ 74,468 |
| | ***Direct: Subtotal Construction Costs*** | | | | ***$ 74,468*** |

**Description: WQBE 21C_High Rate Underground Filter In Urban ROW HMA**

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Cost Estimating Assumptions:**

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6"thick.
The facility treatment area is 16 sf (4'X4') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
Installation is within a roadside right-of-way and does not require easements or acquisition
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
The excavated material is unsuitable for use as backfill.
Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.
A total of 50 LF of 8" storm pipe is required to connect to a downstream main or facility.
Trench Box shoring is used.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
Urban roadway restoration is assumed consisting of 6"HMA/6"CSTC.
Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.
Removals are estimated at 4% of the item construction costs, in conformance with LTCP University GSI cost estimates.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located within the ROW and Traffic control is required. Traffic conditions are assumed to be heavy for the urban setting and light for the rural setting.
A street use permit is required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.
It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_21D_High Rate Underground Filter In Highway ROW HMA | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | High Rate Underground Filter (16 s.f.) | 1 | EA | $ 67,456 | $ 67,456 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 67,456*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 10,118 |
| | | | Street Use Permit (Y/N) | Y | $ 700 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 78,275*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 7,757 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 86,032*** |
| | | | | Construction Sales Tax | $ 8,747 |
| | | | | Outside Agency Construction | $ 1,349 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 96,100*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 10,324 |
| | | | | Construction Management | $ 6,883 |
| | | | | Permitting & Support | $ 430 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 4,302 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 21,938*** |
| | | | | Project Contingency | $ 17,706 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 39,600*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 135,700*** |

**Description: WQBE_21D_High Rate Underground Filter In Highway ROW HMA (2023 Dollars)**

| | | | |
|---|---|---|---|
| Unit | 1 | EA | |
| **Initial Capital Cost** | **$ 135,700** | | |
| Capital cost | $ 135,700.00 | $/Unit | |
| Total Direct O&M/Year | $ 1,903.65 | | |
| Direct O&M cost | $ 1,903.65 | $/Unit | |
| Capital Replacement Costs (10 Years) | $ - | $/unit | No replacement costs |
| Discount rate (%) | 5.25 | $/Unit | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 189,400** | **$/unit** |
| **Annual O&M Cost** | **$ 2,500** | **$/year** |
| Annualized Cost | $1,000 | $/year |

**Materials, Supplies, Other Costs**

| | | | | |
|---|---|---|---|---|
| Mulch Replacement | $ - | $ 113 | $/year | |
| Plant Material | $ - | $ 270 | $/year | |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year | |
| Subtotal | | $ 630 | | |
| Labor | | | | |
| Remove Trash | 6 | hr | | |
| Plant Health | 4 | hr | | |
| Mulch Replacement | 4 | hr | | |
| Activity | 0 | hr | | |
| **Total hours per year** | 14 | | | |
| Raw Labor Rate/Hr | | $ 54 | | |
| Raw labor cost | (embedded) | $ 761 | | |
| Labor cost, burdened | O/H 150.0% | $ 1,904 | $ | 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | | |
| Life Cycle Period: | 30 | years | | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 29,973 | | $ 90,567 | **$256,239** | **$ 189,420** | | | |
| 0 | 1.000 | **$ 135,700** | | | $135,700 | $ 135,700 | $ 135,700 | $ 135,700 | $ 189,420 |
| 1 | 0.950 | $630 | $ - | $ 1,904 | $ 2,534 | $ 2,407 | $ 138,234 | $ 138,107 | $ 53,720 |
| 2 | 0.903 | $ 649 | $ - | $ 1,961 | $ 2,610 | $ 2,356 | $ 140,843 | $ 140,463 | $ 51,313 |
| 3 | 0.858 | $ 668 | $ - | $ 2,020 | $ 2,688 | $ 2,305 | $ 143,531 | $ 142,769 | $ 48,957 |
| 4 | 0.815 | $ 688 | $ - | $ 2,080 | $ 2,769 | $ 2,256 | $ 146,300 | $ 145,025 | $ 46,651 |
| 5 | 0.774 | $ 709 | $ - | $ 2,143 | $ 2,852 | $ 2,208 | $ 149,151 | $ 147,233 | $ 44,395 |
| 6 | 0.736 | $ 730 | $ - | $ 2,207 | $ 2,937 | $ 2,161 | $ 152,089 | $ 149,393 | $ 42,187 |
| 7 | 0.699 | $ 752 | $ - | $ 2,273 | $ 3,025 | $ 2,115 | $ 155,114 | $ 151,508 | $ 40,027 |
| 8 | 0.664 | $ 775 | $ - | $ 2,341 | $ 3,116 | $ 2,069 | $ 158,230 | $ 153,577 | $ 37,912 |
| 9 | 0.631 | $ 798 | $ - | $ 2,411 | $ 3,210 | $ 2,025 | $ 161,440 | $ 155,602 | $ 35,843 |
| 10 | 0.599 | $ 822 | $ - | $ 2,484 | $ 3,306 | $ 1,982 | $ 164,745 | $ 157,584 | $ 33,818 |
| 11 | 0.570 | $ 847 | $ - | $ 2,558 | $ 3,405 | $ 1,939 | $ 168,150 | $ 159,524 | $ 31,836 |
| 12 | 0.541 | $ 872 | $ - | $ 2,635 | $ 3,507 | $ 1,898 | $ 171,658 | $ 161,422 | $ 29,896 |
| 13 | 0.514 | $ 898 | $ - | $ 2,714 | $ 3,612 | $ 1,857 | $ 175,270 | $ 163,279 | $ 27,998 |
| 14 | 0.489 | $ 925 | $ - | $ 2,796 | $ 3,721 | $ 1,818 | $ 178,991 | $ 165,097 | $ 26,141 |
| 15 | 0.464 | $ 953 | $ - | $ 2,879 | $ 3,832 | $ 1,779 | $ 182,823 | $ 166,875 | $ 24,323 |
| 16 | 0.441 | $ 982 | $ - | $ 2,966 | $ 3,947 | $ 1,741 | $ 186,770 | $ 168,616 | $ 22,544 |
| 17 | 0.419 | $ 1,011 | $ - | $ 3,055 | $ 4,066 | $ 1,704 | $ 190,836 | $ 170,320 | $ 20,804 |
| 18 | 0.398 | $ 1,041 | $ - | $ 3,146 | $ 4,188 | $ 1,667 | $ 195,024 | $ 171,987 | $ 19,100 |
| 19 | 0.378 | $ 1,073 | $ - | $ 3,241 | $ 4,313 | $ 1,632 | $ 199,337 | $ 173,619 | $ 17,433 |
| 20 | 0.359 | $ 1,105 | $ - | $ 3,338 | $ 4,443 | $ 1,597 | $ 203,780 | $ 175,215 | $ 15,801 |
| 21 | 0.341 | $ 1,138 | $ - | $ 3,438 | $ 4,576 | $ 1,563 | $ 208,356 | $ 176,778 | $ 14,205 |
| 22 | 0.324 | $ 1,172 | $ - | $ 3,541 | $ 4,713 | $ 1,529 | $ 213,070 | $ 178,307 | $ 12,642 |
| 23 | 0.308 | $ 1,207 | $ - | $ 3,648 | $ 4,855 | $ 1,496 | $ 217,924 | $ 179,803 | $ 11,113 |
| 24 | 0.293 | $ 1,243 | $ - | $ 3,757 | $ 5,000 | $ 1,464 | $ 222,925 | $ 181,268 | $ 9,617 |
| 25 | 0.278 | $ 1,281 | $ - | $ 3,870 | $ 5,150 | $ 1,433 | $ 228,075 | $ 182,701 | $ 8,152 |
| 26 | 0.264 | $ 1,319 | $ - | $ 3,986 | $ 5,305 | $ 1,402 | $ 233,380 | $ 184,103 | $ 6,719 |
| 27 | 0.251 | $ 1,359 | $ - | $ 4,105 | $ 5,464 | $ 1,373 | $ 238,844 | $ 185,476 | $ 5,317 |
| 28 | 0.239 | $ 1,399 | $ - | $ 4,229 | $ 5,628 | $ 1,343 | $ 244,472 | $ 186,819 | $ 3,944 |
| 29 | 0.227 | $ 1,441 | $ - | $ 4,355 | $ 5,797 | $ 1,314 | $ 250,269 | $ 188,134 | $ 2,601 |
| 30 | 0.215 | $ 1,485 | $ - | $ 4,486 | $ 5,971 | $ 1,286 | $ 256,239 | $ 189,420 | $ 1,286 |

**Description: WQBE_21D_High Rate Underground Filter In Highway ROW HMA**
An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Life-Cycle Cost Model Input Assumptions:**
Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

6 Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year.

4 Biannually the 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours. Assumed annual cost of $113 for mulch.

4 Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 1 hour per visit. Total of 4 man hours.

Annual mulch and plan replacements 5 plants at $54/Plant

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Replacement Assumptions:**
No capital replacement assumed in 30-year life.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_21D_High Rate Underground Filter In Highway ROW HMA | | | **Version:** | 3 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Treatment BMP** | | | $ - | $ - |
| 2 | Filterra Unit 4'X4' (complete) | 1 | EA | $ 19,680 | $ 19,680 |
| 3 | Structural Excavation to Waste (10'W X10'L X 5'D) + (50'LX5'WX6'D) | 74 | CY | $ 79 | $ 5,852 |
| 4 | Imported Structural Fill | 71 | CY | $ 44 | $ 3,129 |
| 5 | Crushed Base | 1 | CY | $ 64 | $ 64 |
| 6 | Inlets with energy dissipating rocks | 1 | EA | $ 1,481 | $ 1,481 |
| 7 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 8 | Pipe 8" PSD, DI CL 50 | 50 | LF | $ 160 | $ 8,000 |
| 9 | Trench Box Shoring (Shallow) | 390 | SF | $ 10 | $ 3,900 |
| 10 | **Restoration** | | | $ - | $ - |
| 11 | Pavement Patching HMA 4" HMA/4"CSBC | 36 | SY | $ 71 | $ 2,564 |
| 12 | Concrete Curb and Gutter | 15 | LF | $ 111 | $ 1,665 |
| 13 | Sidewalk 6' Wide | 10 | SY | $ 125 | $ 1,250 |
| 14 | Landscaping, planting, and restoration | 10 | SY | $ 59 | $ 590 |
| 15 | Street Tree | 1 | EA | $ 720 | $ 720 |
| 16 | **Additional Costs** | | | | $ - |
| 17 | Removals @ 4% Construction Costs | 4.0% | LS | $ 52,795 | $ 2,112 |
| 18 | Traffic Control (Light) | 0.5 | MO | $ 10,430 | $ 5,215 |
| 19 | TESC @2% Construction Costs | 2% | LS | $ 60,122 | $ 1,202 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 61,324 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 6,132 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 67,456 |
| ***Direct: Subtotal Construction Costs ( SF Area)*** | | | ***$ 67,456*** |

**Description: WQBE_21D_High Rate Underground Filter In Highway ROW HMA**

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Cost Estimating Assumptions:**

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6"thick.
The facility treatment area is 16 sf (4'X4') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
Installation is within a roadside right-of-way and does not require easements or acquisition
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
The excavated material is unsuitable for use as backfill.
Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.
A total of 50 LF of 8" storm pipe is required to connect to a downstream main or facility.
Trench Box shoring is used.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
Rural roadway restoration is assumed consisting of 4"HMA/4"CSTC.
Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.
Removals are estimated at 4% of the item construction costs, in conformance with LTCP University GSI cost estimates.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located within the ROW and Traffic control is required. Traffic conditions are assumed to be heavy for the urban setting and light for the rural setting.
A street use permit is required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.
It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Andrew Staples (HDR) |
| **Description:** | WQBE 21E_High Rate Underground Filter On Public Property | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | High Rate Underground Filter (16 s.f.) | 1 | EA | $ 52,533 | $ 52,533 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 52,533*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 7,880 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 60,413*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 6,041 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 66,454*** |
| | | | | Construction Sales Tax | $ 6,812 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 73,300*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 7,975 |
| | | | | Construction Management | $ 5,316 |
| | | | | Permitting & Support | $ 332 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 3,323 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 16,946*** |
| | | | | Project Contingency | $ 13,537 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 30,500*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 103,800*** |

**Description: WQBE 21E_High Rate Underground Filter On Public Property**
**(2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 103,800** | |
| Capital cost | $ 103,800.00 | $/Unit |
| Total Direct O&M/Year | $ 1,903.65 | |
| Direct O&M cost | $ 1,903.65 | $/Unit |
| Capital Replacement Costs (10 Years) | $ - | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

No replacement costs

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 157,500** | **$/unit** |
| **Annual O&M Cost** | **$ 2,500** | **$/year** |
| Annualized Cost | $1,000 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| Mulch Replacement | $ - | $ 113 | $/year |
| Plant Material | $ - | $ 270 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $ 630 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash | 6 | hr | |
| Plant Health | 4 | hr | |
| Mulch Replacement | 4 | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 14 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 761 | |
| Labor cost, burdened | O/H 150.0% | $ 1,904 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 29,973 | | $ 90,567 | **$224,339** | **$ 157,520** | | | |
| 0 | 1.000 | **$ 103,800** | | | $103,800 | $ 103,800 | $ 103,800 | $ 103,800 | $ 157,520 |
| 1 | 0.950 | $630 | $ - | $ 1,904 | $ 2,534 | $ 2,407 | $ 106,334 | $ 106,207 | $ 53,720 |
| 2 | 0.903 | $ 649 | $ - | $ 1,961 | $ 2,610 | $ 2,356 | $ 108,943 | $ 108,563 | $ 51,313 |
| 3 | 0.858 | $ 668 | $ - | $ 2,020 | $ 2,688 | $ 2,305 | $ 111,631 | $ 110,869 | $ 48,957 |
| 4 | 0.815 | $ 688 | $ - | $ 2,080 | $ 2,769 | $ 2,256 | $ 114,400 | $ 113,125 | $ 46,651 |
| 5 | 0.774 | $ 709 | $ - | $ 2,143 | $ 2,852 | $ 2,208 | $ 117,251 | $ 115,333 | $ 44,395 |
| 6 | 0.736 | $ 730 | $ - | $ 2,207 | $ 2,937 | $ 2,161 | $ 120,189 | $ 117,493 | $ 42,187 |
| 7 | 0.699 | $ 752 | $ - | $ 2,273 | $ 3,025 | $ 2,115 | $ 123,214 | $ 119,608 | $ 40,027 |
| 8 | 0.664 | $ 775 | $ - | $ 2,341 | $ 3,116 | $ 2,069 | $ 126,330 | $ 121,677 | $ 37,912 |
| 9 | 0.631 | $ 798 | $ - | $ 2,411 | $ 3,210 | $ 2,025 | $ 129,540 | $ 123,702 | $ 35,843 |
| 10 | 0.599 | $ 822 | $ - | $ 2,484 | $ 3,306 | $ 1,982 | $ 132,845 | $ 125,684 | $ 33,818 |
| 11 | 0.570 | $ 847 | $ - | $ 2,558 | $ 3,405 | $ 1,939 | $ 136,250 | $ 127,624 | $ 31,836 |
| 12 | 0.541 | $ 872 | $ - | $ 2,635 | $ 3,507 | $ 1,898 | $ 139,758 | $ 129,522 | $ 29,896 |
| 13 | 0.514 | $ 898 | $ - | $ 2,714 | $ 3,612 | $ 1,857 | $ 143,370 | $ 131,379 | $ 27,998 |
| 14 | 0.489 | $ 925 | $ - | $ 2,796 | $ 3,721 | $ 1,818 | $ 147,091 | $ 133,197 | $ 26,141 |
| 15 | 0.464 | $ 953 | $ - | $ 2,879 | $ 3,832 | $ 1,779 | $ 150,923 | $ 134,975 | $ 24,323 |
| 16 | 0.441 | $ 982 | $ - | $ 2,966 | $ 3,947 | $ 1,741 | $ 154,870 | $ 136,716 | $ 22,544 |
| 17 | 0.419 | $ 1,011 | $ - | $ 3,055 | $ 4,066 | $ 1,704 | $ 158,936 | $ 138,420 | $ 20,804 |
| 18 | 0.398 | $ 1,041 | $ - | $ 3,146 | $ 4,188 | $ 1,667 | $ 163,124 | $ 140,087 | $ 19,100 |
| 19 | 0.378 | $ 1,073 | $ - | $ 3,241 | $ 4,313 | $ 1,632 | $ 167,437 | $ 141,719 | $ 17,433 |
| 20 | 0.359 | $ 1,105 | $ - | $ 3,338 | $ 4,443 | $ 1,597 | $ 171,880 | $ 143,315 | $ 15,801 |
| 21 | 0.341 | $ 1,138 | $ - | $ 3,438 | $ 4,576 | $ 1,563 | $ 176,456 | $ 144,878 | $ 14,205 |
| 22 | 0.324 | $ 1,172 | $ - | $ 3,541 | $ 4,713 | $ 1,529 | $ 181,170 | $ 146,407 | $ 12,642 |
| 23 | 0.308 | $ 1,207 | $ - | $ 3,648 | $ 4,855 | $ 1,496 | $ 186,024 | $ 147,903 | $ 11,113 |
| 24 | 0.293 | $ 1,243 | $ - | $ 3,757 | $ 5,000 | $ 1,464 | $ 191,025 | $ 149,368 | $ 9,617 |
| 25 | 0.278 | $ 1,281 | $ - | $ 3,870 | $ 5,150 | $ 1,433 | $ 196,175 | $ 150,801 | $ 8,152 |
| 26 | 0.264 | $ 1,319 | $ - | $ 3,986 | $ 5,305 | $ 1,402 | $ 201,480 | $ 152,203 | $ 6,719 |
| 27 | 0.251 | $ 1,359 | $ - | $ 4,105 | $ 5,464 | $ 1,373 | $ 206,944 | $ 153,576 | $ 5,317 |
| 28 | 0.239 | $ 1,399 | $ - | $ 4,229 | $ 5,628 | $ 1,343 | $ 212,572 | $ 154,919 | $ 3,944 |
| 29 | 0.227 | $ 1,441 | $ - | $ 4,355 | $ 5,797 | $ 1,314 | $ 218,369 | $ 156,234 | $ 2,601 |
| 30 | 0.215 | $ 1,485 | $ - | $ 4,486 | $ 5,971 | $ 1,286 | $ 224,339 | $ 157,520 | $ 1,286 |

**Description: WQBE 21E_High Rate Underground Filter On Public Property**
An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Life-Cycle Cost Model Input Assumptions:**
Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

6 Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year.
4 Biannually the 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours. Assumed annual cost of $113 for mulch.
4 Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 1 hour per visit. Total of 4 man hours.
Annual mulch and plan replacements 5 plants at $54/Plant
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Replacement Assumptions:**
No capital replacement assumed in 30-year life.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Andrew Staples (HDR) |
| **Description:** | WQBE 21E_High Rate Underground Filter On Public Property | | | **Version:** | 3 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Treatment BMP** | | | | $ - |
| 2 | Filterra Unit 4'X4' (complete) | 1 | EA | $ 19,680 | $ 19,680 |
| 3 | Structural Excavation to Waste (10'W X10'L X 5'D) + (50'LX5'WX6'D) | 74 | CY | $ 79 | $ 5,852 |
| 4 | Imported Structural Fill | 71 | CY | $ 44 | $ 3,129 |
| 5 | Crushed Base | 1 | CY | $ 64 | $ 64 |
| 6 | Inlet Drain w/Energy Dissipating Rocks | 1 | EA | $ 1,481 | $ 1,481 |
| 7 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 8 | Pipe 8" dia. | 50 | LF | $ 80 | $ 4,000 |
| 9 | Trench Box Shoring (Shallow) | 390 | SF | $ 10 | $ 3,900 |
| 10 | **Restoration** | | | $ - | $ - |
| 11 | Landscaping, planting, and restoration | 39 | SY | $ 59 | $ 2,294 |
| 12 | Street Tree | 1 | EA | $ 720 | $ 720 |
| 13 | **Additional Costs** | | | | $ - |
| 14 | Removals @ 4% Construction Costs | 4.0% | LS | $ 45,020 | $ 1,801 |
| 15 | TESC @2% Construction Costs | 2% | LS | $ 46,821 | $ 936 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 47,757 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | General Conditions | | 0% | 1 | $ - |
| | Mobilization/Demobilization | | 10% | 1.1 | $ 4,776 |
| | Overhead & Profit (OHP) | | 0% | 1 | $ - |
| | Insurance | | 0.0% | 1 | $ - |
| | Bonding | | 0.0% | 1 | $ - |
| | Escalation Multiplier from ENR-CCI | | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 52,533 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 52,533*** |

**Description: WQBE 21E_High Rate Underground Filter On Public Property**

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Cost Estimating Assumptions:**
Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6"thick.
The facility treatment area is 16 sf (4'X4') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
Installation is on public property and does not require easements or acquisition
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
The excavated material is unsuitable for use as backfill.
Facility is not sited on the roadside and assumes no restoration of curb, gutter or roadway to accommodate the facility.
A total of 50 LF of 8" storm pipe is required to connect to a downstream main or facility.
Trench Box shoring is used.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
No roadway restoration is assumed.
No Concrete curb, gutter, sidewalk restoration will be required for the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.
Removals are estimated at 4% of the item construction costs, in conformance with LTCP University GSI cost estimates.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and Traffic Control is not required.
A street use permit is **not** required.

**Planning Basis Assumptions:**
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.
It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 21F_High Rate Underground Filter with Property Cost | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | High Rate Underground Filter (16 s.f.) | 1 | EA | $ 52,533 | $ 52,533 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 52,533*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 7,880 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 60,413*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 6,041 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 66,454*** |
| | | | | Construction Sales Tax | $ 6,812 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 73,300*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 7,975 |
| | | | | Construction Management | $ 5,316 |
| | | | | Permitting & Support | $ 332 |
| 16 | s.f. Land Area | Medium | Land Purchase/ROW Acquisition | | $ 1,287 |
| | | | | | |
| | | | | WTD Staff Costs & Non-WTD Support | $ 3,323 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 18,233*** |
| | | | | Project Contingency | $ 13,730 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 32,000*** |
| | | | | ***TOTAL PROJECT COST (2023 Dollars)*** | ***$ 105,300*** |

**Description: WQBE 21F_High Rate Underground Filter with Property Cost**
**(2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 105,300** | |
| Capital cost | $ 105,300 | $/Unit |
| Total Direct O&M/Year | $ 1,904 | |
| Direct O&M cost | $ 1,904 | $/Unit |
| Capital Replacement Costs (10 Years) | $ - | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

No replacement costs

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 159,000** | **$/unit** |
| **Annual O&M Cost** | **$ 2,500** | **$/year** |
| Annualized Cost | $1,000 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| Mulch Replacement | $ - | $ 113 | $/year |
| Plant Material | $ - | $ 270 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $ 630 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash | 6 | hr | |
| Plant Health | 4 | hr | |
| Mulch Replacement | 4 | hr | |
| Activity | 0 | hr | |
| **Total hours per year** | 14 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 761 | |
| Labor cost, burdened | O/H 150.0% | $ 1,904 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 29,973 | | $ 90,567 | **$225,839** | **$ 159,020** | | | |
| 0 | 1.000 | **$ 105,300** | | | $105,300 | $ 105,300 | $ 105,300 | $ 105,300 | $ 159,020 |
| 1 | 0.950 | $630 | $ - | $ 1,904 | $ 2,534 | $ 2,407 | $ 107,834 | $ 107,707 | $ 53,720 |
| 2 | 0.903 | $ 649 | $ - | $ 1,961 | $ 2,610 | $ 2,356 | $ 110,443 | $ 110,063 | $ 51,313 |
| 3 | 0.858 | $ 668 | $ - | $ 2,020 | $ 2,688 | $ 2,305 | $ 113,131 | $ 112,369 | $ 48,957 |
| 4 | 0.815 | $ 688 | $ - | $ 2,080 | $ 2,769 | $ 2,256 | $ 115,900 | $ 114,625 | $ 46,651 |
| 5 | 0.774 | $ 709 | $ - | $ 2,143 | $ 2,852 | $ 2,208 | $ 118,751 | $ 116,833 | $ 44,395 |
| 6 | 0.736 | $ 730 | $ - | $ 2,207 | $ 2,937 | $ 2,161 | $ 121,689 | $ 118,993 | $ 42,187 |
| 7 | 0.699 | $ 752 | $ - | $ 2,273 | $ 3,025 | $ 2,115 | $ 124,714 | $ 121,108 | $ 40,027 |
| 8 | 0.664 | $ 775 | $ - | $ 2,341 | $ 3,116 | $ 2,069 | $ 127,830 | $ 123,177 | $ 37,912 |
| 9 | 0.631 | $ 798 | $ - | $ 2,411 | $ 3,210 | $ 2,025 | $ 131,040 | $ 125,202 | $ 35,843 |
| 10 | 0.599 | $ 822 | $ - | $ 2,484 | $ 3,306 | $ 1,982 | $ 134,345 | $ 127,184 | $ 33,818 |
| 11 | 0.570 | $ 847 | $ - | $ 2,558 | $ 3,405 | $ 1,939 | $ 137,750 | $ 129,124 | $ 31,836 |
| 12 | 0.541 | $ 872 | $ - | $ 2,635 | $ 3,507 | $ 1,898 | $ 141,258 | $ 131,022 | $ 29,896 |
| 13 | 0.514 | $ 898 | $ - | $ 2,714 | $ 3,612 | $ 1,857 | $ 144,870 | $ 132,879 | $ 27,998 |
| 14 | 0.489 | $ 925 | $ - | $ 2,796 | $ 3,721 | $ 1,818 | $ 148,591 | $ 134,697 | $ 26,141 |
| 15 | 0.464 | $ 953 | $ - | $ 2,879 | $ 3,832 | $ 1,779 | $ 152,423 | $ 136,475 | $ 24,323 |
| 16 | 0.441 | $ 982 | $ - | $ 2,966 | $ 3,947 | $ 1,741 | $ 156,370 | $ 138,216 | $ 22,544 |
| 17 | 0.419 | $ 1,011 | $ - | $ 3,055 | $ 4,066 | $ 1,704 | $ 160,436 | $ 139,920 | $ 20,804 |
| 18 | 0.398 | $ 1,041 | $ - | $ 3,146 | $ 4,188 | $ 1,667 | $ 164,624 | $ 141,587 | $ 19,100 |
| 19 | 0.378 | $ 1,073 | $ - | $ 3,241 | $ 4,313 | $ 1,632 | $ 168,937 | $ 143,219 | $ 17,433 |
| 20 | 0.359 | $ 1,105 | $ - | $ 3,338 | $ 4,443 | $ 1,597 | $ 173,380 | $ 144,815 | $ 15,801 |
| 21 | 0.341 | $ 1,138 | $ - | $ 3,438 | $ 4,576 | $ 1,563 | $ 177,956 | $ 146,378 | $ 14,205 |
| 22 | 0.324 | $ 1,172 | $ - | $ 3,541 | $ 4,713 | $ 1,529 | $ 182,670 | $ 147,907 | $ 12,642 |
| 23 | 0.308 | $ 1,207 | $ - | $ 3,648 | $ 4,855 | $ 1,496 | $ 187,524 | $ 149,403 | $ 11,113 |
| 24 | 0.293 | $ 1,243 | $ - | $ 3,757 | $ 5,000 | $ 1,464 | $ 192,525 | $ 150,868 | $ 9,617 |
| 25 | 0.278 | $ 1,281 | $ - | $ 3,870 | $ 5,150 | $ 1,433 | $ 197,675 | $ 152,301 | $ 8,152 |
| 26 | 0.264 | $ 1,319 | $ - | $ 3,986 | $ 5,305 | $ 1,402 | $ 202,980 | $ 153,703 | $ 6,719 |
| 27 | 0.251 | $ 1,359 | $ - | $ 4,105 | $ 5,464 | $ 1,373 | $ 208,444 | $ 155,076 | $ 5,317 |
| 28 | 0.239 | $ 1,399 | $ - | $ 4,229 | $ 5,628 | $ 1,343 | $ 214,072 | $ 156,419 | $ 3,944 |
| 29 | 0.227 | $ 1,441 | $ - | $ 4,355 | $ 5,797 | $ 1,314 | $ 219,869 | $ 157,734 | $ 2,601 |
| 30 | 0.215 | $ 1,485 | $ - | $ 4,486 | $ 5,971 | $ 1,286 | $ 225,839 | $ 159,020 | $ 1,286 |

**Description: WQBE 21F_High Rate Underground Filter with Property Cost**

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

6 Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year.

4 Biannually the 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours. Assumed annual cost of $113 for mulch.

4 Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 1 hour per visit. Total of 4 man hours.

Annual mulch and plan replacements 5 plants at $54/Plant

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Replacement Assumptions:**

No capital replacement assumed in 30-year life.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation - WO12 | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 21F_High Rate Underground Filter with Property Cost | | | **Version:** | 3 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Treatment BMP** | | | | $ - |
| 2 | Filterra Unit 4'X4' (complete) | 1 | EA | $ 19,680 | $ 19,680 |
| 3 | Structural Excavation to Waste (10'W X10'L X 5'D) + (50'LX5'WX6'D) | 74 | CY | $ 79 | $ 5,852 |
| 4 | Imported Structural Fill | 71 | CY | $ 44 | $ 3,129 |
| 5 | Crushed Base | 1 | CY | $ 64 | $ 64 |
| 6 | Inlet Drain w/Energy Dissipating Rocks | 1 | EA | $ 1,481 | $ 1,481 |
| 7 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 8 | Pipe 8" dia. | 50 | LF | $ 80 | $ 4,000 |
| 9 | Trench Box Shoring (Shallow) | 390 | SF | $ 10 | $ 3,900 |
| 10 | **Restoration** | | | $ - | $ - |
| 11 | Landscaping, planting, and restoration | 39 | SY | $ 59 | $ 2,294 |
| 12 | Street Tree | 1 | EA | $ 720 | $ 720 |
| 13 | **Additional Costs** | | | | $ - |
| 14 | Removals @ 4% Construction Costs | 4.0% | LS | $ 45,020 | $ 1,801 |
| 15 | TESC @2% Construction Costs | 2% | LS | $ 46,821 | $ 936 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 47,757 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 4,776 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 52,533 |
| ***Direct: Subtotal Construction Costs)*** | | | ***$ 52,533*** |

**Description: WQBE 21F_High Rate Underground Filter with Property Cost**

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Cost Estimating Assumptions:**

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6"thick.
The facility treatment area is 16 sf (4'X4') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
It is assumed that this facility is on property. Property acquisition and easement costs **are** included.
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
The excavated material is unsuitable for use as backfill.
Facility is not sited on the roadside and assumes no restoration of curb, gutter or roadway to accommodate the facility.
A total of 50 LF of 8" storm pipe is required to connect to a downstream main or facility.
Trench Box shoring is used.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
No roadway restoration is assumed.
No Concrete curb, gutter, sidewalk restoration will be required for the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.
Removals are estimated at 4% of the item construction costs, in conformance with LTCP University GSI cost estimates.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and Traffic Control is not required.
A street use permit is not required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.
It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Updated on: 06/07/24

Phase 2 Updated on: 5/6/21

| | | | | | | | PHASE 3 COSTS (2023 Dollars) | | | | | | | | PHASE 2 COSTS (2019 Dollars) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item No. | Action | Class | Complexity | Description | Sub-Action Number | Subcategory | Action Unit | Design Drainage Area | Total Direct Construction Cost | Property acquisition | Total Indirect Non-Construction Costs | Total Project Cost | O&M Costs (Annual) | Life Cycle Cost (NPV) | Action Unit | Total Direct Construction Cost | Property acquisition | Total Indirect Non-Construction Costs | Total Project Cost | O&M Costs (Annual) | Life Cycle Cost (NPV) |
| 11 | Detention Vault | Class 10 | Routine | WQBE_11A_Detention Vault on Public Property | 11A | On property without Acquisition | 1 Each | 28,658 SF | $3,281,800 | $0 | $2,493,700 | $5,775,500 | $5,200 | $5,905,200 | 1 Each | $3,519,000 | $0 | $2,710,000 | $6,229,000 | $4,900 | $6,352,000 |
| | | | | WQBE_11B_Detention Vault in ROW | 11B | In ROW/Highway | 1 Each | 28,658 SF | $3,638,400 | $0 | $2,664,000 | $6,302,400 | $5,200 | $6,432,100 | 1 Each | $4,473,000 | $0 | $3,130,500 | $7,603,000 | $4,900 | $7,727,000 |
| | | | | WQBE_11C_Detention Vault With Property Cost | 11C | On Property with Acquisition | 1 Each | 28,658 SF | $3,281,800 | $422,603 | $3,043,100 | $6,324,900 | $5,200 | $6,454,600 | 1 Each | $3,519,000 | $589,000 | $3,446,000 | $6,965,000 | $4,900 | $7,085,000 |
| 12 | Detention Pond | Class 10 | Routine | WQBE_12A_Detention Pond on Public Property | 12A | On Property/Highway without Acquisition | 1 Each | 36,569 SF | $694,600 | $0 | $527,800 | $1,222,400 | $10,000 | $1,444,200 | 1 Each | $617,000 | $0 | $484,000 | $1,102,000 | $9,400 | $1,473,000 |
| | | | | WQBE_12B_Detention Pond With Property Cost | 12B | On property with Acquisition | 1 Each | 36,569 SF | $694,200 | $1,144,543 | $2,015,400 | $2,709,600 | $10,000 | $2,931,400 | 1 Each | $617,000 | $1,073,000 | $1,826,000 | $2,443,000 | $9,400 | $2,807,000 |
| 13 | Infiltration Pond | Class 10 | Routine | WQBE_13A_Infiltration Pond Till Soil on Public Property | 13A | On Property/Highway without Acquisition - In Till Soil | 1 Each | 36,595 SF | $500,500 | $0 | $380,300 | $880,800 | $5,900 | $1,016,100 | 1 Each | $395,000 | $0 | $310,000 | $705,000 | $5,500 | $971,000 |
| | | | | WQBE_13B_Infiltration Pond Outwash Soil on Public Property | 13B | On Property/Highway without Acquisition - In Outwash Soil | 1 Each | 46,396 SF | $448,200 | $0 | $340,600 | $788,800 | $3,700 | $878,000 | 1 Each | $352,000 | $0 | $276,000 | $629,000 | $3,500 | $836,000 |
| | | | | WQBE_13C_Infiltration Pond Till Soil with Property Cost | 13C | On property with Acquisition - Till Soil | 1 Each | 36,595 SF | $500,500 | $891,189 | $1,538,800 | $2,039,300 | $5,900 | $2,174,600 | 1 Each | $395,000 | $903,000 | $1,439,000 | $1,834,000 | $5,500 | $2,094,000 |
| | | | | WQBE_13D_Infiltration Pond Outwash Soil with Property Cost | 13D | On property with Acquisition - Outwash Soil | 1 Each | 46,396 SF | $448,200 | $891,189 | $1,499,100 | $1,947,300 | $3,700 | $2,036,500 | 1 Each | $352,000 | $903,000 | $1,405,000 | $1,758,000 | $3,500 | $1,959,000 |
| | | | | WQBE_13E_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Public Property | 13E | On Property without Acquisition - In Outwash Soil with High Rate Underground Filter System | 1 Each | 52,164 SF | $529,400 | $0 | $402,300 | $931,700 | $6,600 | $1,082,700 | 1 Each | $424,000 | $0 | $332,000 | $756,000 | $6,400 | $1,033,000 |
| | | | | WQBE_13F_Infiltration Pond Outwash Soil with High Rate Underground Filter System with Property Cost | 13F | On Property with Acquisition - In Outwash Soil with High Rate Underground Filter System | 1 Each | 52,164 SF | $529,400 | $893,119 | $1,563,300 | $2,092,700 | $6,600 | $2,243,700 | | | | | | | |
| 14 | Infiltration Vault | Class 10 | Routine | WQBE_14A_Infiltration Vault Till Soil on Public Property | 14A | On Property/Highway without Acquisition - In Till Soil | 1 Each | 28,719 SF | $2,262,300 | $0 | $1,719,000 | $3,981,300 | $4,800 | $4,104,000 | 1 Each | $2,577,000 | $0 | $2,012,000 | $4,589,000 | $4,900 | $4,721,000 |
| | | | | WQBE_14B_Infiltration Vault Outwash Soil on Public Property | 14B | On Property/Highway without Acquisition - In Outwash Soil | 1 Each | 39,365 SF | $1,870,200 | $0 | $1,421,100 | $3,291,300 | $4,800 | $3,414,000 | 1 Each | $2,009,000 | $0 | $1,562,000 | $3,572,000 | $4,900 | $3,709,000 |
| | | | | WQBE_14C_Infiltration Vault Till Soil in ROW | 14C | In ROW/Highway - In Till Soil | 1 Each | 28,719 SF | $2,782,300 | $0 | $2,038,800 | $4,821,100 | $4,800 | $4,943,800 | 1 Each | $3,008,000 | $0 | $2,245,000 | $5,253,000 | $4,900 | $5,384,000 |
| | | | | WQBE_14D_Infiltration Vault Outwash Soil in ROW | 14D | In ROW/Highway - In Outwash Soil | 1 Each | 39,365 SF | $2,282,500 | $0 | $1,673,800 | $3,956,300 | $4,800 | $4,079,000 | 1 Each | $2,351,000 | $0 | $1,769,000 | $4,120,000 | $4,900 | $4,257,000 |
| | | | | WQBE_14E_Infiltration Vault Till Soil With Property Cost | 14E | On property with Acquisition - Till Soil | 1 Each | 28,719 SF | $2,262,300 | $340,082 | $2,161,200 | $4,423,500 | $4,800 | $4,546,200 | 1 Each | $2,577,000 | $533,000 | $2,679,000 | $5,256,000 | $4,900 | $5,385,000 |
| | | | | WQBE_14F_Infiltration Vault Outwash Soil with Property Cost | 14F | On property with Acquisition - Outwash Soil | 1 Each | 39,365 SF | $1,870,200 | $340,082 | $1,863,200 | $3,733,400 | $4,800 | $3,856,100 | 1 Each | $2,009,000 | $533,000 | $2,229,000 | $4,238,000 | $4,900 | $4,372,000 |
| | | | | WQBE_14G_Infiltration Vault Outwash Soil with High Rate Underground Filter System in ROW | 14G | In ROW/Highway - In Outwash Soil With High Rate Underground Filter System | 1 Each | 52,164 SF | $2,211,100 | $0 | $1,621,700 | $3,832,800 | $6,600 | $3,992,400 | 1 Each | $2,368,000 | $0 | $1,795,000 | $4,163,000 | $7,800 | $4,376,000 |
| | | | | WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System with Property Cost | 14H | On Property with Acquisition - In Outwash Soil With High Rate Underground Filter System | 1 Each | 52,164 SF | $2,175,500 | $342,013 | $2,040,300 | $4,215,800 | $6,600 | $4,375,400 | | | | | | | |
| | | | | WQBE_14I_Infiltration Vault Outwash Soil with High Rate Underground Filter System without Property Cost | 14I | On Property without Acquisition - In Outwash Soil With High Rate Underground Filter System | 1 Each | 52,164 SF | $2,175,500 | $0 | $1,595,700 | $3,771,200 | $6,600 | $3,930,800 | | | | | | | |
| 18 | WetPond | Class 10 | Routine | WQBE_18A_ Wetpond On Public Property | 18A | On Property/Highway without Acquisition | 553 SF | 63,075 SF | $493,900 | $0 | $375,300 | $869,200 | $2,200 | $929,200 | 553 SF | $383,000 | $0 | $300,000 | $683,000 | $2,000 | $852,000 |
| | | | | WQBE_18B_ Wetpond with Property Cost | 18B | On Property with Acquisition | 553 SF | 63,075 SF | $493,900 | $615,475 | $1,175,400 | $1,669,300 | $2,200 | $1,729,300 | 553 SF | $383,000 | $718,000 | $1,198,000 | $1,581,000 | $2,000 | $1,745,000 |
| 19 | WetVault | Class 10 | Routine | WQBE_19A_ WetVault On Public Property | 19A | On property without Acquisition | 1 Each | 63,010 SF | $2,981,300 | $0 | $2,265,400 | $5,246,700 | $3,100 | $5,333,600 | 1 Each | $2,852,000 | $0 | $2,203,000 | $5,055,000 | $2,900 | $5,125,000 |
| | | | | WQBE_19B_ WetVault In ROW | 19B | On Property/Highway without Acquisition | 1 Each | 63,010 SF | $3,342,400 | $0 | $2,447,900 | $5,790,300 | $3,100 | $5,877,200 | 1 Each | $3,314,000 | $0 | $2,493,000 | $5,806,000 | $2,900 | $5,874,000 |
| | | | | WQBE_19C_ WetVault with Property Cost | 19C | On Property with Acquisition | 1 Each | 63,010 SF | $2,981,300 | $347,803 | $2,717,500 | $5,698,800 | $3,100 | $5,785,700 | 1 Each | $2,852,000 | $538,000 | $2,876,000 | $5,728,000 | $2,900 | $5,795,000 |
| 20 | SW Treatment Wetland | Class 10 | Routine | WQBE_20A_ Stormwater Treatment Wetland on Public Property | 20A | On Property/Highway without Acquisition | 503 SF | 62,988 SF | $463,100 | $0 | $351,900 | $815,000 | $2,500 | $880,800 | 503 SF | $360,000 | $0 | $282,000 | $642,000 | $2,300 | $817,000 |
| | | | | WQBE_20B_ Stormwater Treatment Wetland with Property Cost | 20B | On property with Acquisition | 503 SF | 62,988 SF | $463,100 | $555,554 | $1,074,100 | $1,537,200 | $2,500 | $1,603,000 | 503 SF | $360,000 | $678,000 | $1,130,000 | $1,489,000 | $2,300 | $1,659,000 |

| MANDATORY INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |
| Retail Sales Tax Rate | 10.25% | Current Rate within City of Seattle is 10.25%, 10.1% outside of Seattle |
| Allowance for Indeterminates (AFI), Dependenent Upon Project Phase | 20% | Complexity Inputs for AFI (High = 30%; Moderate = 25%; Routine = 20%; Low = 15%) |
| Construction Change Order Allowance | 10% | |
| Project Contingency | 30% | Complexity Inputs (Moderate, & Routine = 30%; Override for Low = 15%) |

| SECONDARY INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |
| Street Use Permit | $ 90,000 | In ROW only - Arterial @ $90,000/Unit; Non-Arterial @use $30000/unit |
| Outside Agency Construction | 10% | For Projects in ROW Utility Outside Agency Construction estimated at 10% construction cost. |

| PROJECT CATEGORY AND INDIRECT PROJECT INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |

**PROPERTY COST**

| Cost Category | $/sf |
| --- | --- |
| Low | $ 10.10 |
| Medium | $ 80.43 |
| High | $ 284.37 |
| None | $ - |

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Tataina Skadorwa (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_11A_Detention Vault on Public Property | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Detention Vault (15,500 cf effective storage) | 1 | EA | $ 2,255,100 | $ 2,255,100 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 2,255,100*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 451,020 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 2,706,120*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 270,612 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 2,976,732*** |
| | | | | Construction Sales Tax | $ 305,115 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 3,281,800*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 654,881 |
| | | | | Construction Management | $ 297,673 |
| | | | | Permitting & Support | $ 29,767 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 178,604 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,160,925*** |
| | | | | Project Contingency | $ 1,332,818 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 2,493,700*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 5,775,500*** |

**Description: WQBE_11A_Detention Vault on Public Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| | | |
| **Initial Capital Cost** | **$ 5,775,500** | Does not include property costs |
| Capital cost | $ 5,775,500 | $/Unit |
| Total Direct O&M/Year | $ 4,351 | |
| Direct O&M cost | $ 4,351 | $/Unit |
| Capital Replacement Costs (20 year equipment) | $ 55,700 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 5,905,200** | **$/unit** |
| **Annual O&M Cost** | **$ 5,200** | **$/year** |
| Annualized Cost | $1,310 | $/year |

**Materials, Supplies, Other Costs**

| | | | | |
|---|---|---|---|---|
| | | $ - | $/year | |
| Cement Patching | 2023 dollars | $ 113 | $/year | |
| Vacuum Truck Equipment + Labor | 2023 dollars | $ 711 | $/year | |
| Subtotal | | $824 | | |
| Labor | | | | |
| Vactor to remove sediment and debris | 16 | hr | | |
| Inspection and joint repair, crack repair | 16 | hr | | |
| | 0 | hr | | |
| | 0 | hr | | |
| **Total hours per year** | 32 | | | |
| Raw Labor Rate/Hr | | $ 54 | | |
| Raw labor cost | (embedded) | $ 1,740 | | |
| Labor cost, burdened | O/H 150.0% | $ 4,351 | | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | | |
| Life Cycle Period: | 30 | years | | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 39,202 | | $ 207,010 | **$6,077,412** | **$ 5,905,245** | | | |
| 0 | 1.000 | **$ 5,775,500** | | | $5,775,500 | $ 5,775,500 | $ 5,775,500 | $ 5,775,500 | $ 5,905,245 |
| 1 | 0.950 | $824 | $ - | $ 4,351 | $ 5,175 | $ 4,917 | $ 5,780,675 | $ 5,780,417 | $ 129,745 |
| 2 | 0.903 | $ 849 | $ - | $ 4,482 | $ 5,330 | $ 4,812 | $ 5,786,006 | $ 5,785,229 | $ 124,828 |
| 3 | 0.858 | $ 874 | $ - | $ 4,616 | $ 5,490 | $ 4,709 | $ 5,791,496 | $ 5,789,938 | $ 120,016 |
| 4 | 0.815 | $ 900 | $ - | $ 4,755 | $ 5,655 | $ 4,608 | $ 5,797,151 | $ 5,794,546 | $ 115,307 |
| 5 | 0.774 | $ 927 | $ - | $ 4,897 | $ 5,825 | $ 4,510 | $ 5,802,976 | $ 5,799,056 | $ 110,699 |
| 6 | 0.736 | $ 955 | $ - | $ 5,044 | $ 5,999 | $ 4,413 | $ 5,808,975 | $ 5,803,470 | $ 106,189 |
| 7 | 0.699 | $ 984 | $ - | $ 5,196 | $ 6,179 | $ 4,319 | $ 5,815,155 | $ 5,807,789 | $ 101,775 |
| 8 | 0.664 | $ 1,013 | $ - | $ 5,351 | $ 6,365 | $ 4,227 | $ 5,821,520 | $ 5,812,016 | $ 97,456 |
| 9 | 0.631 | $ 1,044 | $ - | $ 5,512 | $ 6,556 | $ 4,136 | $ 5,828,075 | $ 5,816,152 | $ 93,229 |
| 10 | 0.599 | $ 1,075 | $ - | $ 5,677 | $ 6,752 | $ 4,048 | $ 5,834,828 | $ 5,820,200 | $ 89,093 |
| 11 | 0.570 | $ 1,107 | $ - | $ 5,848 | $ 6,955 | $ 3,961 | $ 5,841,783 | $ 5,824,162 | $ 85,045 |
| 12 | 0.541 | $ 1,141 | $ - | $ 6,023 | $ 7,164 | $ 3,877 | $ 5,848,947 | $ 5,828,038 | $ 81,084 |
| 13 | 0.514 | $ 1,175 | $ - | $ 6,204 | $ 7,379 | $ 3,794 | $ 5,856,325 | $ 5,831,832 | $ 77,207 |
| 14 | 0.489 | $ 1,210 | $ - | $ 6,390 | $ 7,600 | $ 3,713 | $ 5,863,925 | $ 5,835,545 | $ 73,413 |
| 15 | 0.464 | $ 1,246 | $ - | $ 6,582 | $ 7,828 | $ 3,633 | $ 5,871,753 | $ 5,839,179 | $ 69,700 |
| 16 | 0.441 | $ 1,284 | $ - | $ 6,779 | $ 8,063 | $ 3,556 | $ 5,879,816 | $ 5,842,734 | $ 66,067 |
| 17 | 0.419 | $ 1,322 | $ - | $ 6,982 | $ 8,305 | $ 3,480 | $ 5,888,121 | $ 5,846,214 | $ 62,511 |
| 18 | 0.398 | $ 1,362 | $ - | $ 7,192 | $ 8,554 | $ 3,405 | $ 5,896,674 | $ 5,849,619 | $ 59,031 |
| 19 | 0.378 | $ 1,403 | $ - | $ 7,408 | $ 8,810 | $ 3,333 | $ 5,905,485 | $ 5,852,952 | $ 55,626 |
| 20 | 0.359 | $ 1,445 | $ 55,700 | $ 7,630 | $ 64,775 | $ 23,279 | $ 5,970,260 | $ 5,876,231 | $ 52,293 |
| 21 | 0.341 | $ 1,488 | $ - | $ 7,859 | $ 9,347 | $ 3,192 | $ 5,979,607 | $ 5,879,423 | $ 29,014 |
| 22 | 0.324 | $ 1,533 | $ - | $ 8,095 | $ 9,627 | $ 3,123 | $ 5,989,234 | $ 5,882,546 | $ 25,823 |
| 23 | 0.308 | $ 1,579 | $ - | $ 8,337 | $ 9,916 | $ 3,057 | $ 5,999,150 | $ 5,885,602 | $ 22,699 |
| 24 | 0.293 | $ 1,626 | $ - | $ 8,587 | $ 10,214 | $ 2,991 | $ 6,009,364 | $ 5,888,594 | $ 19,643 |
| 25 | 0.278 | $ 1,675 | $ - | $ 8,845 | $ 10,520 | $ 2,927 | $ 6,019,884 | $ 5,891,521 | $ 16,651 |
| 26 | 0.264 | $ 1,725 | $ - | $ 9,110 | $ 10,836 | $ 2,865 | $ 6,030,720 | $ 5,894,386 | $ 13,724 |
| 27 | 0.251 | $ 1,777 | $ - | $ 9,384 | $ 11,161 | $ 2,803 | $ 6,041,880 | $ 5,897,189 | $ 10,859 |
| 28 | 0.239 | $ 1,830 | $ - | $ 9,665 | $ 11,496 | $ 2,744 | $ 6,053,376 | $ 5,899,933 | $ 8,056 |
| 29 | 0.227 | $ 1,885 | $ - | $ 9,955 | $ 11,840 | $ 2,685 | $ 6,065,217 | $ 5,902,618 | $ 5,312 |
| 30 | 0.215 | $ 1,942 | $ - | $ 10,254 | $ 12,196 | $ 2,628 | $ 6,077,412 | $ 5,905,245 | $ 2,628 |

**Description: WQBE_11A_Detention Vault on Public Property**
Box-shaped underground facility that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

**Life-Cycle Cost Model Input Assumptions:**
Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**
Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work
16 day using a vactor truck at $711 total cost for equipment.
Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an
16 8 hour work day. Assume annual cost of $113 for cement patching mix.
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.
**Capital Replacement Assumptions:**
Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Tataina Skadorwa (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_11A_Detention Vault on Public Property | | | **Version:** | 2 |
| | **CONSTRUCTION COSTS** | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Detention Vault on Public Property** | | | | $ - |
| 2 | ***Detention Vault Assumptions*** | | | | $ - |
| 3 | *Exterior Length* | 73 | FT | | $ - |
| 4 | *Interior Length* | 70 | FT | | $ - |
| 5 | *Sump Length* | 4 | FT | | $ - |
| 6 | *Sump Wall Width* | 25 | FT | | $ - |
| | *Sump Interior Depth* | 4 | FT | | $ - |
| | *Sump Wall Total Length* | 64 | FT | | $ - |
| | *Exterior Width* | 28 | FT | | $ - |
| | *Interior Width* | 25 | FT | | $ - |
| | *Interior Structure Height (Ave.)* | 10.5 | FT | | $ - |
| | *Storage Depth (Ave)* | 9 | FT | | $ - |
| | *Sediment Storage Depth* | 0.5 | FT | | $ - |
| | *Freeboard (Ave.)* | 1 | FT | | $ - |
| | *Storage Facility Exterior Footprint Area* | 2,044 | SF | | $ - |
| | | | | | $ - |
| | ***Storage Volume*** | | | | $ - |
| | *Storage Facility interior Area* | 1,750 | SF | | $ - |
| | *Effective Storage Volume (15.500 cf target)* | 15,575 | CF | | $ - |
| | *Vault Storage Volume* | 0.12 | MG | | $ - |
| | | | | | $ - |
| | ***Structure Concrete Assumptions*** | | | | $ - |
| | *Exterior Wall thickness* | 1.5 | FT | | $ - |
| | *Sump Wall Thickness* | 1.5 | FT | | $ - |
| | *Top Slab Thickness* | 2 | FT | | $ - |
| | *Foundation Slab thickness* | 3 | FT | | $ - |
| | *Concrete Reinforcing Rebar* | 225 | LB/CY | | $ - |
| | *Crushed Base Thickness* | 1 | FT | | $ - |
| | | | | | $ - |
| | **Concrete Structure** | | | | $ - |
| | Vault Interior Walls Concrete @2' Thick (partial for supports) | 5 | CY | $ 650 | $ 3,250 |
| | Sump Wall Concrete | 14 | CY | $ 1,250 | $ 17,778 |
| | Exterior Wall Concrete | 118 | CY | $ 1,250 | $ 147,292 |
| | Top Slab Concrete | 151 | CY | $ 1,250 | $ 189,259 |
| | Foundation Slab Concrete | 227 | CY | $ 950 | $ 215,756 |
| | Stormwater Treatment Rebar @ 225 lbs/cy | 116,004 | LBS | $ 1.38 | $ 160,086 |
| | Crushed Base | 76 | CY | $ 64 | $ 4,845 |
| | | | | | $ - |
| | ***Shoring and Excavation Assumptions*** | | | | $ - |
| | *Construction Room* | 3 | FT | | $ - |
| | *Tank Bury Depth* | 2 | FT | | $ - |
| | *Total Excavation Depth* | 19 | FT | | $ - |
| | *Excavation Length* | 83 | FT | | $ - |
| | *Excavation Width* | 38 | FT | | $ - |
| | | | | | $ - |
| | **Soil Excavation and Disposal** | | | | $ - |
| | Excavation to waste | 2,161 | CY | $ 79 | $ 170,725 |
| | Imported Structure Backfill | 912 | CY | $ 44 | $ 40,126 |
| | | | | | $ - |
| | **Solder Pile Shoring** | | | | $ - |
| | *Solder Pile Shaft Depth (3 x Exc. Depth)* | 56 | FT | | $ - |
| | *Solder Pile Shaft Thickness* | 2 | FT | | $ - |
| | *Center to Center Shaft Spacing* | 6 | FT | | $ - |
| | *Rebar in Shaft* | 114 | LB/CY | | $ - |
| | *Shoring Wall Perimeter* | 234 | FT | | $ - |
| | *Number of Shafts* | 39 | EA | | $ - |
| | Drill Solder Pile Shafts | 252 | CY | $ 262 | $ 65,985 |
| | Set Solder Pile and CDF | 252 | CY | $ 391 | $ 98,474 |
| | Purchase and Salvage Solder Piles | 246,753 | LB | $ 0.7 | $ 172,727 |
| | Tie Backs - one per soldier pile except corners | 35 | EA | $ 2,477 | $ 86,695 |
| | Timber Lagging | 14,883 | BF | $ 9 | $ 133,947 |
| | | | | | $ - |
| | **Gates and Access** | | | | $ - |
| | Flow Restrictor | 1 | EA | $ 24,600 | $ 24,600 |
| | Confined Space Safety | 1 | LS | $ 32,595 | $ 32,595 |
| | Access Hatches | 2 | EA | $ 13,038 | $ 26,076 |
| | | | | | $ - |
| | **Conveyance Pipe** | | | | $ - |
| | 12" Storm Pipe (upstream and discharge) | 200 | LF | $ 140 | $ 28,000 |
| | Trench Excavation to waste (8'W X 15'D) | 889 | CY | $ 79 | $ 70,222 |
| | Trench Box Shoring | 6,000 | SF | $ 10 | $ 60,000 |
| | 48" Diameter Maintenance holes | 4 | EA | $ 10,640 | $ 42,560 |
| | Imported Backfill | 883 | CY | $ 44 | $ 38,855 |
| | Dewater Trench - Sumps | 200 | LF | $ 139 | $ 27,800 |
| | Demolish Surface incl. room for construction (@20' wide) | 444 | SY | $ 14 | $ 6,222 |
| | Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100') | 444 | SY | $ 71 | $ 31,556 |
| | | | | | $ - |
| | **Site Removals and Restoration** | | | | $ - |
| | Disking or tilling of compacted soil (assumed 100'X100') | 526 | SY | $ 4 | $ 2,103 |
| | Seeding, mulching and compost | 526 | SY | $ 10 | $ 5,257 |
| | Demolish Existing Surface | 350 | SY | $ 14 | $ 4,906 |
| | Pavement Restoration (Vault) - 4" HMA/4"CSBC | 350 | SY | $ 71 | $ 24,882 |
| | | | | | $ - |
| | Removals at 4% Construction Costs | 4.0% | LS | $ 1,932,577 | $ 77,303 |
| | TESC at 2% of Construction | 2% | LS | $ 2,009,880 | $ 40,198 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 2,050,078 |
| | **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 205,008 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 2,255,086 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 2,255,100*** |

**Description: WQBE 11A - Detention Vault on Public Property**

Box-shaped underground facility that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

**Cost Estimating Assumptions:**

The Detention Vault installation is per the King Co. SW Design Manual Chapter 5, Section 5.1.3.
The vault is an online storage facility with a flow restricting device.
The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.
The vault is an underground cast in place concrete structure with an interior storage volume of +/-15,500 cf.

The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.12 MG.

Sump interior dimensions 4'W x 4'H.
The minimum vault height is 7 feet deep at the shallowest end.
The vault side slopes are a minimum of 5% towards the center of the vault.
The vault is a flow through system with a minimum of 2 feet above the outlet flow control device (orifice) to retain oil within the vault.
An average of 0.5' of additional storage depth is provided for sediment storage.
Exterior and interior wall thickness is 1.5 feet.
Top slab thickness is 2 feet
Base/Ballast slab thickness is 3 feet (sized to counteract buoyancy)
There is a 1' layer of crushed base beneath the base/ballast slab.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth.
The vault is positively anchored to the shoring piles.
Vault is designed to accommodate traffic loading.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
Two maintenance hole access with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.
Shoring and Lagging is required for construction of the structure.
Pipe length is 200' of 12" Diameter Pipe for both influent and effluent combined.
The storage vault, facility inlet and outlet pipes are sited beneath a parking area.
It is assumed that the tank restoration will consist of parking lot restoration with4" HMA/4" CSTC.
It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.
Allowance for removals estimated at 4% of the construction cost.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
Construction occurs outside of the right-of-way and no traffic control or street use permits are required.
The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Steven Van Loo (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_11B_Detention_Vault in ROW | | | **Version:** | 3 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Detention Vault in Public ROW (2592 sf @ 6' Ave. Storage Depth) | 1 | SF | $ 2,281,500 | $ 2,281,500 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 2,281,500*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 456,300 |
| | | | Street Use Permit (Y/N) | Y | $ 90,000 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 2,827,800*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 273,780 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 3,101,580*** |
| | | | | Construction Sales Tax | $ 308,687 |
| | | | | Outside Agency Construction | $ 228,150 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 3,638,400*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 682,348 |
| | | | | Construction Management | $ 310,158 |
| | | | | Permitting & Support | $ 31,016 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 186,095 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,209,616*** |
| | | | | Project Contingency | $ 1,454,405 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 2,664,000*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 6,302,400*** |

**Description: WQBE_11B_Detention_Vault in ROW (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 6,302,400** | |
| Capital cost | $ 6,302,400 | $/Unit |
| Total Direct O&M/Year | $ 4,351 | |
| Direct O&M cost | $ 4,351 | $/Unit |
| Capital Replacement Costs (20 year equipment) | $ 55,700 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 6,432,100** | **$/unit** |
| **Annual O&M Cost** | **$ 5,200** | **$/year** |
| Annualized Cost | $1,310 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Cement Patching | 2023 dollars | $ 113 | $/year |
| Vacuum Truck Equipment + Labor | 2023 dollars | $ 711 | $/year |
| Subtotal | | $824 | |
| Labor | | | |
| Vactor to remove sediment and debris | 16 | hr | |
| Inspection and joint repair, crack repair | 16 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| **Total hours per year** | 32 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 1,740 | |
| Labor cost, burdened | O/H 150.0% | $ 4,351 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 39,202 | | $ 207,010 | **$6,604,312** | **$ 6,432,145** | | | |
| 0 | 1.000 | **$ 6,302,400** | | | $6,302,400 | $ 6,302,400 | $ 6,302,400 | $ 6,302,400 | $ 6,432,145 |
| 1 | 0.950 | $824 | $ - | $ 4,351 | $ 5,175 | $ 4,917 | $ 6,307,575 | $ 6,307,317 | $ 129,745 |
| 2 | 0.903 | $ 849 | $ - | $ 4,482 | $ 5,330 | $ 4,812 | $ 6,312,906 | $ 6,312,129 | $ 124,828 |
| 3 | 0.858 | $ 874 | $ - | $ 4,616 | $ 5,490 | $ 4,709 | $ 6,318,396 | $ 6,316,838 | $ 120,016 |
| 4 | 0.815 | $ 900 | $ - | $ 4,755 | $ 5,655 | $ 4,608 | $ 6,324,051 | $ 6,321,446 | $ 115,307 |
| 5 | 0.774 | $ 927 | $ - | $ 4,897 | $ 5,825 | $ 4,510 | $ 6,329,876 | $ 6,325,956 | $ 110,699 |
| 6 | 0.736 | $ 955 | $ - | $ 5,044 | $ 5,999 | $ 4,413 | $ 6,335,875 | $ 6,330,370 | $ 106,189 |
| 7 | 0.699 | $ 984 | $ - | $ 5,196 | $ 6,179 | $ 4,319 | $ 6,342,055 | $ 6,334,689 | $ 101,775 |
| 8 | 0.664 | $ 1,013 | $ - | $ 5,351 | $ 6,365 | $ 4,227 | $ 6,348,420 | $ 6,338,916 | $ 97,456 |
| 9 | 0.631 | $ 1,044 | $ - | $ 5,512 | $ 6,556 | $ 4,136 | $ 6,354,975 | $ 6,343,052 | $ 93,229 |
| 10 | 0.599 | $ 1,075 | $ - | $ 5,677 | $ 6,752 | $ 4,048 | $ 6,361,728 | $ 6,347,100 | $ 89,093 |
| 11 | 0.570 | $ 1,107 | $ - | $ 5,848 | $ 6,955 | $ 3,961 | $ 6,368,683 | $ 6,351,062 | $ 85,045 |
| 12 | 0.541 | $ 1,141 | $ - | $ 6,023 | $ 7,164 | $ 3,877 | $ 6,375,847 | $ 6,354,938 | $ 81,084 |
| 13 | 0.514 | $ 1,175 | $ - | $ 6,204 | $ 7,379 | $ 3,794 | $ 6,383,225 | $ 6,358,732 | $ 77,207 |
| 14 | 0.489 | $ 1,210 | $ - | $ 6,390 | $ 7,600 | $ 3,713 | $ 6,390,825 | $ 6,362,445 | $ 73,413 |
| 15 | 0.464 | $ 1,246 | $ - | $ 6,582 | $ 7,828 | $ 3,633 | $ 6,398,653 | $ 6,366,079 | $ 69,700 |
| 16 | 0.441 | $ 1,284 | $ - | $ 6,779 | $ 8,063 | $ 3,556 | $ 6,406,716 | $ 6,369,634 | $ 66,067 |
| 17 | 0.419 | $ 1,322 | $ - | $ 6,982 | $ 8,305 | $ 3,480 | $ 6,415,021 | $ 6,373,114 | $ 62,511 |
| 18 | 0.398 | $ 1,362 | $ - | $ 7,192 | $ 8,554 | $ 3,405 | $ 6,423,574 | $ 6,376,519 | $ 59,031 |
| 19 | 0.378 | $ 1,403 | $ - | $ 7,408 | $ 8,810 | $ 3,333 | $ 6,432,385 | $ 6,379,852 | $ 55,626 |
| 20 | 0.359 | $ 1,445 | $ 55,700 | $ 7,630 | $ 64,775 | $ 23,279 | $ 6,497,160 | $ 6,403,131 | $ 52,293 |
| 21 | 0.341 | $ 1,488 | $ - | $ 7,859 | $ 9,347 | $ 3,192 | $ 6,506,507 | $ 6,406,323 | $ 29,014 |
| 22 | 0.324 | $ 1,533 | $ - | $ 8,095 | $ 9,627 | $ 3,123 | $ 6,516,134 | $ 6,409,446 | $ 25,823 |
| 23 | 0.308 | $ 1,579 | $ - | $ 8,337 | $ 9,916 | $ 3,057 | $ 6,526,050 | $ 6,412,502 | $ 22,699 |
| 24 | 0.293 | $ 1,626 | $ - | $ 8,587 | $ 10,214 | $ 2,991 | $ 6,536,264 | $ 6,415,494 | $ 19,643 |
| 25 | 0.278 | $ 1,675 | $ - | $ 8,845 | $ 10,520 | $ 2,927 | $ 6,546,784 | $ 6,418,421 | $ 16,651 |
| 26 | 0.264 | $ 1,725 | $ - | $ 9,110 | $ 10,836 | $ 2,865 | $ 6,557,620 | $ 6,421,286 | $ 13,724 |
| 27 | 0.251 | $ 1,777 | $ - | $ 9,384 | $ 11,161 | $ 2,803 | $ 6,568,780 | $ 6,424,089 | $ 10,859 |
| 28 | 0.239 | $ 1,830 | $ - | $ 9,665 | $ 11,496 | $ 2,744 | $ 6,580,276 | $ 6,426,833 | $ 8,056 |
| 29 | 0.227 | $ 1,885 | $ - | $ 9,955 | $ 11,840 | $ 2,685 | $ 6,592,117 | $ 6,429,518 | $ 5,312 |
| 30 | 0.215 | $ 1,942 | $ - | $ 10,254 | $ 12,196 | $ 2,628 | $ 6,604,312 | $ 6,432,145 | $ 2,628 |

**Description: WQBE_11B_Detention_Vault in ROW**

Box-shaped underground facility that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work
16 day using a vactor truck at $711 total cost for equipment.
Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an
16 8 hour work day. Assume annual cost of $113 for cement patching mix.
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Capital Replacement Assumptions:**

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Steven Van Loo (HDR)<br>Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_11B_Detention_Vault in ROW | | | **Version:** | 3 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Detention Vault on Public Property** | | | | $ - |
| 2 | ***Detention Vault Assumptions*** | | | | $ - |
| 3 | *Exterior Length* | 73 | FT | | $ - |
| 4 | *Interior Length* | 70 | FT | | $ - |
| 5 | *Sump Length* | 4 | FT | | $ - |
| 6 | *Sump Wall Width* | 25 | FT | | $ - |
| 7 | *Sump Interior Depth* | 4 | FT | | $ - |
| 8 | *Sump Wall Total Length* | 64 | FT | | $ - |
| 9 | *Exterior Width* | 28 | FT | | $ - |
| 10 | *Interior Width* | 25 | FT | | $ - |
| 11 | *Interior Structure Height (Ave.)* | 10.5 | FT | | $ - |
| 12 | *Storage Depth (Ave)* | 9 | FT | | $ - |
| 13 | *Sediment Storage Depth* | 0.5 | FT | | $ - |
| 14 | *Freeboard (Ave.)* | 1 | FT | | $ - |
| 15 | *Storage Facility Exterior Footprint Area* | 2,044 | SF | | $ - |
| 16 | | | | | $ - |
| 17 | ***Storage Volume*** | | | | $ - |
| 18 | *Storage Facility interior Area* | 1,750 | SF | | $ - |
| 19 | *Effective Storage Volume (15.500 cf target)* | 15,575 | CF | | $ - |
| 20 | *Vault Storage Volume* | 0.12 | MG | | $ - |
| 21 | | | | | $ - |
| 22 | ***Structure Concrete Assumptions*** | | | | $ - |
| 23 | *Exterior Wall thickness* | 1.5 | FT | | $ - |
| 24 | *Sump Wall Thickness* | 1.5 | FT | | $ - |
| 25 | *Top Slab Thickness* | 2 | FT | | $ - |
| 26 | *Foundation Slab thickness* | 3 | FT | | $ - |
| 27 | *Concrete Reinforcing Rebar* | 225 | LB/CY | | $ - |
| 28 | *Crushed Base Thickness* | 1 | FT | | $ - |
| 29 | | | | | $ - |
| 30 | **Concrete Structure** | | | | $ - |
| 31 | Vault Interior Walls Concrete @2' Thick (partial for supports) | 5 | CY | $ 650 | $ 3,250 |
| 32 | Sump Wall Concrete | 14 | CY | $ 1,250 | $ 17,778 |
| 33 | Exterior Wall Concrete | 118 | CY | $ 1,250 | $ 147,292 |
| 34 | Top Slab Concrete | 151 | CY | $ 1,250 | $ 189,259 |
| 35 | Foundation Slab Concrete | 227 | CY | $ 950 | $ 215,756 |
| 36 | Stormwater Treatment Rebar @ 225 lbs/cy | 116,004 | LBS | $ 1.38 | $ 160,086 |
| 37 | Crushed Base | 76 | CY | $ 64 | $ 4,845 |
| 38 | | | | | $ - |
| 39 | ***Shoring and Excavation Assumptions*** | | | | $ - |
| 40 | *Construction Room* | 3 | FT | | $ - |
| 41 | *Tank Bury Depth* | 2 | FT | | $ - |
| 42 | *Total Excavation Depth* | 19 | FT | | $ - |
| 43 | *Excavation Length* | 83 | FT | | $ - |
| 44 | *Excavation Width* | 38 | FT | | $ - |
| 45 | | | | | $ - |
| 46 | **Soil Excavation and Disposal** | | | | $ - |
| 47 | Excavation | 2,161 | CY | $ 79 | $ 170,725 |
| 51 | Imported Structure Backfill | 912 | CY | $ 44 | $ 40,126 |
| 52 | | | | | $ - |
| 53 | **Solder Pile Shoring** | | | | $ - |
| 54 | *Solder Pile Shaft Depth (3 x Exc. Depth)* | 56 | FT | | $ - |
| 55 | *Solder Pile Shaft Thickness* | 2 | FT | | $ - |
| 56 | *Center to Center Shaft Spacing* | 6 | FT | | $ - |
| 57 | *Rebar in Shaft* | 114 | LB/CY | | $ - |
| 58 | *Shoring Wall Perimeter* | 234 | FT | | $ - |
| 59 | *Number of Shafts* | 39 | EA | | $ - |
| 60 | Drill Solder Pile Shafts | 252 | CY | $ 262 | $ 65,985 |
| 61 | Set Solder Pile and CDF | 252 | CY | $ 391 | $ 98,474 |
| 62 | Purchase and Salvage Solder Piles | 246,753 | LB | $ 0.7 | $ 172,727 |
| 63 | Tie Backs - one per soldier pile except corners | 35 | EA | $ 2,477 | $ 86,695 |
| 64 | Timber Lagging | 14,883 | BF | $ 9 | $ 133,947 |
| 65 | | | | | $ - |
| 66 | **Gates and Access** | | | | $ - |
| 67 | Flow Restrictor | 1 | EA | $ 24,600 | $ 24,600 |
| 68 | Confined Space Safety | 1 | LS | $ 32,595 | $ 32,595 |
| 69 | Access Hatches | 2 | EA | $ 13,038 | $ 26,076 |
| 70 | | | | | $ - |
| 71 | **Conveyance Pipe** | | | | $ - |
| 72 | 12" Storm Pipe (upstream and discharge) | 200 | LF | $ 140 | $ 28,000 |
| 73 | Trench Excavation to waste (8'W X 15'D) | 889 | CY | $ 79 | $ 70,222 |
| 74 | Trench Box Shoring | 6,000 | SF | $ 10 | $ 60,000 |
| 75 | 48" Diameter Maintenance holes | 4 | EA | $ 10,640 | $ 42,560 |
| 76 | Imported Backfill | 883 | CY | $ 44 | $ 38,855 |
| 77 | Dewater Trench - Sumps | 200 | LF | $ 139 | $ 27,800 |
| 78 | Demolish Surface incl. room for construction (@20' wide) | 444 | SY | $ 14 | $ 6,222 |
| 79 | Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100') | 444 | SY | $ 71 | $ 31,556 |
| 80 | | | | | $ - |
| 81 | **Site Removals and Restoration** | | | | $ - |
| 82 | Road Restoration - 6" HMA/6"CSBC x 60' W X 100' | 350 | SY | $ 110 | $ 38,549 |
| 83 | Sidewalk Est. one side x 5' Wide | 56 | SY | $ 125 | $ 6,944 |
| 84 | Planting Strip Est one side x 8' Wide | 89 | SY | $ 10 | $ 875 |
| 85 | Landscape/Lawn Restoration | 89 | SY | $ 59 | $ 5,248 |
| 86 | Irrigation System Repair est @ 10% Landscape/Lawn | 10% | LS | $ 5,248 | $ 525 |
| 87 | Trees both new and replacements Est @ 4 per 100' | 4 | EA | $ 720 | $ 2,880 |
| 88 | Demolish Existing Surface | 350 | SY | $ 14 | $ 4,742 |
| 89 | | | | | |
| 90 | Removals at 4% Construction Costs | 4.0% | LS | $ 1,955,193 | $ 78,208 |
| 91 | TESC at 2% of Construction | 2% | LS | $ 2,033,400 | $ 40,668 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | *Item Subtotal Construction Costs (Year 2023)* | $ 2,074,068 |
| | **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | |
| | General Conditions | 0% | | 1 | $ - |
| | Mobilization/Demobilization | 10% | | 1.1 | $ 207,407 |
| | Overhead & Profit (OHP) | 0% | | 1 | $ - |
| | Insurance | 0.0% | | 1 | $ - |
| | Bonding | 0.0% | | 1 | $ - |
| | Escalation Multiplier from ENR-CCI | 0% | | 1.0000 | $ - |
| | | | | *Item Subtotal Construction Costs (Year 2023)* | $ 2,281,475 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 2,281,500*** |

**Description: WQBE 11B - Detention Vault in Highway ROW**

Box-shaped underground facility that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

**Cost Estimating Assumptions:**

The Detention Vault installation is per the King Co. SW Design Manual Chapter 5, Section 5.1.3.

The vault is an online storage facility with a flow restricting device.

The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.

The vault is an underground cast in place concrete structure with an interior storage volume of +/-15,500 cf.

The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.12 MG.

Sump interior dimensions 4'W x 4'H.

The minimum vault height is 7 feet deep at the shallowest end.

The vault side slopes are a minimum of 5% towards the center of the vault.

The vault is a flow through system with a minimum of 2 feet above the outlet flow control device (orifice) to retain oil within the vault.

An average of 0.5' of additional storage depth is provided for sediment storage.

Exterior and interior wall thickness is 1.5 feet.

Top slab thickness is 2 feet

Base/Ballast slab thickness is 3 feet (sized to counteract buoyancy)

There is a 1' layer of crushed base beneath the base/ballast slab.

The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.

No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.

The shafts are 3 times the excavation depth.

The vault is positively anchored to the shoring piles.

Vault is designed for heavy traffic loads.

All metal is galvanized or stainless steel per SW Manual.

Access hatches are provided as shown on the WTD detail.

Two maintenance hole access with ladder rungs.

The excavated material is unsuitable for use as backfill.

An excavation width of 3 feet is assumed on each side of the structure.

Shoring and Lagging is required for construction of the structure.

Pipe length is 200' of 12" Diameter Pipe for both influent and effluent.

Full width arterial roadway restoration is assumed, including the sidewalks and landscape areas on both sides of the roadway.

Removals are estimated at 4% of the item construction costs, in conformance with LTCP GSI cost estimates.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Due to the facility width, utility relocation work is estimated at 10% of the total construction costs.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Tataina Skadorwa (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_11C_Detention Vault With Property Costs | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Detention Vault Property (2592 sf @ 6' Ave. Storage Depth) | 1 | EA | $ 2,255,100 | $ 2,255,100 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 2,255,100*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 451,020 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 2,706,120*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 270,612 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 2,976,732*** |
| | | | | Construction Sales Tax | $ 305,115 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 3,281,800*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 654,881 |
| | | | | Construction Management | $ 297,673 |
| | | | | Permitting & Support | $ 29,767 |
| 4752 | s.f. Land Area | Medium | Land Purchase/ROW Acquisition | | $ 382,203 |
| 4000 | s.f. Land Area | Low | Permanent Easements | | $ 40,400 |
| | | | | WTD Staff Costs & Non-WTD Support | $ 178,604 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,583,529*** |
| | | | | Project Contingency | $ 1,459,599 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 3,043,100*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 6,324,900*** |

**Description: WQBE_11C_Detention_Vault with Property Costs (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 6,324,900** | Does not include property costs |
| Capital cost | $ 6,324,900 | $/Unit |
| Total Direct O&M/Year | $ 4,351 | |
| Direct O&M cost | $ 4,351 | $/Unit |
| Capital Replacement Costs (20 year equipment) | $ 55,700 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 6,454,600** | **$/unit** |
| **Annual O&M Cost** | **$ 5,200** | **$/year** |
| Annualized Cost | $1,310 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Cement Patching | 2023 dollars | $ 113 | $/year |
| Vactor Truck Equipment | 2023 dollars | $ 711 | $/year |
| Subtotal | | $824 | |
| Labor | | | |
| Vactor to remove sediment and debris | 16 | hr | |
| Inspection and joint repair, crack repair | 16 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| **Total hours per year** | 32 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 1,740 | |
| Labor cost, burdened | O/H 150.0% | $ 4,351 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 39,202 | | $ 207,010 | **$6,626,812** | **$ 6,454,645** | | | |
| 0 | 1.000 | **$ 6,324,900** | | | $6,324,900 | $ 6,324,900 | $ 6,324,900 | $ 6,324,900 | $ 6,454,645 |
| 1 | 0.950 | $824 | $ - | $ 4,351 | $ 5,175 | $ 4,917 | $ 6,330,075 | $ 6,329,817 | $ 129,745 |
| 2 | 0.903 | $ 849 | $ - | $ 4,482 | $ 5,330 | $ 4,812 | $ 6,335,406 | $ 6,334,629 | $ 124,828 |
| 3 | 0.858 | $ 874 | $ - | $ 4,616 | $ 5,490 | $ 4,709 | $ 6,340,896 | $ 6,339,338 | $ 120,016 |
| 4 | 0.815 | $ 900 | $ - | $ 4,755 | $ 5,655 | $ 4,608 | $ 6,346,551 | $ 6,343,946 | $ 115,307 |
| 5 | 0.774 | $ 927 | $ - | $ 4,897 | $ 5,825 | $ 4,510 | $ 6,352,376 | $ 6,348,456 | $ 110,699 |
| 6 | 0.736 | $ 955 | $ - | $ 5,044 | $ 5,999 | $ 4,413 | $ 6,358,375 | $ 6,352,870 | $ 106,189 |
| 7 | 0.699 | $ 984 | $ - | $ 5,196 | $ 6,179 | $ 4,319 | $ 6,364,555 | $ 6,357,189 | $ 101,775 |
| 8 | 0.664 | $ 1,013 | $ - | $ 5,351 | $ 6,365 | $ 4,227 | $ 6,370,920 | $ 6,361,416 | $ 97,456 |
| 9 | 0.631 | $ 1,044 | $ - | $ 5,512 | $ 6,556 | $ 4,136 | $ 6,377,475 | $ 6,365,552 | $ 93,229 |
| 10 | 0.599 | $ 1,075 | $ - | $ 5,677 | $ 6,752 | $ 4,048 | $ 6,384,228 | $ 6,369,600 | $ 89,093 |
| 11 | 0.570 | $ 1,107 | $ - | $ 5,848 | $ 6,955 | $ 3,961 | $ 6,391,183 | $ 6,373,562 | $ 85,045 |
| 12 | 0.541 | $ 1,141 | $ - | $ 6,023 | $ 7,164 | $ 3,877 | $ 6,398,347 | $ 6,377,438 | $ 81,084 |
| 13 | 0.514 | $ 1,175 | $ - | $ 6,204 | $ 7,379 | $ 3,794 | $ 6,405,725 | $ 6,381,232 | $ 77,207 |
| 14 | 0.489 | $ 1,210 | $ - | $ 6,390 | $ 7,600 | $ 3,713 | $ 6,413,325 | $ 6,384,945 | $ 73,413 |
| 15 | 0.464 | $ 1,246 | $ - | $ 6,582 | $ 7,828 | $ 3,633 | $ 6,421,153 | $ 6,388,579 | $ 69,700 |
| 16 | 0.441 | $ 1,284 | $ - | $ 6,779 | $ 8,063 | $ 3,556 | $ 6,429,216 | $ 6,392,134 | $ 66,067 |
| 17 | 0.419 | $ 1,322 | $ - | $ 6,982 | $ 8,305 | $ 3,480 | $ 6,437,521 | $ 6,395,614 | $ 62,511 |
| 18 | 0.398 | $ 1,362 | $ - | $ 7,192 | $ 8,554 | $ 3,405 | $ 6,446,074 | $ 6,399,019 | $ 59,031 |
| 19 | 0.378 | $ 1,403 | $ - | $ 7,408 | $ 8,810 | $ 3,333 | $ 6,454,885 | $ 6,402,352 | $ 55,626 |
| 20 | 0.359 | $ 1,445 | $ 55,700 | $ 7,630 | $ 64,775 | $ 23,279 | $ 6,519,660 | $ 6,425,631 | $ 52,293 |
| 21 | 0.341 | $ 1,488 | $ - | $ 7,859 | $ 9,347 | $ 3,192 | $ 6,529,007 | $ 6,428,823 | $ 29,014 |
| 22 | 0.324 | $ 1,533 | $ - | $ 8,095 | $ 9,627 | $ 3,123 | $ 6,538,634 | $ 6,431,946 | $ 25,823 |
| 23 | 0.308 | $ 1,579 | $ - | $ 8,337 | $ 9,916 | $ 3,057 | $ 6,548,550 | $ 6,435,002 | $ 22,699 |
| 24 | 0.293 | $ 1,626 | $ - | $ 8,587 | $ 10,214 | $ 2,991 | $ 6,558,764 | $ 6,437,994 | $ 19,643 |
| 25 | 0.278 | $ 1,675 | $ - | $ 8,845 | $ 10,520 | $ 2,927 | $ 6,569,284 | $ 6,440,921 | $ 16,651 |
| 26 | 0.264 | $ 1,725 | $ - | $ 9,110 | $ 10,836 | $ 2,865 | $ 6,580,120 | $ 6,443,786 | $ 13,724 |
| 27 | 0.251 | $ 1,777 | $ - | $ 9,384 | $ 11,161 | $ 2,803 | $ 6,591,280 | $ 6,446,589 | $ 10,859 |
| 28 | 0.239 | $ 1,830 | $ - | $ 9,665 | $ 11,496 | $ 2,744 | $ 6,602,776 | $ 6,449,333 | $ 8,056 |
| 29 | 0.227 | $ 1,885 | $ - | $ 9,955 | $ 11,840 | $ 2,685 | $ 6,614,617 | $ 6,452,018 | $ 5,312 |
| 30 | 0.215 | $ 1,942 | $ - | $ 10,254 | $ 12,196 | $ 2,628 | $ 6,626,812 | $ 6,454,645 | $ 2,628 |

**Description: WQBE_11C_Detention_Vault with Property Costs**

Box-shaped underground facility that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**

16 Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day using a vactor truck at $711 total cost for equipment.

16 Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an 8 hour work day. Assume annual cost of $113 for cement patching mix.

**Capital Replacement Assumptions:**

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer (HDR)<br>Tataina Skadorwa (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_11C_Detention Vault With Property Costs | | | **Version:** | 2 |
| | **CONSTRUCTION COSTS** | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Detention Vault on Public Property** | | | | $ - |
| 2 | ***Detention Vault Assumptions*** | | | | $ - |
| 3 | *Exterior Length* | 73 | FT | | $ - |
| 4 | *Interior Length* | 70 | FT | | $ - |
| 5 | *Sump Length* | 4 | FT | | $ - |
| 6 | *Sump Wall Width* | 25 | FT | | $ - |
| 7 | *Sump Interior Depth* | 4 | FT | | $ - |
| 8 | *Sump Wall Total Length* | 64 | FT | | $ - |
| 9 | *Exterior Width* | 28 | FT | | $ - |
| 10 | *Interior Width* | 25 | FT | | $ - |
| 11 | *Interior Structure Height (Ave.)* | 10.5 | FT | | $ - |
| 12 | *Storage Depth (Ave)* | 9 | FT | | $ - |
| 13 | *Sediment Storage Depth* | 0.5 | FT | | $ - |
| 14 | *Freeboard (Ave.)* | 1 | FT | | $ - |
| 15 | *Storage Facility Exterior Footprint Area* | 2,044 | SF | | $ - |
| 16 | | | | | $ - |
| 17 | ***Storage Volume*** | | | | $ - |
| 18 | *Storage Facility interior Area* | 1,750 | SF | | $ - |
| 19 | *Effective Storage Volume (15.500 cf target)* | 15,575 | CF | | $ - |
| 20 | *Vault Storage Volume* | 0.12 | MG | | $ - |
| 21 | | | | | $ - |
| 22 | ***Structure Concrete Assumptions*** | | | | $ - |
| 23 | *Exterior Wall thickness* | 1.5 | FT | | $ - |
| 24 | *Sump Wall Thickness* | 1.5 | FT | | $ - |
| 25 | *Top Slab Thickness* | 2 | FT | | $ - |
| 26 | *Foundation Slab thickness* | 3 | FT | | $ - |
| 27 | *Concrete Reinforcing Rebar* | 225 | LB/CY | | $ - |
| 28 | *Crushed Base Thickness* | 1 | FT | | $ - |
| 29 | | | | | $ - |
| 30 | **Concrete Structure** | | | | $ - |
| 31 | Vault Interior Walls Concrete @2' Thick (partial for supports) | 5 | CY | $ 650 | $ 3,250 |
| 32 | Sump Wall Concrete | 14 | CY | $ 1,250 | $ 17,778 |
| 33 | Exterior Wall Concrete | 118 | CY | $ 1,250 | $ 147,292 |
| 34 | Top Slab Concrete | 151 | CY | $ 1,250 | $ 189,259 |
| 35 | Foundation Slab Concrete | 227 | CY | $ 950 | $ 215,756 |
| 36 | Stormwater Treatment Rebar @ 225 lbs/cy | 116,004 | LBS | $ 1.38 | $ 160,086 |
| 37 | Crushed Base | 76 | CY | $ 64 | $ 4,845 |
| 38 | | | | | $ - |
| 39 | ***Shoring and Excavation Assumptions*** | | | | $ - |
| 40 | *Construction Room* | 3 | FT | | $ - |
| 41 | *Tank Bury Depth* | 2 | FT | | $ - |
| 42 | *Total Excavation Depth* | 19 | FT | | $ - |
| 43 | *Excavation Length* | 83 | FT | | $ - |
| 44 | *Excavation Width* | 38 | FT | | $ - |
| 45 | | | | | $ - |
| 46 | **Soil Excavation and Disposal** | | | | $ - |
| 47 | Excavation | 2,161 | CY | $ 79 | $ 170,725 |
| 51 | Imported Structure Backfill | 912 | CY | $ 44 | $ 40,126 |
| 52 | | | | | $ - |
| 53 | **Solder Pile Shoring** | | | | $ - |
| 54 | *Solder Pile Shaft Depth (3 x Exc. Depth)* | 56 | FT | | $ - |
| 55 | *Solder Pile Shaft Thickness* | 2 | FT | | $ - |
| 56 | *Center to Center Shaft Spacing* | 6 | FT | | $ - |
| 57 | *Rebar in Shaft* | 114 | LB/CY | | $ - |
| 58 | *Shoring Wall Perimeter* | 234 | FT | | $ - |
| 59 | *Number of Shafts* | 39 | EA | | $ - |
| 60 | Drill Solder Pile Shafts | 252 | CY | $ 262 | $ 65,985 |
| 61 | Set Solder Pile and CDF | 252 | CY | $ 391 | $ 98,474 |
| 62 | Purchase and Salvage Solder Piles | 246,753 | LB | $ 0.7 | $ 172,727 |
| 63 | Tie Backs - one per soldier pile except corners | 35 | EA | $ 2,477 | $ 86,695 |
| 64 | Timber Lagging | 14,883 | BF | $ 9 | $ 133,947 |
| 65 | | | | | $ - |
| 66 | **Gates and Access** | | | | $ - |
| 67 | Flow Restrictor | 1 | EA | $ 24,600 | $ 24,600 |
| 68 | Confined Space Safety | 1 | LS | $ 32,595 | $ 32,595 |
| 69 | Access Hatches | 2 | EA | $ 13,038 | $ 26,076 |
| 70 | | | | | $ - |
| 71 | **Conveyance Pipe** | | | | $ - |
| 72 | 12" Storm Pipe (upstream and discharge) | 200 | LF | $ 140 | $ 28,000 |
| 73 | Trench Excavation to waste (8'W X 15'D) | 889 | CY | $ 79 | $ 70,222 |
| 74 | Trench Box Shoring | 6,000 | SF | $ 10 | $ 60,000 |
| 75 | 48" Diameter Maintenance holes | 4 | EA | $ 10,640 | $ 42,560 |
| 76 | Imported Backfill | 883 | CY | $ 44 | $ 38,855 |
| 77 | Dewater Trench - Sumps | 200 | LF | $ 139 | $ 27,800 |
| 78 | Demolish Surface incl. room for construction (@20' wide) | 444 | SY | $ 14 | $ 6,222 |
| 79 | Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100') | 444 | SY | $ 71 | $ 31,556 |
| 80 | | | | | $ - |
| 81 | **Site Removals and Restoration** | | | | $ - |
| 82 | Disking or tilling of compacted soil (assumed 100'X100') | 526 | SY | $ 4 | $ 2,103 |
| 83 | Seeding, mulching and compost | 526 | SY | $ 10 | $ 5,257 |
| 84 | Demolish Existing Surface | 350 | SY | $ 14 | $ 4,906 |
| 85 | Pavement Restoration (Vault) - 4" HMA/4"CSBC | 350 | SY | $ 71 | $ 24,882 |
| 86 | | | | | |
| 87 | Removals at 4% Construction Costs | 4.0% | LS | $ 1,932,577 | $ 77,303 |
| 88 | TESC at 2% of Construction | 2% | LS | $ 2,009,880 | $ 40,198 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 2,050,078 |
| | **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 205,008 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 2,255,086 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 2,255,100*** |

**Description: WQBE 11C - Detention Vault With Property Cost**

Box-shaped underground facility that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

**Cost Estimating Assumptions:**

The Detention Vault installation is per the King Co. SW Design Manual Chapter 5, Section 5.1.3.
It is assumed that no agency mitigation costs will be required.
The vault is an online storage facility with a flow restricting device.

The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.

The vault is an underground cast in place concrete structure with an interior storage volume of +/-15,500 cf.
The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.12 MG.
Sump interior dimensions 4'W x 4'H.
The minimum vault height is 7 feet deep at the shallowest end.

The vault side slopes are a minimum of 5% towards the center of the vault.
The vault is a flow through system with a minimum of 2 feet above the outlet flow control device (orifice) to retain oil within the vault.
An average of 0.5' of additional storage depth is provided for sediment storage.
Exterior and interior wall thickness is 1.5 feet.
Top slab thickness is 2 feet
Base/Ballast slab thickness is 3 feet (sized to counteract buoyancy)
There is a 1' layer of crushed base beneath the base/ballast slab.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth.
The vault is positively anchored to the shoring piles.
Vault is designed to accommodate traffic loading.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
Two maintenance hole access with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.
Shoring and Lagging is required for construction of the structure.
Pipe length is 200' of 12" Diameter Pipe for both influent and effluent combined.
The storage vault, facility inlet and outlet pipes are sited beneath a parking area.
It is assumed that the tank restoration will consist of parking lot restoration with4" HMA/4" CSTC.
It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.
Allowance for removals estimated at 4% of the construction cost.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and traffic control is not required.
A street use permit is not required.
The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to Medium.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jeff Price (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_12A_Detention Pond On Public Property | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Detention Pond Installation (4,500 s.f. bottom area @ 4 ft. Storage Depth) | 1 | EA | $ 477,300 | $ 477,300 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 477,300*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 95,460 |
| | | | | Street Use Permit (Y/N) N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 572,760*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 57,276 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 630,036*** |
| | | | | Construction Sales Tax | $ 64,579 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 694,600*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 138,608 |
| | | | | Construction Management | $ 63,004 |
| | | | | Permitting & Support | $ 6,300 |
| | s.f. Land Area | None | | Land Purchase/ROW Acquisition | $ - |
| | s.f. Land Area | None | | Permanent Easements | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 37,802 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 245,714*** |
| | | | | Project Contingency | $ 282,094 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 527,800*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 1,222,400*** |

**WQBE_12A_Detention Pond On Public Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 1,222,400** | |
| Capital cost | $ 1,222,400 | $/Unit |
| Total Direct O&M/Year | $ 9,790 | |
| Direct O&M cost | $ 9,790 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 11,100 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 1,444,200** | **$/unit** |
| **Annual O&M Cost** | **$ 10,000** | **$/year** |
| Annualized Cost | $270 | $/year |

**Materials, Supplies, Other Costs**

| | | | | |
|---|---|---|---|---|
| | | $ - | $/year | |
| Grass seeding | 2023 dollars | $ 113 | $/year | |
| Chain Saw Rental | 2023 dollars | $ 56 | $/year | |
| Subtotal | | $169 | | |
| Labor | | | | |
| Remove trash, sediment, debris and replace vegetation | 16 | hr | | |
| Remove dead trees | 32 | hr | | |
| stabilize eroded berms and embankments | 24 | hr | | |
| | 0 | hr | | |
| **Total hours per year** | 72 | | | |
| Raw Labor Rate/Hr | | $ 54 | | |
| Raw labor cost | (embedded) | $ 3,916 | | |
| Labor cost, burdened | O/H 150.0% | $ 9,790 | $ | 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | | |
| Life Cycle Period: | 30 | years | | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 8,040 | | $ 465,773 | **$1,718,413** | **$ 1,444,204** | | | |
| 0 | 1.000 | **$ 1,222,400** | | | $1,222,400 | $ 1,222,400 | $ 1,222,400 | $1,222,400 | $ 1,444,204 |
| 1 | 0.950 | $169 | $ - | $ 9,790 | $ 9,959 | $ 9,462 | $ 1,232,359 | $1,231,862 | $ 221,804 |
| 2 | 0.903 | $ 174 | $ - | $ 10,084 | $ 10,258 | $ 9,260 | $ 1,242,617 | $1,241,123 | $ 212,342 |
| 3 | 0.858 | $ 179 | $ - | $ 10,386 | $ 10,566 | $ 9,062 | $ 1,253,183 | $1,250,185 | $ 203,082 |
| 4 | 0.815 | $ 185 | $ - | $ 10,698 | $ 10,883 | $ 8,868 | $ 1,264,066 | $1,259,053 | $ 194,019 |
| 5 | 0.774 | $ 190 | $ - | $ 11,019 | $ 11,209 | $ 8,679 | $ 1,275,275 | $1,267,732 | $ 185,151 |
| 6 | 0.736 | $ 196 | $ - | $ 11,350 | $ 11,545 | $ 8,493 | $ 1,286,820 | $1,276,225 | $ 176,472 |
| 7 | 0.699 | $ 202 | $ - | $ 11,690 | $ 11,892 | $ 8,312 | $ 1,298,712 | $1,284,537 | $ 167,979 |
| 8 | 0.664 | $ 208 | $ - | $ 12,041 | $ 12,249 | $ 8,134 | $ 1,310,961 | $1,292,671 | $ 159,667 |
| 9 | 0.631 | $ 214 | $ - | $ 12,402 | $ 12,616 | $ 7,960 | $ 1,323,577 | $1,300,631 | $ 151,533 |
| 10 | 0.599 | $ 221 | $ 11,100 | $ 12,774 | $ 24,094 | $ 14,444 | $ 1,347,671 | $1,315,076 | $ 143,573 |
| 11 | 0.570 | $ 227 | $ - | $ 13,157 | $ 13,384 | $ 7,623 | $ 1,361,055 | $1,322,699 | $ 129,128 |
| 12 | 0.541 | $ 234 | $ - | $ 13,552 | $ 13,786 | $ 7,461 | $ 1,374,841 | $1,330,160 | $ 121,505 |
| 13 | 0.514 | $ 241 | $ - | $ 13,958 | $ 14,199 | $ 7,301 | $ 1,389,041 | $1,337,461 | $ 114,044 |
| 14 | 0.489 | $ 248 | $ - | $ 14,377 | $ 14,625 | $ 7,145 | $ 1,403,666 | $1,344,606 | $ 106,743 |
| 15 | 0.464 | $ 256 | $ - | $ 14,809 | $ 15,064 | $ 6,992 | $ 1,418,730 | $1,351,598 | $ 99,598 |
| 16 | 0.441 | $ 263 | $ - | $ 15,253 | $ 15,516 | $ 6,843 | $ 1,434,246 | $1,358,441 | $ 92,606 |
| 17 | 0.419 | $ 271 | $ - | $ 15,710 | $ 15,982 | $ 6,696 | $ 1,450,228 | $1,365,137 | $ 85,764 |
| 18 | 0.398 | $ 279 | $ - | $ 16,182 | $ 16,461 | $ 6,553 | $ 1,466,689 | $1,371,690 | $ 79,067 |
| 19 | 0.378 | $ 288 | $ - | $ 16,667 | $ 16,955 | $ 6,413 | $ 1,483,644 | $1,378,104 | $ 72,514 |
| 20 | 0.359 | $ 296 | $ 11,100 | $ 17,167 | $ 28,564 | $ 10,265 | $ 1,512,207 | $1,388,369 | $ 66,101 |
| 21 | 0.341 | $ 305 | $ - | $ 17,682 | $ 17,987 | $ 6,142 | $ 1,530,195 | $1,394,511 | $ 55,835 |
| 22 | 0.324 | $ 314 | $ - | $ 18,213 | $ 18,527 | $ 6,011 | $ 1,548,722 | $1,400,521 | $ 49,693 |
| 23 | 0.308 | $ 324 | $ - | $ 18,759 | $ 19,083 | $ 5,882 | $ 1,567,805 | $1,406,403 | $ 43,683 |
| 24 | 0.293 | $ 334 | $ - | $ 19,322 | $ 19,655 | $ 5,756 | $ 1,587,460 | $1,412,160 | $ 37,801 |
| 25 | 0.278 | $ 344 | $ - | $ 19,901 | $ 20,245 | $ 5,633 | $ 1,607,705 | $1,417,793 | $ 32,044 |
| 26 | 0.264 | $ 354 | $ - | $ 20,499 | $ 20,852 | $ 5,513 | $ 1,628,557 | $1,423,306 | $ 26,411 |
| 27 | 0.251 | $ 364 | $ - | $ 21,113 | $ 21,478 | $ 5,395 | $ 1,650,035 | $1,428,701 | $ 20,898 |
| 28 | 0.239 | $ 375 | $ - | $ 21,747 | $ 22,122 | $ 5,280 | $ 1,672,158 | $1,433,981 | $ 15,503 |
| 29 | 0.227 | $ 387 | $ - | $ 22,399 | $ 22,786 | $ 5,167 | $ 1,694,944 | $1,439,148 | $ 10,223 |
| 30 | 0.215 | $ 398 | $ - | $ 23,071 | $ 23,470 | $ 5,056 | $ 1,718,413 | $1,444,204 | $ 5,056 |

**WQBE_12A_Detention Pond On Public Property**

Surface basin that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**

16 Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal performed annually by a crew of two over a 8 hour workday.

32 Removal of dead, diseased or dying trees annually by a crew of four using hand tools and a chainsaw as needed (8 hour work day). Assume annual cost of chainsaw rental as $56.

24 Stabilization of eroded berms, slopes, embankments, and animal borrows. Biannual site visits by 2 crew members, 6 hour work day. Grass seed mix as needed to stabilize at an estimated cost of $113 per year.

**Capital Replacement Assumptions:**

Replacement of items highlighted in blue on estimate sheet every 10 years (i.e. riprap pads, gates, etc.)

| Estimate - AACEI Class 10 | | | |
|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | **Estimator:** | Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jeff Price (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_12A_Detention Pond On Public Property | **Version:** | 2 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Detention Pond on Public Property** | | | | $ - |
| 2 | ***Pond Assumptions*** | | | | $ - |
| 3 | *Pond Bottom Area* | 4,500 | SF | | $ - |
| 4 | *Pond Top Area* | 8,493 | SF | | $ - |
| 5 | *Pond Top Area* | | | | $ - |
| 6 | *Pond Bottom Length* | 95 | FT | | $ - |
| 7 | *Pond Top Length* | 119 | FT | | $ - |
| 8 | *Pond Bottom Width* | 47 | FT | | $ - |
| 9 | *Pond Top Width* | 71 | | | $ - |
| 10 | *Pond Exc. Depth* | 4 | FT | | $ - |
| 11 | *Slope Run/Rise* | 3 | :1 | | $ - |
| 12 | *Slope Length* | 12 | FT | | $ - |
| 13 | *Freeboard (Ave.)* | 1 | FT | | $ - |
| 14 | *Imported Treatment Liner depth* | 2 | FT | | $ - |
| 15 | | | | | $ - |
| 16 | ***Storage Volume*** | | | | $ - |
| 17 | *Pond Effective Storage Depth (Ave.)* | 3 | FT | | $ - |
| 18 | *Pond Storage Top Area* | 7,387 | SF | | $ - |
| 19 | *Storage Facility interior Area (Ave.)* | 5,943 | SF | | $ - |
| 20 | *Effective Storage Volume* | 23,773 | CF | | $ - |
| 21 | *Storage Volume* | 0.18 | MG | | $ - |
| 22 | | | | | $ - |
| 23 | ***Compacted Berm Assumptions (per KC Manual)*** | | | | $ - |
| 24 | *Berm Height (Average)* | 3.5 | FT | | $ - |
| 25 | *Berm slope Length@2:1 Slopes* | 7 | FT | | $ - |
| 26 | *Berm flat top Width* | 6 | FT | | $ - |
| 27 | *Berm Bottom Width* | 20 | FT | | $ - |
| 28 | *Distance to CL Berm - Width* | 10 | FT | | $ - |
| 29 | *Berm Centerline Length (for perimeter calcs)* | 129 | FT | | $ - |
| 30 | *Berm Centerline Width (for perimeter calcs)* | 81 | FT | | $ - |
| 31 | *Berm perimeter (at CL Length)* | 420 | FT | | $ - |
| 32 | Berm Area/LF | 46 | SF/FT | | $ - |
| 33 | Imported Fill for Berm | 708 | CY | $ 44 | $ 31,142 |
| 34 | Embankment Compaction | 708 | CY | $ 22 | $ 15,571 |
| 35 | | | | | $ - |
| 36 | **Spillway Assumptions KCSWDM Table 4.2.2A** | | | | $ - |
| 37 | RipRap Lining for Overflow | 5 | CY | $ 346 | $ 1,845 |
| 38 | *Width* | 6 | FT | | $ - |
| 39 | *Length* | 12 | FT | | $ - |
| 40 | *RipRap Depth* | 2 | FT | | $ - |
| 41 | *Slope Run:Rise* | 3 | :1 | | $ - |
| 42 | | | | | $ - |
| 43 | **Wetpond Excavation and Liner** | | | | $ - |
| 44 | Facility Excavation to Berm and Waste | 962 | CY | $ 79 | $ 76,032 |
| 45 | Imported Treatment Liner @ 2' thick | 629 | CY | $ 105 | $ 66,055 |
| 46 | | | | | $ - |
| 47 | **Outlet Pipe** | | | | $ - |
| 48 | Pipe - 12" Diameter | 100 | LF | $ 140 | $ 14,000 |
| 49 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 50 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 51 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 52 | Control Structure | 1 | EA | $ 24,860 | $ 24,860 |
| 53 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 54 | Pipe Discharge Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 55 | Debris Barrier | 1 | EA | $ 14,808 | $ 14,808 |
| 56 | | | | | $ - |
| 57 | **Conveyance Pipe** | | | | $ - |
| 58 | Pipe - 12" Diameter | 100 | LF | $ 140 | $ 14,000 |
| 59 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 60 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 61 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 62 | Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 63 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 64 | | | | | $ - |
| 65 | **Site Removals and Restoration** | | | | $ - |
| 66 | Access Gate (16 ft wide gate) | 1 | EA | $ 3,085 | $ 3,085 |
| 67 | Access Roadway (12'W X 200'L) to site (4" HMA/4" CSBC) and gate | 267 | SY | $ 72 | $ 19,200 |
| 68 | Disking or tilling of compacted soil (180'W X 140'L est. disturbance) | 2,800 | SY | $ 4 | $ 10,332 |
| 69 | Seeding, mulching and compost (Emergent, Riparian & Upland) | 2,800 | SY | $ 10 | $ 27,552 |
| 70 | Plantings (Emergent & Riparian) est. @ 25% of the seeded area | 700 | SY | $ 19 | $ 13,300 |
| 71 | | | | | $ - |
| 72 | **Additional Costs** | | | | $ - |
| 73 | Removals at 4 % Construction Costs | 4.0% | LS | $ 409,061 | $ 16,362 |
| 74 | TESC at 2% of Construction | 2% | LS | $ 425,423 | $ 8,508 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 433,931 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 43,393 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 477,325 |
| ***Direct: Subtotal Construction Costs*** | | | ***$ 477,300*** |

**Description: WQBE 12A Detention Pond On Public Property**

Surface basin that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

**Cost Estimating Assumptions:**

The detention pond is designed in accordance with the King Co. Surface Water Design Manual (KC SWDM) Section 5.1.1 and is generally as described below:
The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside ,right-of way. No property easements or acquisition are required.
It is assumed that no agency mitigation costs will be required.
The detention pond has a bottom area of 4,500 s.f. and has a storage depth of 4' deep (48-inches).
The pond storage volume is generally located below grade.

The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 47 ft. width and is 95 ft. in length.

The pond is constructed with 3:1 side slopes.
The design includes 6 inches for freeboard and 6 inches for sediment storage.
The facility is assumed to be lined with a 2 ft. deep treatment liner in accordance with KC SWDM Section 6.2.4.
An emergency overflow spillway is included.

Emergency Spillway is 12 ft. long w/ a slope of 3:1, H:V.
The spillway is riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.
The infiltration pond includes a compacted berm that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content
A flow restrictor (weir) is included in accordance with Figure 4.1.4C from the KC SWDM.
A pre-settling pond is not included.
Pipe length is 200' of 12" diameter pipe for both influent and effluent combined.
Dewatering is not required.
Trench Box shoring for pipe installation.
A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.
Property is assumed to be existing open space without building or pavement removal.
Fencing is not required, but a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced to help restrict vehicular access.
Disturbed areas are seeded and it is assumed that a portion of the area has plantings.
Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jeff Price (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_12B_Detention Pond With Property Cost | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Detention Pond Installation (4,500 s.f. bottom area @ 4 ft. Storage Depth) | 1 | EA | $ 477,000 | $ 477,000 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 477,000*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 95,400 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 572,400*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 57,240 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 629,640*** |
| | | | | Construction Sales Tax | $ 64,538 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 694,200*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 138,521 |
| | | | | Construction Management | $ 62,964 |
| | | | | Permitting & Support | $ 6,296 |
| 13728 | s.f. Land Area | Medium | Land Purchase/ROW Acquisition | | $ 1,104,143 |
| 4000 | s.f. Land Area | Low | Permanent Easements | | $ 40,400 |
| | | | | WTD Staff Costs & Non-WTD Support | $ 37,778 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,390,103*** |
| | | | | Project Contingency | $ 625,291 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 2,015,400*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 2,709,600*** |

**WQBE_12B_Detention Pond With Property Cost (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 2,709,600** | |
| Capital cost | $ 2,709,600 | $/Unit |
| Total Direct O&M/Year | $ 9,790 | |
| Direct O&M cost | $ 9,790 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 11,100 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 2,931,400** | **$/unit** |
| **Annual O&M Cost** | **$ 10,000** | **$/year** |
| Annualized Cost | $270 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Grass seeding | 2023 dollars | $ 113 | $/year |
| Chain Saw Rental | 2023 dollars | $ 56 | $/year |
| Subtotal | | $169 | |
| Labor | | | |
| Remove trash, sediment, debris and replace vegetation | 16 | hr | |
| Remove dead trees | 32 | hr | |
| stabilize eroded berms and embankments | 24 | hr | |
| | 0 | hr | |
| **Total hours per year** | 72 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 3,916 | |
| Labor cost, burdened | O/H 150.0% | $ 9,790 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 8,040 | | $ 465,773 | **$3,205,613** | **$ 2,931,404** | | | |
| 0 | 1.000 | **$ 2,709,600** | | | $2,709,600 | $ 2,709,600 | $ 2,709,600 | $ 2,709,600 | $ 2,931,404 |
| 1 | 0.950 | $169 | $ - | $ 9,790 | $ 9,959 | $ 9,462 | $ 2,719,559 | $ 2,719,062 | $ 221,804 |
| 2 | 0.903 | $ 174 | $ - | $ 10,084 | $ 10,258 | $ 9,260 | $ 2,729,817 | $ 2,728,323 | $ 212,342 |
| 3 | 0.858 | $ 179 | $ - | $ 10,386 | $ 10,566 | $ 9,062 | $ 2,740,383 | $ 2,737,385 | $ 203,082 |
| 4 | 0.815 | $ 185 | $ - | $ 10,698 | $ 10,883 | $ 8,868 | $ 2,751,266 | $ 2,746,253 | $ 194,019 |
| 5 | 0.774 | $ 190 | $ - | $ 11,019 | $ 11,209 | $ 8,679 | $ 2,762,475 | $ 2,754,932 | $ 185,151 |
| 6 | 0.736 | $ 196 | $ - | $ 11,350 | $ 11,545 | $ 8,493 | $ 2,774,020 | $ 2,763,425 | $ 176,472 |
| 7 | 0.699 | $ 202 | $ - | $ 11,690 | $ 11,892 | $ 8,312 | $ 2,785,912 | $ 2,771,737 | $ 167,979 |
| 8 | 0.664 | $ 208 | $ - | $ 12,041 | $ 12,249 | $ 8,134 | $ 2,798,161 | $ 2,779,871 | $ 159,667 |
| 9 | 0.631 | $ 214 | $ - | $ 12,402 | $ 12,616 | $ 7,960 | $ 2,810,777 | $ 2,787,831 | $ 151,533 |
| 10 | 0.599 | $ 221 | $ 11,100 | $ 12,774 | $ 24,094 | $ 14,444 | $ 2,834,871 | $ 2,802,276 | $ 143,573 |
| 11 | 0.570 | $ 227 | $ - | $ 13,157 | $ 13,384 | $ 7,623 | $ 2,848,255 | $ 2,809,899 | $ 129,128 |
| 12 | 0.541 | $ 234 | $ - | $ 13,552 | $ 13,786 | $ 7,461 | $ 2,862,041 | $ 2,817,360 | $ 121,505 |
| 13 | 0.514 | $ 241 | $ - | $ 13,958 | $ 14,199 | $ 7,301 | $ 2,876,241 | $ 2,824,661 | $ 114,044 |
| 14 | 0.489 | $ 248 | $ - | $ 14,377 | $ 14,625 | $ 7,145 | $ 2,890,866 | $ 2,831,806 | $ 106,743 |
| 15 | 0.464 | $ 256 | $ - | $ 14,809 | $ 15,064 | $ 6,992 | $ 2,905,930 | $ 2,838,798 | $ 99,598 |
| 16 | 0.441 | $ 263 | $ - | $ 15,253 | $ 15,516 | $ 6,843 | $ 2,921,446 | $ 2,845,641 | $ 92,606 |
| 17 | 0.419 | $ 271 | $ - | $ 15,710 | $ 15,982 | $ 6,696 | $ 2,937,428 | $ 2,852,337 | $ 85,764 |
| 18 | 0.398 | $ 279 | $ - | $ 16,182 | $ 16,461 | $ 6,553 | $ 2,953,889 | $ 2,858,890 | $ 79,067 |
| 19 | 0.378 | $ 288 | $ - | $ 16,667 | $ 16,955 | $ 6,413 | $ 2,970,844 | $ 2,865,304 | $ 72,514 |
| 20 | 0.359 | $ 296 | $ 11,100 | $ 17,167 | $ 28,564 | $ 10,265 | $ 2,999,407 | $ 2,875,569 | $ 66,101 |
| 21 | 0.341 | $ 305 | $ - | $ 17,682 | $ 17,987 | $ 6,142 | $ 3,017,395 | $ 2,881,711 | $ 55,835 |
| 22 | 0.324 | $ 314 | $ - | $ 18,213 | $ 18,527 | $ 6,011 | $ 3,035,922 | $ 2,887,721 | $ 49,693 |
| 23 | 0.308 | $ 324 | $ - | $ 18,759 | $ 19,083 | $ 5,882 | $ 3,055,005 | $ 2,893,603 | $ 43,683 |
| 24 | 0.293 | $ 334 | $ - | $ 19,322 | $ 19,655 | $ 5,756 | $ 3,074,660 | $ 2,899,360 | $ 37,801 |
| 25 | 0.278 | $ 344 | $ - | $ 19,901 | $ 20,245 | $ 5,633 | $ 3,094,905 | $ 2,904,993 | $ 32,044 |
| 26 | 0.264 | $ 354 | $ - | $ 20,499 | $ 20,852 | $ 5,513 | $ 3,115,757 | $ 2,910,506 | $ 26,411 |
| 27 | 0.251 | $ 364 | $ - | $ 21,113 | $ 21,478 | $ 5,395 | $ 3,137,235 | $ 2,915,901 | $ 20,898 |
| 28 | 0.239 | $ 375 | $ - | $ 21,747 | $ 22,122 | $ 5,280 | $ 3,159,358 | $ 2,921,181 | $ 15,503 |
| 29 | 0.227 | $ 387 | $ - | $ 22,399 | $ 22,786 | $ 5,167 | $ 3,182,144 | $ 2,926,348 | $ 10,223 |
| 30 | 0.215 | $ 398 | $ - | $ 23,071 | $ 23,470 | $ 5,056 | $ 3,205,613 | $ 2,931,404 | $ 5,056 |

**WQBE_12B_Detention Pond With Property Cost**

Surface basin that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**

16 Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal performed annually by a crew of two over a 8 hour workday.

32 Removal of dead, diseased or dying trees annually by a crew of four using hand tools and a chainsaw as needed (8 hour work day). Assume annual cost of chainsaw rental as $56.

24 Stabilization of eroded berms, slopes, embankments, and animal borrows. Biannual site visits by 2 crew members, 6 hour work day. Grass seed mix as needed to stabilize at an estimated cost of $113 per year.

**Capital Replacement Assumptions:**

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Replacement will also include replacement of access gate every ten years. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Cindy Kinzer (HDR)<br>Jeff Price (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_12B_Detention Pond With Property Cost | | | **Version:** | 2 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Detention Pond on Public Property** | | | | $ - |
| 2 | ***Pond Assumptions*** | | | | $ - |
| 3 | *Pond Bottom Area* | 4,500 | SF | | $ - |
| 4 | *Pond Top Area* | 8,493 | SF | | $ - |
| 5 | *Pond Top Area* | | | | $ - |
| 6 | *Pond Bottom Length* | 95 | FT | | $ - |
| 7 | *Pond Top Length* | 119 | FT | | $ - |
| 8 | *Pond Bottom Width* | 47 | FT | | $ - |
| 9 | *Pond Top Width* | 71 | | | $ - |
| 10 | *Pond Exc. Depth* | 4 | FT | | $ - |
| 11 | *Slope Run/Rise* | 3 | :1 | | $ - |
| 12 | *Slope Length* | 12 | FT | | $ - |
| 13 | *Freeboard (Ave.)* | 1 | FT | | $ - |
| 14 | *Imported Treatment Liner depth* | 2 | FT | | $ - |
| 15 | | | | | $ - |
| 16 | ***Storage Volume*** | | | | $ - |
| 17 | *Pond Effective Storage Depth (Ave.)* | 3 | FT | | $ - |
| 18 | *Pond Storage Top Area* | 7,387 | SF | | $ - |
| 19 | *Storage Facility interior Area (Ave.)* | 5,943 | SF | | $ - |
| 20 | *Effective Storage Volume* | 23,773 | CF | | $ - |
| 21 | *Storage Volume* | 0.18 | MG | | $ - |
| 22 | | | | | $ - |
| 23 | ***Compacted Berm Assumptions (per KC Manual)*** | | | | $ - |
| 24 | *Berm Height (Average)* | 3.5 | FT | | $ - |
| 25 | *Berm slope Length@2:1 Slopes* | 7 | FT | | $ - |
| 26 | *Berm flat top Width* | 6 | FT | | $ - |
| 27 | *Berm Bottom Width* | 20 | FT | | $ - |
| 28 | *Distance to CL Berm - Width* | 10 | FT | | $ - |
| 29 | *Berm Centerline Length (for perimeter calcs)* | 129 | FT | | $ - |
| 30 | *Berm Centerline Width (for perimeter calcs)* | 81 | FT | | $ - |
| 31 | *Berm perimeter (at CL Length)* | 420 | FT | | $ - |
| 32 | *Berm Area/LF* | 46 | SF/FT | | $ - |
| 33 | Imported Fill for Berm | 708 | CY | $ 44 | $ 31,142 |
| 34 | Embankment Compaction | 708 | CY | $ 22 | $ 15,571 |
| 35 | | | | | $ - |
| 36 | **Spillway Assumptions KCSWDM Table 4.2.2A** | | | | $ - |
| 37 | RipRap Lining for Overflow | 5 | CY | $ 346 | $ 1,845 |
| 38 | *Width* | 6 | FT | | $ - |
| 39 | *Length* | 12 | FT | | $ - |
| 40 | *RipRap Depth* | 2 | FT | | $ - |
| 41 | *Slope Run:Rise* | 3 | :1 | | $ - |
| 42 | | | | | $ - |
| 43 | **Wetpond Excavation and Liner** | | | | $ - |
| 44 | Facility Excavation to Berm and Waste | 962 | CY | $ 79 | $ 76,032 |
| 45 | Imported Treatment Liner @ 2' thick | 629 | CY | $ 105 | $ 66,055 |
| 46 | | | | | $ - |
| 47 | **Outlet Pipe** | | | | $ - |
| 48 | Pipe - 12" Diameter | 100 | LF | $ 140 | $ 14,000 |
| 49 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 50 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 51 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 52 | Control Structure | 1 | EA | $ 24,860 | $ 24,860 |
| 53 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 54 | Pipe Discharge Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 55 | Debris Barrier | 1 | EA | $ 14,808 | $ 14,808 |
| 56 | | | | | $ - |
| 57 | **Conveyance Pipe** | | | | $ - |
| 58 | Pipe - 12" Diameter | 100 | LF | $ 140 | $ 14,000 |
| 59 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 60 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 61 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 62 | Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 63 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 64 | | | | | $ - |
| 65 | **Site Removals and Restoration** | | | | $ - |
| 66 | Access Gate (16 ft wide gate) | 1 | EA | $ 3,085 | $ 3,085 |
| 67 | Access Roadway (12'W X 200'L) to site (4" HMA/4" CSBC) and gate | 267 | SY | $ 71 | $ 18,933 |
| 68 | Disking or tilling of compacted soil (180'W X 140'L est. disturbance) | 2,800 | SY | $ 4 | $ 10,332 |
| 69 | Seeding, mulching and compost (Emergent, Riparian & Upland) | 2,800 | SY | $ 10 | $ 27,552 |
| 70 | Plantings (Emergent & Riparian) est. @ 25% of the seeded area | 700 | SY | $ 19 | $ 13,300 |
| 71 | | | | | $ - |
| 72 | **Additional Costs** | | | | $ - |
| 73 | Removals at 4 % Construction Costs | 4.0% | LS | $ 408,794 | $ 16,352 |
| 74 | TESC at 2% of Construction | 2% | LS | $ 425,146 | $ 8,503 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 433,649 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | General Conditions | 0% | | 1 | $ - |
| | Mobilization/Demobilization | 10% | | 1.1 | $ 43,365 |
| | Overhead & Profit (OHP) | 0% | | 1 | $ - |
| | Insurance | 0.0% | | 1 | $ - |
| | Bonding | 0.0% | | 1 | $ - |
| | Escalation Multiplier from ENR-CCI | 0% | | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 477,013 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 477,000*** |

**Description: WQBE 12B Detention Pond With Property Cost**

Surface basin that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

**Cost Estimating Assumptions:**

The detention pond is designed in accordance with the King Co. Surface Water Design Manual (KC SWDM) Section 5.1.1 and is generally as described below:

The installation is on property and will require easement and property acquisition.
The detention pond has a bottom area of 4,500 s.f. and has a storage depth of 4' deep (48-inches).

The pond storage volume is generally located below grade.
The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 47 ft. width and is 95 ft. in length.
The pond is constructed with 3:1 side slopes.
The design includes 6 inches for freeboard and 6 inches for sediment storage.
The facility is assumed to be lined with a 2 ft. deep treatment liner in accordance with KC SWDM Section 6.2.4.
An emergency overflow spillway is included.
Emergency Spillway is 12 ft. long w/ a slope of 3:1, H:V.
The spillway is riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.

The infiltration pond includes a compacted berm that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content
A flow restrictor (weir) is included in accordance with Figure 4.1.4C from the KC SWDM.
A pre-settling pond is not included.
Pipe length is 200' of 12" diameter pipe for both influent and effluent combined.
Dewatering is not required.
Trench Box shoring for pipe installation.
A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.
Property is assumed to be existing open space without building or pavement removal.
Fencing is not required, but a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced to help restrict vehicular access.
Disturbed areas are seeded and it is assumed that a portion of the area has plantings.
Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

**Planning Basis Assumptions:**
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**
All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**
This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 13A_Infiltration Pond Till Soil on Public Property | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Infiltration Pond Till Soil (2785 sf bottom area @ 4 ft. Storage Depth) | 1 | EA | $ 343,900 | $ 343,900 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 343,900*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 68,780 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 412,680*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 41,268 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 453,948*** |
| | | | | Construction Sales Tax | $ 46,530 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 500,500*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 99,869 |
| | | | | Construction Management | $ 45,395 |
| | | | | Permitting & Support | $ 4,539 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 27,237 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 177,040*** |
| | | | | Project Contingency | $ 203,262 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 380,300*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 880,800*** |

**Description: WQBE 13A_Infiltration Pond Till Soil on Public Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 880,800** | |
| Capital cost | $ 880,800 | $/Unit |
| Total Direct O&M/Year | $ 5,711 | |
| Direct O&M cost | $ 5,711 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 11,100 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 1,016,100** | **$/unit** |
| **Annual O&M Cost** | **$ 5,900** | **$/year** |
| Annualized Cost | $270 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Grass seeding | 2023 dollars | $ 113 | $/year |
| Chain Saw Rental | 2023 dollars | $ 56 | $/year |
| Subtotal | | $169 | |
| Labor | | | |
| Remove Trash | 10 | hr | |
| Remove Dead,Diseased or Dying Trees | 24 | hr | |
| Remediation of erosion | 8 | hr | |
| | 0 | hr | |
| **Total hours per year** | 42 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 2,284 | |
| Labor cost, burdened | O/H 150.0% | $ 5,711 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 8,040 | | $ 271,701 | **$1,182,741** | **#########** | | | |
| 0 | 1.000 | **$ 880,800** | | | $880,800 | $ 880,800 | $ 880,800 | $ 880,800 | $ 1,016,114 |
| 1 | 0.950 | $169 | $ - | $ 5,711 | $ 5,880 | $ 5,587 | $ 886,680 | $ 886,387 | $ 135,314 |
| 2 | 0.903 | $ 174 | $ - | $ 5,882 | $ 6,056 | $ 5,467 | $ 892,736 | $ 891,854 | $ 129,727 |
| 3 | 0.858 | $ 179 | $ - | $ 6,059 | $ 6,238 | $ 5,350 | $ 898,974 | $ 897,204 | $ 124,260 |
| 4 | 0.815 | $ 185 | $ - | $ 6,241 | $ 6,425 | $ 5,236 | $ 905,400 | $ 902,440 | $ 118,909 |
| 5 | 0.774 | $ 190 | $ - | $ 6,428 | $ 6,618 | $ 5,124 | $ 912,017 | $ 907,564 | $ 113,673 |
| 6 | 0.736 | $ 196 | $ - | $ 6,621 | $ 6,816 | $ 5,014 | $ 918,834 | $ 912,579 | $ 108,549 |
| 7 | 0.699 | $ 202 | $ - | $ 6,819 | $ 7,021 | $ 4,907 | $ 925,855 | $ 917,486 | $ 103,535 |
| 8 | 0.664 | $ 208 | $ - | $ 7,024 | $ 7,232 | $ 4,802 | $ 933,086 | $ 922,288 | $ 98,628 |
| 9 | 0.631 | $ 214 | $ - | $ 7,234 | $ 7,449 | $ 4,700 | $ 940,535 | $ 926,988 | $ 93,825 |
| 10 | 0.599 | $ 221 | $ 11,100 | $ 7,451 | $ 18,772 | $ 11,254 | $ 959,307 | $ 938,242 | $ 89,125 |
| 11 | 0.570 | $ 227 | $ - | $ 7,675 | $ 7,902 | $ 4,501 | $ 967,209 | $ 942,743 | $ 77,872 |
| 12 | 0.541 | $ 234 | $ - | $ 7,905 | $ 8,139 | $ 4,405 | $ 975,348 | $ 947,147 | $ 73,371 |
| 13 | 0.514 | $ 241 | $ - | $ 8,142 | $ 8,383 | $ 4,311 | $ 983,732 | $ 951,458 | $ 68,966 |
| 14 | 0.489 | $ 248 | $ - | $ 8,387 | $ 8,635 | $ 4,218 | $ 992,367 | $ 955,676 | $ 64,656 |
| 15 | 0.464 | $ 256 | $ - | $ 8,638 | $ 8,894 | $ 4,128 | $ 1,001,261 | $ 959,805 | $ 60,437 |
| 16 | 0.441 | $ 263 | $ - | $ 8,897 | $ 9,161 | $ 4,040 | $ 1,010,421 | $ 963,844 | $ 56,309 |
| 17 | 0.419 | $ 271 | $ - | $ 9,164 | $ 9,436 | $ 3,954 | $ 1,019,857 | $ 967,798 | $ 52,269 |
| 18 | 0.398 | $ 279 | $ - | $ 9,439 | $ 9,719 | $ 3,869 | $ 1,029,576 | $ 971,667 | $ 48,315 |
| 19 | 0.378 | $ 288 | $ - | $ 9,723 | $ 10,010 | $ 3,786 | $ 1,039,586 | $ 975,454 | $ 44,446 |
| 20 | 0.359 | $ 296 | $ 11,100 | $ 10,014 | $ 21,411 | $ 7,695 | $ 1,060,996 | $ 983,148 | $ 40,660 |
| 21 | 0.341 | $ 305 | $ - | $ 10,315 | $ 10,620 | $ 3,626 | $ 1,071,616 | $ 986,774 | $ 32,965 |
| 22 | 0.324 | $ 314 | $ - | $ 10,624 | $ 10,938 | $ 3,549 | $ 1,082,555 | $ 990,323 | $ 29,339 |
| 23 | 0.308 | $ 324 | $ - | $ 10,943 | $ 11,267 | $ 3,473 | $ 1,093,821 | $ 993,796 | $ 25,790 |
| 24 | 0.293 | $ 334 | $ - | $ 11,271 | $ 11,605 | $ 3,399 | $ 1,105,426 | $ 997,194 | $ 22,318 |
| 25 | 0.278 | $ 344 | $ - | $ 11,609 | $ 11,953 | $ 3,326 | $ 1,117,379 | $ 1,000,520 | $ 18,919 |
| 26 | 0.264 | $ 354 | $ - | $ 11,957 | $ 12,311 | $ 3,255 | $ 1,129,690 | $ 1,003,775 | $ 15,593 |
| 27 | 0.251 | $ 364 | $ - | $ 12,316 | $ 12,681 | $ 3,185 | $ 1,142,371 | $ 1,006,961 | $ 12,338 |
| 28 | 0.239 | $ 375 | $ - | $ 12,686 | $ 13,061 | $ 3,117 | $ 1,155,432 | $ 1,010,078 | $ 9,153 |
| 29 | 0.227 | $ 387 | $ - | $ 13,066 | $ 13,453 | $ 3,051 | $ 1,168,885 | $ 1,013,128 | $ 6,036 |
| 30 | 0.215 | $ 398 | $ - | $ 13,458 | $ 13,856 | $ 2,985 | $ 1,182,741 | $ 1,016,114 | $ 2,985 |

**Description: WQBE 13A_Infiltration Pond Till Soil on Public Property**
Basin that stores and infiltrates stormwater runoff.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash,
10 sediment and debris removal performed annually by a crew of two over a 5 hour workday.

Removal of dead, diseased or dying trees annually by a crew of four using hand tools and a chainsaw as
24 needed (6 hour work day). Assume annual cost of $56 for chainsaw rental.

Stabilization of eroded berms, slopes, embankments, and animal borrows. Assume annual visit with 2 crew
8 members, 4 hour work day. Grass seed mix as needed to stabilize at an estimated cost of $113 per year.

**Capital Replacement Assumptions:**

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Replacement will also include replacement of access gate every ten years. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 13A_Infiltration Pond Till Soil on Public Property | | | **Version:** | 2 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Infiltration Pond on Public Property** | | | | $ - |
| 2 | ***Pond Assumptions*** | | | | $ - |
| 3 | *Pond Bottom Area* | 2,785 | SF | | $ - |
| 4 | *Pond Top Area* | 6,046 | SF | | $ - |
| 5 | *Pond Top Area* | | | | $ - |
| 6 | *Pond Bottom Length* | 75 | FT | | $ - |
| 7 | *Pond Top Length* | 99 | FT | | $ - |
| 8 | *Pond Bottom Width* | 37 | FT | | $ - |
| 9 | *Pond Top Width* | 61 | | | $ - |
| 10 | *Pond Exc. Depth* | 4 | FT | | $ - |
| 11 | *Slope Run/Rise* | 3 | :1 | | $ - |
| 12 | *Slope Length* | 12 | FT | | $ - |
| 13 | *Freeboard (Ave.)* | 1 | FT | | $ - |
| 14 | | | | | $ - |
| 15 | | | | | $ - |
| 16 | **Storage Volume** | | | | $ - |
| 17 | *Pond Effective Storage Depth (Ave.)* | 3 | FT | | $ - |
| 18 | *Pond Storage Top Area* | 5,123 | SF | | $ - |
| 19 | *Storage Facility interior Area (Ave.)* | 3,954 | SF | | $ - |
| 20 | *Effective Storage Volume (15.500 cf target)* | 15,816 | CF | | $ - |
| 21 | *Storage Volume* | 0.12 | MG | | $ - |
| 22 | | | | | $ - |
| 23 | **Compacted Berm Assumptions (per KC Manual)** | | | | $ - |
| 24 | *Berm Height (Average)* | 3.5 | FT | | $ - |
| 25 | *Berm slope Length@2:1 Slopes* | 7 | FT | | $ - |
| 26 | *Berm flat top Width* | 6 | FT | | $ - |
| 27 | *Berm Bottom Width* | 20 | FT | | $ - |
| 28 | *Distance to CL Berm - Width* | 10 | FT | | $ - |
| 29 | *Berm Centerline Length (for perimeter calcs)* | 109 | FT | | $ - |
| 30 | *Berm Centerline Width (for perimeter calcs)* | 71 | FT | | $ - |
| 31 | *Berm perimeter (at CL Length)* | 295 | FT | | $ - |
| 32 | *Berm Area/LF* | 45 | SF/FT | | $ - |
| 33 | Imported Fill for Berm | 492 | CY | $ 44 | $ 21,633 |
| 34 | Embankment Compaction | 492 | CY | $ 22 | $ 10,817 |
| 35 | | | | | $ - |
| 36 | **Spillway Assumptions KCSWDM Table 4.2.2A** | | | | $ - |
| 37 | RipRap Lining for Overflow | 5 | CY | $ 346 | $ 1,845 |
| 38 | *Width* | 6 | FT | | $ - |
| 39 | *Length* | 12 | FT | | $ - |
| 40 | *RipRap Depth* | 2 | FT | | $ - |
| 41 | *Slope Run:Rise* | 3 | :1 | | $ - |
| 42 | | | | | $ - |
| 43 | **Wetpond Excavation and Liner** | | | | $ - |
| 44 | Facility Excavation to Berm and Waste | 654 | CY | $ 79 | $ 51,680 |
| 45 | | | | | $ - |
| 46 | | | | | $ - |
| 47 | **Outlet Pipe** | | | | $ - |
| 48 | Pipe - 12" Diameter | 100 | LF | $ 140 | $ 14,000 |
| 49 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 50 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 51 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 52 | Control Structure | 1 | EA | $ 24,860 | $ 24,860 |
| 53 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 54 | Pipe Discharge Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 55 | Debris Barrier | 1 | EA | $ 14,808 | $ 14,808 |
| 56 | | | | | $ - |
| 57 | **Conveyance Pipe** | | | | $ - |
| 58 | Pipe - 12" Diameter | 100 | LF | $ 140 | $ 14,000 |
| 59 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 60 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 61 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 62 | Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 63 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 64 | | | | | $ - |
| 65 | **Site Removals and Restoration** | | | | $ - |
| 66 | Access Gate (16 ft wide gate) | 1 | EA | $ 3,085 | $ 3,085 |
| 67 | Access Roadway (12'W X 200'L) to site (4" HMA/4" CSBC) and gate | 267 | SY | $ 71 | $ 18,933 |
| 68 | Disking or tilling of compacted soil (180'W X 140'L est. disturbance) | 2,286 | SY | $ 4 | $ 8,437 |
| 69 | Seeding, mulching and compost (Emergent, Riparian & Upland) | 2,286 | SY | $ 10 | $ 22,499 |
| 70 | Plantings (Emergent & Riparian) est. @ 25% of the seeded area | 572 | SY | $ 19 | $ 10,861 |
| 71 | | | | | $ - |
| 72 | **Additional Costs** | | | | $ - |
| 73 | Removals at 4 % Construction Costs | 4.0% | LS | $ 294,735 | $ 11,789 |
| 74 | TESC at 2% of Construction | 2% | LS | $ 306,525 | $ 6,130 |
| | | | | | $ - |
| | | | | | $ - |
| | ***Item Subtotal Construction Costs (Year 2023)*** | | | | $ 312,655 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | General Conditions | | 0% | 1 | $ - |
| | Mobilization/Demobilization | | 10% | 1.1 | $ 31,266 |
| | Overhead & Profit (OHP) | | 0% | 1 | $ - |
| | Insurance | | 0.0% | 1 | $ - |
| | Bonding | | 0.0% | 1 | $ - |
| | Escalation Multiplier from ENR-CCI | | 0% | 1.0000 | $ - |
| | ***Item Subtotal Construction Costs (Year 2023)*** | | | | $ 343,921 |
| | ***Direct: Subtotal Construction Costs*** | | | | ***$ 343,900*** |

**Description: WQBE 13A_Infiltration Pond Till Soil on Public Property**

Basin that stores and infiltrates stormwater runoff.

**Cost Estimating Assumptions:**

The infiltration pond is designed in accordance with KC SW Manual Section 5.2.2 and is generally as described below:
It is assumed that stormwater will be pre-treated prior to conveyance to this facility and that a pre-settling pond will not be required.
The infiltration pond is located in till soils and has a bottom area of 2,785 s.f. and a storage depth of 4 feet deep (48 inches).
The pond storage volume is generally located below grade.
The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 37.3 ft. wide and 74.6 ft. long.
The pond is constructed with 3:1 side slopes.
The design includes 1' of freeboard.
An emergency overflow spillway is included.
The spillway is riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.
Emergency Spillway is 12 ft. long w/ a slope of 3:1, H:V.
The infiltration pond includes a compacted berm along three sides that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content
A Type 2 minimum 72" dia. flow restrictor (weir) is included with shear gate, and frame and grate for secondary inlet.
Approximately 100 feet of 12-inch and 100 feet of 12-inch diameter pipes are included.
Dewatering is not required.
Trench Box shoring for pipe installation.
A 200 ft. long and 12 ft. wide paved maintenance access road is provided.
Property is assumed to be existing open space without building or pavement removal.
Fencing is not required, but a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced to help restrict vehicular access.
Disturbed areas are seeded and it is assumed that a portion of the area has plantings.
The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.
Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 13B_Infiltration Pond Outwash Soil on Public Property | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Infiltration Pond (1479 sf bottom area @ 4 ft. Storage Depth) | 1 | EA | $ 308,000 | $ 308,000 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 308,000*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 61,600 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 369,600*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 36,960 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 406,560*** |
| | | | | Construction Sales Tax | $ 41,672 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 448,200*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 89,443 |
| | | | | Construction Management | $ 40,656 |
| | | | | Permitting & Support | $ 4,066 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 24,394 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 158,558*** |
| | | | | Project Contingency | $ 182,028 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 340,600*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 788,800*** |

**Description: WQBE 13B_Infiltration Pond Outwash Soil on Public Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 788,800** | |
| Capital cost | $ 788,800 | $/Unit |
| Total Direct O&M/Year | $ 3,535 | |
| Direct O&M cost | $ 3,535 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 11,100 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 878,000** | **$/unit** |
| **Annual O&M Cost** | **$ 3,700** | **$/year** |
| Annualized Cost | $270 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | |
| Grass seeding | 2023 dollars | $ 113 | $/year |
| Chain Saw Rental | 2023 dollars | $ 56 | $/year |
| Subtotal | | $169 | |
| Labor | | | |
| Remove Trash | 6 | hr | |
| Remove Dead,Diseased or Dying Trees | 12 | hr | |
| Remediation of erosion | 8 | hr | |
| | 0 | hr | |
| **Total hours per year** | 26 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 1,414 | |
| Labor cost, burdened | O/H 150.0% | $ 3,535 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 8,040 | | $ 168,196 | **$987,236** | **$ 877,985** | | | |
| 0 | 1.000 | **$ 788,800** | | | $788,800 | $ 788,800 | $ 788,800 | $ 788,800 | $ 877,985 |
| 1 | 0.950 | $169 | $ - | $ 3,535 | $ 3,704 | $ 3,520 | $ 792,504 | $ 792,320 | $ 89,185 |
| 2 | 0.903 | $ 174 | $ - | $ 3,641 | $ 3,815 | $ 3,444 | $ 796,320 | $ 795,764 | $ 85,666 |
| 3 | 0.858 | $ 179 | $ - | $ 3,751 | $ 3,930 | $ 3,371 | $ 800,250 | $ 799,135 | $ 82,221 |
| 4 | 0.815 | $ 185 | $ - | $ 3,863 | $ 4,048 | $ 3,299 | $ 804,298 | $ 802,433 | $ 78,851 |
| 5 | 0.774 | $ 190 | $ - | $ 3,979 | $ 4,169 | $ 3,228 | $ 808,467 | $ 805,661 | $ 75,552 |
| 6 | 0.736 | $ 196 | $ - | $ 4,098 | $ 4,294 | $ 3,159 | $ 812,761 | $ 808,820 | $ 72,324 |
| 7 | 0.699 | $ 202 | $ - | $ 4,221 | $ 4,423 | $ 3,092 | $ 817,184 | $ 811,912 | $ 69,165 |
| 8 | 0.664 | $ 208 | $ - | $ 4,348 | $ 4,556 | $ 3,025 | $ 821,740 | $ 814,938 | $ 66,073 |
| 9 | 0.631 | $ 214 | $ - | $ 4,478 | $ 4,693 | $ 2,961 | $ 826,433 | $ 817,898 | $ 63,048 |
| 10 | 0.599 | $ 221 | $ 11,100 | $ 4,613 | $ 15,933 | $ 9,552 | $ 842,366 | $ 827,450 | $ 60,087 |
| 11 | 0.570 | $ 227 | $ - | $ 4,751 | $ 4,978 | $ 2,836 | $ 847,345 | $ 830,286 | $ 50,535 |
| 12 | 0.541 | $ 234 | $ - | $ 4,894 | $ 5,128 | $ 2,775 | $ 852,472 | $ 833,061 | $ 47,699 |
| 13 | 0.514 | $ 241 | $ - | $ 5,041 | $ 5,282 | $ 2,716 | $ 857,754 | $ 835,776 | $ 44,924 |
| 14 | 0.489 | $ 248 | $ - | $ 5,192 | $ 5,440 | $ 2,658 | $ 863,194 | $ 838,434 | $ 42,209 |
| 15 | 0.464 | $ 256 | $ - | $ 5,348 | $ 5,603 | $ 2,601 | $ 868,797 | $ 841,035 | $ 39,551 |
| 16 | 0.441 | $ 263 | $ - | $ 5,508 | $ 5,771 | $ 2,545 | $ 874,568 | $ 843,580 | $ 36,951 |
| 17 | 0.419 | $ 271 | $ - | $ 5,673 | $ 5,944 | $ 2,491 | $ 880,513 | $ 846,071 | $ 34,405 |
| 18 | 0.398 | $ 279 | $ - | $ 5,843 | $ 6,123 | $ 2,438 | $ 886,635 | $ 848,508 | $ 31,915 |
| 19 | 0.378 | $ 288 | $ - | $ 6,019 | $ 6,306 | $ 2,385 | $ 892,942 | $ 850,894 | $ 29,477 |
| 20 | 0.359 | $ 296 | $ 11,100 | $ 6,199 | $ 17,596 | $ 6,324 | $ 910,537 | $ 857,217 | $ 27,092 |
| 21 | 0.341 | $ 305 | $ - | $ 6,385 | $ 6,690 | $ 2,285 | $ 917,228 | $ 859,502 | $ 20,768 |
| 22 | 0.324 | $ 314 | $ - | $ 6,577 | $ 6,891 | $ 2,236 | $ 924,119 | $ 861,737 | $ 18,484 |
| 23 | 0.308 | $ 324 | $ - | $ 6,774 | $ 7,098 | $ 2,188 | $ 931,217 | $ 863,925 | $ 16,248 |
| 24 | 0.293 | $ 334 | $ - | $ 6,977 | $ 7,311 | $ 2,141 | $ 938,528 | $ 866,066 | $ 14,060 |
| 25 | 0.278 | $ 344 | $ - | $ 7,187 | $ 7,530 | $ 2,095 | $ 946,058 | $ 868,162 | $ 11,919 |
| 26 | 0.264 | $ 354 | $ - | $ 7,402 | $ 7,756 | $ 2,051 | $ 953,814 | $ 870,212 | $ 9,824 |
| 27 | 0.251 | $ 364 | $ - | $ 7,624 | $ 7,989 | $ 2,007 | $ 961,803 | $ 872,219 | $ 7,773 |
| 28 | 0.239 | $ 375 | $ - | $ 7,853 | $ 8,228 | $ 1,964 | $ 970,031 | $ 874,183 | $ 5,766 |
| 29 | 0.227 | $ 387 | $ - | $ 8,089 | $ 8,475 | $ 1,922 | $ 978,506 | $ 876,104 | $ 3,803 |
| 30 | 0.215 | $ 398 | $ - | $ 8,331 | $ 8,730 | $ 1,881 | $ 987,236 | $ 877,985 | $ 1,881 |

**Description: WQBE 13B_Infiltration Pond Outwash Soil on Public Property**
Basin that stores and infiltrates stormwater runoff.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by
6 trash, sediment and debris removal performed annually by a crew of two over a 3 hour workday.
Removal of dead, diseased or dying trees annually by a crew of four using hand tools and a
12 chainsaw as needed (3 hour work day). Assume annual cost of $50 for chainsaw rental.
Stabilization of eroded berms, slopes, embankments, and animal borrows. Assume annual visit of 2 crew members, 4 hour work day. Grass seed mix as needed to stabilize at an estimated cost of $100
8 per year.

**Capital Replacement Assumptions:**

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Replacement will also include replacement of access gate every ten years. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| Project Name: | King County Water Quality Benefits Evaluation | | Date: | | 6/7/2024 |
| Location: | King County, WA | | Estimator: | | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| Description: | WQBE 13A_Infiltration Pond Till Soil on Public Property | | Version: | | 2 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Infiltration Pond on Public Property** | | | | $ - |
| 2 | ***Pond Assumptions*** | | | | $ - |
| 3 | *Pond Bottom Area* | 1,479 | SF | | $ - |
| 4 | *Pond Top Area* | 4,009 | SF | | $ - |
| 5 | *Pond Top Area* | | | | $ - |
| 6 | *Pond Bottom Length* | 54.0 | FT | | $ - |
| 7 | *Pond Top Length* | 78 | FT | | $ - |
| 8 | *Pond Bottom Width* | 27.4 | FT | | $ - |
| 9 | *Pond Top Width* | 51 | | | $ - |
| 10 | *Pond Exc. Depth* | 4 | FT | | $ - |
| 11 | *Slope Run/Rise* | 3 | :1 | | $ - |
| 12 | *Slope Length* | 12 | FT | | $ - |
| 13 | *Freeboard (Ave.)* | 1 | FT | | $ - |
| 14 | | | | | $ - |
| 15 | | | | | $ - |
| 16 | ***Storage Volume*** | | | | $ - |
| 17 | *Pond Effective Storage Depth (Ave.)* | 3 | FT | | $ - |
| 18 | *Pond Storage Top Area* | 3,268 | SF | | $ - |
| 19 | *Storage Facility interior Area (Ave.)* | 2,374 | SF | | $ - |
| 20 | *Effective Storage Volume* | 9,495 | CF | | $ - |
| 21 | *Storage Volume* | 0.07 | MG | | $ - |
| 22 | | | | | $ - |
| 23 | ***Compacted Berm Assumptions (per KC Manual)*** | | | | $ - |
| 24 | *Berm Height (Average)* | 3.5 | FT | | $ - |
| 25 | *Berm slope Length@2:1 Slopes* | 7 | FT | | $ - |
| 26 | *Berm flat top Width* | 6 | FT | | $ - |
| 27 | *Berm Bottom Width* | 20 | FT | | $ - |
| 28 | *Distance to CL Berm - Width* | 10 | FT | | $ - |
| 29 | *Berm Centerline Length (for perimeter calcs)* | 88 | FT | | $ - |
| 30 | *Berm Centerline Width (for perimeter calcs)* | 61 | FT | | $ - |
| 31 | *Berm perimeter (at CL Length)* | 245 | FT | | $ - |
| 32 | *Berm Area/LF* | 45 | SF/FT | | $ - |
| 33 | Imported Fill for Berm | 408 | CY | $ 44 | $ 17,967 |
| 34 | Embankment Compaction | 408 | CY | $ 22 | $ 8,983 |
| 35 | | | | | $ - |
| 36 | **Spillway Assumptions KCSWDM Table 4.2.2A** | | | | $ - |
| 37 | RipRap Lining for Overflow | 5 | CY | $ 346 | $ 1,845 |
| 38 | *Width* | 6 | FT | | $ - |
| 39 | *Length* | 12 | FT | | $ - |
| 40 | *RipRap Depth* | 2 | FT | | $ - |
| 41 | *Slope Run:Rise* | 3 | :1 | | $ - |
| 42 | | | | | $ - |
| 43 | **Pond Excavation and Liner** | | | | $ - |
| 44 | Facility Excavation to Berm and Waste | 406 | CY | $ 79 | $ 32,113 |
| 45 | | | | | $ - |
| 46 | | | | | $ - |
| 47 | **Outlet Pipe** | | | | $ - |
| 48 | Pipe - 12" Diameter | 100 | LF | $ 140 | $ 14,000 |
| 49 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 50 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 51 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 52 | Control Structure | 1 | EA | $ 24,860 | $ 24,860 |
| 53 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 54 | Pipe Discharge Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 55 | Debris Barrier | 1 | EA | $ 14,808 | $ 14,808 |
| 56 | | | | | $ - |
| 57 | **Conveyance Pipe** | | | | $ - |
| 58 | Pipe - 12" Diameter | 100 | LF | $ 140 | $ 14,000 |
| 59 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 60 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 61 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 62 | Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 63 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 64 | | | | | $ - |
| 65 | **Site Removals and Restoration** | | | | $ - |
| 66 | Access Gate (16 ft wide gate) | 1 | EA | $ 3,085 | $ 3,085 |
| 67 | Access Roadway (12'W X 200'L) to site (4" HMA/4" CSBC) and gate | 267 | SY | $ 71 | $ 18,933 |
| 68 | Disking or tilling of compacted soil (180'W X 140'L est. disturbance) | 1,972 | SY | $ 4 | $ 7,278 |
| 69 | Seeding, mulching and compost (Emergent, Riparian & Upland) | 1,972 | SY | $ 10 | $ 19,409 |
| 70 | Plantings (Emergent & Riparian) est. @ 25% of the seeded area | 493 | SY | $ 19 | $ 9,369 |
| 71 | | | | | $ - |
| 72 | **Additional Costs** | | | | $ - |
| 73 | Removals at 4 % Construction Costs | 4.0% | LS | $ 263,928 | $ 10,557 |
| 74 | TESC at 2% of Construction | 2% | LS | $ 274,485 | $ 5,490 |
| | | | | | $ - |
| | | | | | $ - |
| | ***Item Subtotal Construction Costs (Year 2023)*** | | | | $ 279,975 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 27,997 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 307,972 |
| ***Direct: Subtotal Construction Costs*** | | | ***$ 308,000*** |

**Description: WQBE 13B_Infiltration Pond Outwash Soil on Public Property**

Basin that stores and infiltrates stormwater runoff.

**Cost Estimating Assumptions:**

The infiltration pond is designed in accordance with KC SW Manual Section 5.2.2 and is generally as described below:
It is assumed that stormwater will be pre-treated prior to conveyance to this facility and that a pre-settling pond will not be required.
The infiltration pond is located in outwash soils and has a bottom area of 1,479 s.f. and a storage depth of 4 feet deep (48 inches).
The pond storage volume is generally located below grade.
The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 27.4 ft. wide and 54.0 ft. long.
The pond is constructed with 3:1 side slopes.
The design includes 1' of freeboard.
An emergency overflow spillway is included.
The spillway is riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.
Emergency Spillway is 12 ft. long w/ a slope of 3:1, H:V.
The infiltration pond includes a compacted berm along three sides that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content.
A Type 2 minimum 72" dia. flow restrictor (weir) is included with shear gate, and frame and grate for secondary inlet.
The pond is approximately 8.5 feet long by 7 feet wide with 4 feet of storage depth.
Approximately 100 feet of 12-inch and 100 feet of 12-inch diameter pipes are included.
Dewatering is not required.
Trench Box shoring for pipe installation.
A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.
Property is assumed to be existing open space without building or pavement removal.
Fencing is not required, but a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced to help restrict vehicular access.
Disturbed areas are seeded and it is assumed that a portion of the area has plantings.
The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.
Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 13C_Infiltration Pond Till Soil with Property Cost | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Infiltration Pond Till Soil (2785 sf bottom area @ 4 ft. Storage Depth) | 1 | EA | $ 343,900 | $ 343,900 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 343,900*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 68,780 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 412,680*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 41,268 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 453,948*** |
| | | | | Construction Sales Tax | $ 46,530 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 500,500*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 99,869 |
| | | | | Construction Management | $ 45,395 |
| | | | | Permitting & Support | $ 4,539 |
| 10578 | s.f. Land Area | Medium | | Land Purchase/ROW Acquisition | $ 850,789 |
| 4000 | s.f. Land Area | Low | | Permanent Easements | $ 40,400 |
| | | | | WTD Staff Costs & Non-WTD Support | $ 27,237 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,068,228*** |
| | | | | Project Contingency | $ 470,618 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 1,538,800*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 2,039,300*** |

**Description: WQBE 13C_Infiltration Pond Till Soil with Property Cost (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 2,039,300** | |
| Capital cost | $ 2,039,300 | $/Unit |
| Total Direct O&M/Year | $ 5,711 | |
| Direct O&M cost | $ 5,711 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 11,100 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 2,174,600** | **$/unit** |
| **Annual O&M Cost** | **$ 5,900** | **$/year** |
| Annualized Cost | $270 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Grass seeding | 2023 dollars | $ 113 | $/year |
| Chain Saw Rental | 2023 dollars | $ 56 | $/year |
| Subtotal | | $169 | |
| Labor | | | |
| Remove Trash | 10 | hr | |
| Remove Dead,Diseased or Dying Trees | 24 | hr | |
| Remediation of erosion | 8 | hr | |
| | 0 | hr | |
| **Total hours per year** | 42 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 2,284 | |
| Labor cost, burdened | O/H 150.0% | $ 5,711 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 8,040 | | $ 271,701 | **$2,341,241** | **$ 2,174,614** | | | |
| 0 | 1.000 | **$ 2,039,300** | | | $2,039,300 | $ 2,039,300 | $ 2,039,300 | $ 2,039,300 | $ 2,174,614 |
| 1 | 0.950 | $169 | $ - | $ 5,711 | $ 5,880 | $ 5,587 | $ 2,045,180 | $ 2,044,887 | $ 135,314 |
| 2 | 0.903 | $ 174 | $ - | $ 5,882 | $ 6,056 | $ 5,467 | $ 2,051,236 | $ 2,050,354 | $ 129,727 |
| 3 | 0.858 | $ 179 | $ - | $ 6,059 | $ 6,238 | $ 5,350 | $ 2,057,474 | $ 2,055,704 | $ 124,260 |
| 4 | 0.815 | $ 185 | $ - | $ 6,241 | $ 6,425 | $ 5,236 | $ 2,063,900 | $ 2,060,940 | $ 118,909 |
| 5 | 0.774 | $ 190 | $ - | $ 6,428 | $ 6,618 | $ 5,124 | $ 2,070,517 | $ 2,066,064 | $ 113,673 |
| 6 | 0.736 | $ 196 | $ - | $ 6,621 | $ 6,816 | $ 5,014 | $ 2,077,334 | $ 2,071,079 | $ 108,549 |
| 7 | 0.699 | $ 202 | $ - | $ 6,819 | $ 7,021 | $ 4,907 | $ 2,084,355 | $ 2,075,986 | $ 103,535 |
| 8 | 0.664 | $ 208 | $ - | $ 7,024 | $ 7,232 | $ 4,802 | $ 2,091,586 | $ 2,080,788 | $ 98,628 |
| 9 | 0.631 | $ 214 | $ - | $ 7,234 | $ 7,449 | $ 4,700 | $ 2,099,035 | $ 2,085,488 | $ 93,825 |
| 10 | 0.599 | $ 221 | $ 11,100 | $ 7,451 | $ 18,772 | $ 11,254 | $ 2,117,807 | $ 2,096,742 | $ 89,125 |
| 11 | 0.570 | $ 227 | $ - | $ 7,675 | $ 7,902 | $ 4,501 | $ 2,125,709 | $ 2,101,243 | $ 77,872 |
| 12 | 0.541 | $ 234 | $ - | $ 7,905 | $ 8,139 | $ 4,405 | $ 2,133,848 | $ 2,105,647 | $ 73,371 |
| 13 | 0.514 | $ 241 | $ - | $ 8,142 | $ 8,383 | $ 4,311 | $ 2,142,232 | $ 2,109,958 | $ 68,966 |
| 14 | 0.489 | $ 248 | $ - | $ 8,387 | $ 8,635 | $ 4,218 | $ 2,150,867 | $ 2,114,176 | $ 64,656 |
| 15 | 0.464 | $ 256 | $ - | $ 8,638 | $ 8,894 | $ 4,128 | $ 2,159,761 | $ 2,118,305 | $ 60,437 |
| 16 | 0.441 | $ 263 | $ - | $ 8,897 | $ 9,161 | $ 4,040 | $ 2,168,921 | $ 2,122,344 | $ 56,309 |
| 17 | 0.419 | $ 271 | $ - | $ 9,164 | $ 9,436 | $ 3,954 | $ 2,178,357 | $ 2,126,298 | $ 52,269 |
| 18 | 0.398 | $ 279 | $ - | $ 9,439 | $ 9,719 | $ 3,869 | $ 2,188,076 | $ 2,130,167 | $ 48,315 |
| 19 | 0.378 | $ 288 | $ - | $ 9,723 | $ 10,010 | $ 3,786 | $ 2,198,086 | $ 2,133,954 | $ 44,446 |
| 20 | 0.359 | $ 296 | $ 11,100 | $ 10,014 | $ 21,411 | $ 7,695 | $ 2,219,496 | $ 2,141,648 | $ 40,660 |
| 21 | 0.341 | $ 305 | $ - | $ 10,315 | $ 10,620 | $ 3,626 | $ 2,230,116 | $ 2,145,274 | $ 32,965 |
| 22 | 0.324 | $ 314 | $ - | $ 10,624 | $ 10,938 | $ 3,549 | $ 2,241,055 | $ 2,148,823 | $ 29,339 |
| 23 | 0.308 | $ 324 | $ - | $ 10,943 | $ 11,267 | $ 3,473 | $ 2,252,321 | $ 2,152,296 | $ 25,790 |
| 24 | 0.293 | $ 334 | $ - | $ 11,271 | $ 11,605 | $ 3,399 | $ 2,263,926 | $ 2,155,694 | $ 22,318 |
| 25 | 0.278 | $ 344 | $ - | $ 11,609 | $ 11,953 | $ 3,326 | $ 2,275,879 | $ 2,159,020 | $ 18,919 |
| 26 | 0.264 | $ 354 | $ - | $ 11,957 | $ 12,311 | $ 3,255 | $ 2,288,190 | $ 2,162,275 | $ 15,593 |
| 27 | 0.251 | $ 364 | $ - | $ 12,316 | $ 12,681 | $ 3,185 | $ 2,300,871 | $ 2,165,461 | $ 12,338 |
| 28 | 0.239 | $ 375 | $ - | $ 12,686 | $ 13,061 | $ 3,117 | $ 2,313,932 | $ 2,168,578 | $ 9,153 |
| 29 | 0.227 | $ 387 | $ - | $ 13,066 | $ 13,453 | $ 3,051 | $ 2,327,385 | $ 2,171,628 | $ 6,036 |
| 30 | 0.215 | $ 398 | $ - | $ 13,458 | $ 13,856 | $ 2,985 | $ 2,341,241 | $ 2,174,614 | $ 2,985 |

**Description: WQBE 13C_Infiltration Pond Till Soil with Property Cost**
Basin that stores and infiltrates stormwater runoff.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**

| | |
|---|---|
| 10 | Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal performed annually by a crew of two over a 5 hour workday. |
| 24 | Removal of dead, diseased or dying trees annually by a crew of four using hand tools and a chainsaw as needed (6 hour work day). Assume annual cost of $56 for chainsaw rental. |
| 8 | Stabilization of eroded berms, slopes, embankments, and animal borrows. Assume annual visit with 2 crew members, 4 hour work day. Grass seed mix as needed to stabilize at an estimated cost of $113 per year. |

**Capital Replacement Assumptions:**

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Replacement will also include replacement of access gate every ten years. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | #SPILL! | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 13C_Infiltration Pond Till Soil with Property Cost | | | **Version:** | 2 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Infiltration Pond on Property** | | | | $ - |
| 2 | ***Pond Assumptions*** | | | | $ - |
| 3 | *Pond Bottom Area* | 2,785 | SF | | $ - |
| 4 | *Pond Top Area* | 6,046 | SF | | $ - |
| 5 | *Pond Top Area* | | | | $ - |
| 6 | *Pond Bottom Length* | 75 | FT | | $ - |
| 7 | *Pond Top Length* | 99 | FT | | $ - |
| 8 | *Pond Bottom Width* | 37 | FT | | $ - |
| 9 | *Pond Top Width* | 61 | | | $ - |
| 10 | *Pond Exc. Depth* | 4 | FT | | $ - |
| 11 | *Slope Run/Rise* | 3 | :1 | | $ - |
| 12 | *Slope Length* | 12 | FT | | $ - |
| 13 | *Freeboard (Ave.)* | 1 | FT | | $ - |
| 14 | | | | | $ - |
| 15 | | | | | $ - |
| 16 | ***Storage Volume*** | | | | $ - |
| 17 | *Pond Effective Storage Depth (Ave.)* | 3 | FT | | $ - |
| 18 | *Pond Storage Top Area* | 5,123 | SF | | $ - |
| 19 | *Storage Facility interior Area (Ave.)* | 3,954 | SF | | $ - |
| 20 | *Effective Storage Volume (15.500 cf target)* | 15,816 | CF | | $ - |
| 21 | *Storage Volume* | 0.12 | MG | | $ - |
| 22 | | | | | $ - |
| 23 | ***Compacted Berm Assumptions (per KC Manual)*** | | | | $ - |
| 24 | *Berm Height (Average)* | 3.5 | FT | | $ - |
| 25 | *Berm slope Length@2:1 Slopes* | 7 | FT | | $ - |
| 26 | *Berm flat top Width* | 6 | FT | | $ - |
| 27 | *Berm Bottom Width* | 20 | FT | | $ - |
| 28 | *Distance to CL Berm - Width* | 10 | FT | | $ - |
| 29 | *Berm Centerline Length (for perimeter calcs)* | 109 | FT | | $ - |
| 30 | *Berm Centerline Width (for perimeter calcs)* | 71 | FT | | $ - |
| 31 | *Berm perimeter (at CL Length)* | 295 | FT | | $ - |
| 32 | *Berm Area/LF* | 45 | SF/FT | | $ - |
| 33 | Imported Fill for Berm | 492 | CY | $ 44 | $ 21,633 |
| 34 | Embankment Compaction | 492 | CY | $ 22 | $ 10,817 |
| 35 | | | | | $ - |
| 36 | **Spillway Assumptions KCSWDM Table 4.2.2A** | | | | $ - |
| 37 | RipRap Lining for Overflow | 5 | CY | $ 346 | $ 1,845 |
| 38 | *Width* | 6 | FT | | $ - |
| 39 | *Length* | 12 | FT | | $ - |
| 40 | *RipRap Depth* | 2 | FT | | $ - |
| 41 | *Slope Run:Rise* | 3 | :1 | | $ - |
| 42 | | | | | $ - |
| 43 | **Wetpond Excavation and Liner** | | | | $ - |
| 44 | Facility Excavation to Berm and Waste | 654 | CY | $ 79 | $ 51,680 |
| 45 | Imported Treatment Liner @ 2' thick | 0 | CY | $ 105 | $ - |
| 46 | | | | | $ - |
| 47 | **Outlet Pipe** | | | | $ - |
| 48 | Pipe - 12" Diameter | 100 | LF | $ 140 | $ 14,000 |
| 49 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 50 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 51 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 52 | Control Structure | 1 | EA | $ 24,860 | $ 24,860 |
| 53 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 54 | Pipe Discharge Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 55 | Debris Barrier | 1 | EA | $ 14,808 | $ 14,808 |
| 56 | | | | | $ - |
| 57 | **Conveyance Pipe** | | | | $ - |
| 58 | Pipe - 12" Diameter | 100 | LF | $ 140 | $ 14,000 |
| 59 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 60 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 61 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 62 | Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 63 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 64 | | | | | $ - |
| 65 | **Site Removals and Restoration** | | | | $ - |
| 66 | Access Gate (16 ft wide gate) | 1 | EA | $ 3,085 | $ 3,085 |
| 67 | Access Roadway (12'W X 200'L) to site (4" HMA/4" CSBC) and gate | 267 | SY | $ 71 | $ 18,933 |
| 68 | Disking or tilling of compacted soil (180'W X 140'L est. disturbance) | 2,286 | SY | $ 4 | $ 8,437 |
| 69 | Seeding, mulching and compost (Emergent, Riparian & Upland) | 2,286 | SY | $ 10 | $ 22,499 |
| 70 | Plantings (Emergent & Riparian) est. @ 25% of the seeded area | 572 | SY | $ 19 | $ 10,861 |
| 71 | | | | | $ - |
| 72 | **Additional Costs** | | | | $ - |
| 73 | Removals at 4 % Construction Costs | 4.0% | LS | $ 294,735 | $ 11,789 |
| 74 | TESC at 2% of Construction | 2% | LS | $ 306,525 | $ 6,130 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 312,655 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 31,266 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 343,921 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 343,900*** |

**Description: WQBE 13C_Infiltration Pond Till Soil with Property Cost**

Basin that stores and infiltrates stormwater runoff.

**Cost Estimating Assumptions:**

The infiltration pond is designed in accordance with KC SW Manual Section 5.2.2 and is generally as described below:
The infiltration pond is located in till soils and has a bottom area of 2,785 s.f. and a storage depth of 4 feet deep (48 inches).
The pond storage volume is generally located below grade.
The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 37.3 ft. wide and 74.6 ft. long.
The pond is constructed with 3:1 side slopes.
The design includes 1' of freeboard.
An emergency overflow spillway is included.
The spillway is riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.
Emergency Spillway is 12 ft. long w/ a slope of 3:1, H:V.
The infiltration pond includes a compacted berm along three sides that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content
A Type 2 minimum 72" dia. flow restrictor (weir) is included with shear gate, and frame and grate for secondary inlet.
The pond is approximately 21 feet long by 10 feet wide with 4 feet of storage depth.
Approximately 100 feet of 12-inch and 100 feet of 12-inch diameter pipes are included.
Dewatering is not required.
Trench Box shoring for pipe installation.
A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.
Full width arterial roadway restoration is assumed, including the sidewalks and landscape areas on both sides of the roadway.
Fencing is not required, but a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced to help restrict vehicular access.
Disturbed areas are seeded and it is assumed that a portion of the area has plantings.
Installation is on Property and includes easements and property acquisition.
Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 13D_Infiltration Pond Outwash Soil with Property Cost | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Infiltration Pond (1479 sf bottom area @ 4 ft. Storage Depth) | 1 | EA | $ 308,000 | $ 308,000 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 308,000*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 61,600 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 369,600*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 36,960 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 406,560*** |
| | | | | Construction Sales Tax | $ 41,672 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 448,200*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 89,443 |
| | | | | Construction Management | $ 40,656 |
| | | | | Permitting & Support | $ 4,066 |
| 10578 | s.f. Land Area | Medium | Land Purchase/ROW Acquisition | | $ 850,789 |
| 4000 | s.f. Land Area | Low | Permanent Easements | | $ 40,400 |
| | | | | WTD Staff Costs & Non-WTD Support | $ 24,394 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,049,747*** |
| | | | | Project Contingency | $ 449,384 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 1,499,100*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 1,947,300*** |

**Description: WQBE 13D_Infiltration Pond Outwash Soil with Property Cost (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 1,947,300** | |
| Capital cost | $ 1,947,300 | $/Unit |
| Total Direct O&M/Year | $ 3,535 | |
| Direct O&M cost | $ 3,535 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 11,100 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 2,036,500** | **$/unit** |
| **Annual O&M Cost** | **$ 3,700** | **$/year** |
| Annualized Cost | $270 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Grass seeding | 2023 dollars | $ 113 | $/year |
| Chain Saw Rental | 2023 dollars | $ 56 | $/year |
| Subtotal | | $169 | |
| Labor | | | |
| Remove Trash | 6 | hr | |
| Remove Dead,Diseased or Dying Trees | 12 | hr | |
| Remediation of erosion | 8 | hr | |
| | 0 | hr | |
| **Total hours per year** | 26 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 1,414 | |
| Labor cost, burdened | O/H 150.0% | $ 3,535 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 8,040 | | $ 168,196 | **$2,145,736** | **$ 2,036,485** | | | |
| 0 | 1.000 | **$ 1,947,300** | | | $1,947,300 | $ 1,947,300 | $ 1,947,300 | $ 1,947,300 | $ 2,036,485 |
| 1 | 0.950 | $169 | $ - | $ 3,535 | $ 3,704 | $ 3,520 | $ 1,951,004 | $ 1,950,820 | $ 89,185 |
| 2 | 0.903 | $ 174 | $ - | $ 3,641 | $ 3,815 | $ 3,444 | $ 1,954,820 | $ 1,954,264 | $ 85,666 |
| 3 | 0.858 | $ 179 | $ - | $ 3,751 | $ 3,930 | $ 3,371 | $ 1,958,750 | $ 1,957,635 | $ 82,221 |
| 4 | 0.815 | $ 185 | $ - | $ 3,863 | $ 4,048 | $ 3,299 | $ 1,962,798 | $ 1,960,933 | $ 78,851 |
| 5 | 0.774 | $ 190 | $ - | $ 3,979 | $ 4,169 | $ 3,228 | $ 1,966,967 | $ 1,964,161 | $ 75,552 |
| 6 | 0.736 | $ 196 | $ - | $ 4,098 | $ 4,294 | $ 3,159 | $ 1,971,261 | $ 1,967,320 | $ 72,324 |
| 7 | 0.699 | $ 202 | $ - | $ 4,221 | $ 4,423 | $ 3,092 | $ 1,975,684 | $ 1,970,412 | $ 69,165 |
| 8 | 0.664 | $ 208 | $ - | $ 4,348 | $ 4,556 | $ 3,025 | $ 1,980,240 | $ 1,973,438 | $ 66,073 |
| 9 | 0.631 | $ 214 | $ - | $ 4,478 | $ 4,693 | $ 2,961 | $ 1,984,933 | $ 1,976,398 | $ 63,048 |
| 10 | 0.599 | $ 221 | $ 11,100 | $ 4,613 | $ 15,933 | $ 9,552 | $ 2,000,866 | $ 1,985,950 | $ 60,087 |
| 11 | 0.570 | $ 227 | $ - | $ 4,751 | $ 4,978 | $ 2,836 | $ 2,005,845 | $ 1,988,786 | $ 50,535 |
| 12 | 0.541 | $ 234 | $ - | $ 4,894 | $ 5,128 | $ 2,775 | $ 2,010,972 | $ 1,991,561 | $ 47,699 |
| 13 | 0.514 | $ 241 | $ - | $ 5,041 | $ 5,282 | $ 2,716 | $ 2,016,254 | $ 1,994,276 | $ 44,924 |
| 14 | 0.489 | $ 248 | $ - | $ 5,192 | $ 5,440 | $ 2,658 | $ 2,021,694 | $ 1,996,934 | $ 42,209 |
| 15 | 0.464 | $ 256 | $ - | $ 5,348 | $ 5,603 | $ 2,601 | $ 2,027,297 | $ 1,999,535 | $ 39,551 |
| 16 | 0.441 | $ 263 | $ - | $ 5,508 | $ 5,771 | $ 2,545 | $ 2,033,068 | $ 2,002,080 | $ 36,951 |
| 17 | 0.419 | $ 271 | $ - | $ 5,673 | $ 5,944 | $ 2,491 | $ 2,039,013 | $ 2,004,571 | $ 34,405 |
| 18 | 0.398 | $ 279 | $ - | $ 5,843 | $ 6,123 | $ 2,438 | $ 2,045,135 | $ 2,007,008 | $ 31,915 |
| 19 | 0.378 | $ 288 | $ - | $ 6,019 | $ 6,306 | $ 2,385 | $ 2,051,442 | $ 2,009,394 | $ 29,477 |
| 20 | 0.359 | $ 296 | $ 11,100 | $ 6,199 | $ 17,596 | $ 6,324 | $ 2,069,037 | $ 2,015,717 | $ 27,092 |
| 21 | 0.341 | $ 305 | $ - | $ 6,385 | $ 6,690 | $ 2,285 | $ 2,075,728 | $ 2,018,002 | $ 20,768 |
| 22 | 0.324 | $ 314 | $ - | $ 6,577 | $ 6,891 | $ 2,236 | $ 2,082,619 | $ 2,020,237 | $ 18,484 |
| 23 | 0.308 | $ 324 | $ - | $ 6,774 | $ 7,098 | $ 2,188 | $ 2,089,717 | $ 2,022,425 | $ 16,248 |
| 24 | 0.293 | $ 334 | $ - | $ 6,977 | $ 7,311 | $ 2,141 | $ 2,097,028 | $ 2,024,566 | $ 14,060 |
| 25 | 0.278 | $ 344 | $ - | $ 7,187 | $ 7,530 | $ 2,095 | $ 2,104,558 | $ 2,026,662 | $ 11,919 |
| 26 | 0.264 | $ 354 | $ - | $ 7,402 | $ 7,756 | $ 2,051 | $ 2,112,314 | $ 2,028,712 | $ 9,824 |
| 27 | 0.251 | $ 364 | $ - | $ 7,624 | $ 7,989 | $ 2,007 | $ 2,120,303 | $ 2,030,719 | $ 7,773 |
| 28 | 0.239 | $ 375 | $ - | $ 7,853 | $ 8,228 | $ 1,964 | $ 2,128,531 | $ 2,032,683 | $ 5,766 |
| 29 | 0.227 | $ 387 | $ - | $ 8,089 | $ 8,475 | $ 1,922 | $ 2,137,006 | $ 2,034,604 | $ 3,803 |
| 30 | 0.215 | $ 398 | $ - | $ 8,331 | $ 8,730 | $ 1,881 | $ 2,145,736 | $ 2,036,485 | $ 1,881 |

**Description: WQBE 13D_Infiltration Pond Outwash Soil with Property Cost**
Basin that stores and infiltrates stormwater runoff.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash,
6 sediment and debris removal performed annually by a crew of two over a 3 hour workday.
Removal of dead, diseased or dying trees annually by a crew of four using hand tools and a chainsaw
12 as needed (3 hour work day). Assume annual cost of $56 for chainsaw rental.
Stabilization of eroded berms, slopes, embankments, and animal borrows. Assume annual visit of 2
crew members, 4 hour work day. Grass seed mix as needed to stabilize at an estimated cost of $113
8 per year.

**Capital Replacement Assumptions:**

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Replacement will also include replacement of access gate every ten years. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | |
|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 13D_Infiltration Pond Outwash Soil with Property Cost | **Version:** | 2 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Infiltration Pond on Property** | | | | $ - |
| 2 | ***Pond Assumptions*** | | | | $ - |
| 3 | *Pond Bottom Area* | 1,479 | SF | | $ - |
| 4 | *Pond Top Area* | 4,009 | SF | | $ - |
| 5 | *Pond Top Area* | | | | $ - |
| 6 | *Pond Bottom Length* | 54.0 | FT | | $ - |
| 7 | *Pond Top Length* | 78 | FT | | $ - |
| 8 | *Pond Bottom Width* | 27.4 | FT | | $ - |
| 9 | *Pond Top Width* | 51 | | | $ - |
| 10 | *Pond Exc. Depth* | 4 | FT | | $ - |
| 11 | *Slope Run/Rise* | 3 | :1 | | $ - |
| 12 | *Slope Length* | 12 | FT | | $ - |
| 13 | *Freeboard (Ave.)* | 1 | FT | | $ - |
| 14 | | | | | $ - |
| 15 | | | | | $ - |
| 16 | ***Storage Volume*** | | | | $ - |
| 17 | *Pond Effective Storage Depth (Ave.)* | 3 | FT | | $ - |
| 18 | *Pond Storage Top Area* | 3,268 | SF | | $ - |
| 19 | *Storage Facility interior Area (Ave.)* | 2,374 | SF | | $ - |
| 20 | *Effective Storage Volume* | 9,495 | CF | | $ - |
| 21 | *Storage Volume* | 0.07 | MG | | $ - |
| 22 | | | | | $ - |
| 23 | ***Compacted Berm Assumptions (per KC Manual)*** | | | | $ - |
| 24 | *Berm Height (Average)* | 3.5 | FT | | $ - |
| 25 | *Berm slope Length@2:1 Slopes* | 7 | FT | | $ - |
| 26 | *Berm flat top Width* | 6 | FT | | $ - |
| 27 | *Berm Bottom Width* | 20 | FT | | $ - |
| 28 | *Distance to CL Berm - Width* | 10 | FT | | $ - |
| 29 | *Berm Centerline Length (for perimeter calcs)* | 88 | FT | | $ - |
| 30 | *Berm Centerline Width (for perimeter calcs)* | 61 | FT | | $ - |
| 31 | *Berm perimeter (at CL Length)* | 245 | FT | | $ - |
| 32 | *Berm Area/LF* | 45 | SF/FT | | $ - |
| 33 | Imported Fill for Berm | 408 | CY | $ 44 | $ 17,967 |
| 34 | Embankment Compaction | 408 | CY | $ 22 | $ 8,983 |
| 35 | | | | | $ - |
| 36 | **Spillway Assumptions KCSWDM Table 4.2.2A** | | | | $ - |
| 37 | RipRap Lining for Overflow | 5 | CY | $ 346 | $ 1,845 |
| 38 | *Width* | 6 | FT | | $ - |
| 39 | *Length* | 12 | FT | | $ - |
| 40 | *RipRap Depth* | 2 | FT | | $ - |
| 41 | *Slope Run:Rise* | 3 | :1 | | $ - |
| 42 | | | | | $ - |
| 43 | **Pond Excavation and Liner** | | | | $ - |
| 44 | Facility Excavation to Berm and Waste | 406 | CY | $ 79 | $ 32,113 |
| 45 | | | | | $ - |
| 46 | | | | | $ - |
| 47 | **Outlet Pipe** | | | | $ - |
| 48 | Pipe - 12" Diameter | 100 | LF | $ 140 | $ 14,000 |
| 49 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 50 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 51 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 52 | Control Structure | 1 | EA | $ 24,860 | $ 24,860 |
| 53 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 54 | Pipe Discharge Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 55 | Debris Barrier | 1 | EA | $ 14,808 | $ 14,808 |
| 56 | | | | | $ - |
| 57 | **Conveyance Pipe** | | | | $ - |
| 58 | Pipe - 12" Diameter | 100 | LF | $ 140 | $ 14,000 |
| 59 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 60 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 61 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 62 | Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 63 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 64 | | | | | $ - |
| 65 | **Site Removals and Restoration** | | | | $ - |
| 66 | Access Gate (16 ft wide gate) | 1 | EA | $ 3,085 | $ 3,085 |
| 67 | Access Roadway (12'W X 200'L) to site (4" HMA/4" CSBC) and gate | 267 | SY | $ 71 | $ 18,933 |
| 68 | Disking or tilling of compacted soil (180'W X 140'L est. disturbance) | 1,972 | SY | $ 4 | $ 7,278 |
| 69 | Seeding, mulching and compost (Emergent, Riparian & Upland) | 1,972 | SY | $ 10 | $ 19,409 |
| 70 | Plantings (Emergent & Riparian) est. @ 25% of the seeded area | 493 | SY | $ 19 | $ 9,369 |
| 71 | | | | | $ - |
| 72 | **Additional Costs** | | | | $ - |
| 73 | Removals at 4 % Construction Costs | 4.0% | LS | $ 263,928 | $ 10,557 |
| 74 | TESC at 2% of Construction | 2% | LS | $ 274,485 | $ 5,490 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 279,975 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | | |
|---|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 27,997 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 307,972 |
| ***Direct: Subtotal Construction Costs*** | | | ***$ 308,000*** |

**Description: WQBE 13D_Infiltration Pond Outwash Soil with Property Cost**

Basin that stores and infiltrates stormwater runoff.

**Cost Estimating Assumptions:**

The infiltration pond is designed in accordance with KC SW Manual Section 5.2.2 and is generally as described below:
The infiltration pond is located in outwash soils and has a bottom area of 1,479 s.f. and a storage depth of 4 feet deep (48 inches).
The pond storage volume is generally located below grade.
The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 27.4 ft. wide and 54.0 ft. long.
The pond is constructed with 3:1 side slopes.
The design includes 1' of freeboard.
An emergency overflow spillway is included.
The spillway is riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.
Emergency Spillway is 12 ft. long w/ a slope of 3:1, H:V.
The infiltration pond includes a compacted berm along three sides that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content.
A Type 2 minimum 72" dia. flow restrictor (weir) is included with shear gate, and frame and grate for secondary inlet.
The pond is approximately 8.5 feet long by 7 feet wide with 4 feet of storage depth.
Storm overflows from the pre-settling pond outlet into the main infiltration pond via a riprap lined spillway.
Approximately 100 feet of 12-inch and 50 feet of 12-inch diameter pipes are included.
Dewatering is not required.
Trench Box shoring for pipe installation.
A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.
Full width arterial roadway restoration is assumed, including the sidewalks and landscape areas on both sides of the roadway.
Fencing is not required, but a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced to help restrict vehicular access.
Disturbed areas are seeded and it is assumed that a portion of the area has plantings.
Construction occurs outside of the right-of-way and no traffic control or street use permits are required.
Installation is on Property and includes easements and property acquisition.
Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_13E_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Public Property | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Infiltration Pond (1479 sf bottom area @ 4 ft. Storage Depth) with High Rate Underground Filter (24 s.f. bottom area) | 1 | EA | $ 363,800 | $ 363,800 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 363,800*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 72,760 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 436,560*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 43,656 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 480,216*** |
| | | | | Construction Sales Tax | $ 49,222 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 529,400*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 105,648 |
| | | | | Construction Management | $ 48,022 |
| | | | | Permitting & Support | $ 4,802 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 28,813 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 187,284*** |
| | | | | Project Contingency | $ 215,005 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 402,300*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 931,700*** |

**Description: WQBE_13E_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Public Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 931,700** | |
| Capital cost | $ 931,700 | $/Unit |
| Total Direct O&M/Year | $ 5,439 | |
| Direct O&M cost | $ 5,439 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 11,100 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 1,082,700** | **$/unit** |
| **Annual O&M Cost** | **$ 6,600** | **$/year** |
| Annualized Cost | $1,870 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| Vacuum Truck Equipment + Labor | 2023 dollars | $ 360 | $/year |
| Grass seeding & Annual Plan Replacement | 2023 dollars | $ 766 | $/year |
| Chain Saw Rental | 2023 dollars | $ 56 | $/year |
| Subtotal | | $ 1,182 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash, Debris, and Sediment | 12 | hr | |
| Remove Dead, Diseased, or Dying Trees | 12 | hr | |
| Remediation of erosion | 12 | hr | |
| Plant health | 4 | hr | |
| **Total hours per year** | 40 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 2,176 | |
| Labor cost, burdened | O/H 150.0% | $ 5,439 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 56,234 | | $ 258,763 | **$1,268,897** | **########** | | | |
| 0 | 1.000 | **$ 931,700** | | | $931,700 | $ 931,700 | $ 931,700 | $ 931,700 | $ 1,082,726 |
| 1 | 0.950 | $1,182 | $ - | $ 5,439 | $ 6,621 | $ 6,291 | $ 938,321 | $ 937,991 | $ 151,026 |
| 2 | 0.903 | $ 1,217 | $ - | $ 5,602 | $ 6,820 | $ 6,156 | $ 945,141 | $ 944,147 | $ 144,735 |
| 3 | 0.858 | $ 1,254 | $ - | $ 5,770 | $ 7,024 | $ 6,025 | $ 952,165 | $ 950,172 | $ 138,579 |
| 4 | 0.815 | $ 1,292 | $ - | $ 5,943 | $ 7,235 | $ 5,896 | $ 959,400 | $ 956,067 | $ 132,554 |
| 5 | 0.774 | $ 1,330 | $ - | $ 6,122 | $ 7,452 | $ 5,770 | $ 966,852 | $ 961,837 | $ 126,658 |
| 6 | 0.736 | $ 1,370 | $ - | $ 6,305 | $ 7,676 | $ 5,646 | $ 974,527 | $ 967,484 | $ 120,888 |
| 7 | 0.699 | $ 1,411 | $ - | $ 6,494 | $ 7,906 | $ 5,526 | $ 982,433 | $ 973,010 | $ 115,242 |
| 8 | 0.664 | $ 1,454 | $ - | $ 6,689 | $ 8,143 | $ 5,408 | $ 990,576 | $ 978,417 | $ 109,716 |
| 9 | 0.631 | $ 1,497 | $ - | $ 6,890 | $ 8,387 | $ 5,292 | $ 998,963 | $ 983,709 | $ 104,309 |
| 10 | 0.599 | $ 1,542 | $ 11,100 | $ 7,097 | $ 19,739 | $ 11,833 | $ 1,018,702 | $ 995,542 | $ 99,016 |
| 11 | 0.570 | $ 1,589 | $ - | $ 7,310 | $ 8,898 | $ 5,068 | $ 1,027,600 | $ 1,000,611 | $ 87,183 |
| 12 | 0.541 | $ 1,636 | $ - | $ 7,529 | $ 9,165 | $ 4,960 | $ 1,036,765 | $ 1,005,570 | $ 82,115 |
| 13 | 0.514 | $ 1,685 | $ - | $ 7,755 | $ 9,440 | $ 4,854 | $ 1,046,205 | $ 1,010,424 | $ 77,155 |
| 14 | 0.489 | $ 1,736 | $ - | $ 7,987 | $ 9,723 | $ 4,750 | $ 1,055,929 | $ 1,015,174 | $ 72,301 |
| 15 | 0.464 | $ 1,788 | $ - | $ 8,227 | $ 10,015 | $ 4,649 | $ 1,065,943 | $ 1,019,823 | $ 67,551 |
| 16 | 0.441 | $ 1,842 | $ - | $ 8,474 | $ 10,315 | $ 4,549 | $ 1,076,259 | $ 1,024,372 | $ 62,903 |
| 17 | 0.419 | $ 1,897 | $ - | $ 8,728 | $ 10,625 | $ 4,452 | $ 1,086,883 | $ 1,028,824 | $ 58,354 |
| 18 | 0.398 | $ 1,954 | $ - | $ 8,990 | $ 10,944 | $ 4,357 | $ 1,097,827 | $ 1,033,181 | $ 53,902 |
| 19 | 0.378 | $ 2,012 | $ - | $ 9,260 | $ 11,272 | $ 4,264 | $ 1,109,099 | $ 1,037,444 | $ 49,545 |
| 20 | 0.359 | $ 2,073 | $ 11,100 | $ 9,537 | $ 22,710 | $ 8,162 | $ 1,131,809 | $ 1,045,606 | $ 45,282 |
| 21 | 0.341 | $ 2,135 | $ - | $ 9,823 | $ 11,958 | $ 4,083 | $ 1,143,767 | $ 1,049,689 | $ 37,120 |
| 22 | 0.324 | $ 2,199 | $ - | $ 10,118 | $ 12,317 | $ 3,996 | $ 1,156,084 | $ 1,053,685 | $ 33,037 |
| 23 | 0.308 | $ 2,265 | $ - | $ 10,422 | $ 12,687 | $ 3,911 | $ 1,168,771 | $ 1,057,595 | $ 29,041 |
| 24 | 0.293 | $ 2,333 | $ - | $ 10,734 | $ 13,067 | $ 3,827 | $ 1,181,838 | $ 1,061,422 | $ 25,130 |
| 25 | 0.278 | $ 2,403 | $ - | $ 11,056 | $ 13,459 | $ 3,745 | $ 1,195,297 | $ 1,065,167 | $ 21,303 |
| 26 | 0.264 | $ 2,475 | $ - | $ 11,388 | $ 13,863 | $ 3,665 | $ 1,209,160 | $ 1,068,832 | $ 17,558 |
| 27 | 0.251 | $ 2,549 | $ - | $ 11,730 | $ 14,279 | $ 3,587 | $ 1,223,438 | $ 1,072,419 | $ 13,893 |
| 28 | 0.239 | $ 2,626 | $ - | $ 12,082 | $ 14,707 | $ 3,510 | $ 1,238,146 | $ 1,075,929 | $ 10,307 |
| 29 | 0.227 | $ 2,704 | $ - | $ 12,444 | $ 15,148 | $ 3,435 | $ 1,253,294 | $ 1,079,364 | $ 6,797 |
| 30 | 0.215 | $ 2,785 | $ - | $ 12,817 | $ 15,603 | $ 3,362 | $ 1,268,897 | $ 1,082,726 | $ 3,362 |

**Description: WQBE_13E_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Public Property**

An infiltration pond is a basin that stores and infiltrates stormwater runoff. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions (Pond):**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by
6 trash, sediment and debris removal performed annually by a crew of two over a 3 hour workday.

Removal of dead, diseased or dying trees annually by a crew of four using hand tools and a
12 chainsaw as needed (3 hour work day). Assume annual cost of $56 for chainsaw rental.

Stabilization of eroded berms, slopes, embankments, and animal borrows. Assume annual visit of 2 crew members, 4 hour work day. Grass seed mix as needed to stabilize at an estimated cost of
8 $113 per year.

**O&M Estimating Assumptions (Filter):**

Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year.
6 Assume use of vactor truck.

Biannually 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man
4 hours. Assumed annual cost of $113 for mulch.

Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 1 hour per visit.
4 Total of 4 man hours.

Annual plant replacement allowance of $540. Will allow for the replacement of approximately 10 shrubs or other medium sized plant material.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Capital Replacement Assumptions (Pond):**

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Replacement will also include replacement of access gate every ten years. Items will include those highlighted in blue on the cost estimate sheet.

**Capital Replacement Assumptions (Filter):**

No capital replacement within 30-year life per Filterra Owner's Manual.

| Estimate - AACEI Class 10 | | | |
|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_13E_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Public Property | **Version:** | 2 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Infiltration Pond on Public Property** | | | | $ - |
| 2 | ***Pond Assumptions*** | | | | $ - |
| 3 | *Pond Bottom Area* | 1,479 | SF | | $ - |
| 4 | *Pond Top Area* | 4,009 | SF | | $ - |
| 5 | *Pond Top Area* | | | | $ - |
| 6 | *Pond Bottom Length* | 54.0 | FT | | $ - |
| 7 | *Pond Top Length* | 78 | FT | | $ - |
| 8 | *Pond Bottom Width* | 27.4 | FT | | $ - |
| 9 | *Pond Top Width* | 51 | | | $ - |
| 10 | *Pond Exc. Depth* | 4 | FT | | $ - |
| 11 | *Slope Run/Rise* | 3 | :1 | | $ - |
| 12 | *Slope Length* | 12 | FT | | $ - |
| 13 | *Freeboard (Ave.)* | 1 | FT | | $ - |
| 14 | | | | | $ - |
| 15 | | | | | $ - |
| 16 | ***Storage Volume*** | | | | $ - |
| 17 | *Pond Effective Storage Depth (Ave.)* | 3 | FT | | $ - |
| 18 | *Pond Storage Top Area* | 3,268 | SF | | $ - |
| 19 | *Storage Facility interior Area (Ave.)* | 2,374 | SF | | $ - |
| 20 | *Effective Storage Volume* | 9,495 | CF | | $ - |
| 21 | *Storage Volume* | 0.07 | MG | | $ - |
| 22 | | | | | $ - |
| 23 | ***Compacted Berm Assumptions (per KC Manual)*** | | | | $ - |
| 24 | *Berm Height (Average)* | 3.5 | FT | | $ - |
| 25 | *Berm slope Length@2:1 Slopes* | 7 | FT | | $ - |
| 26 | *Berm flat top Width* | 6 | FT | | $ - |
| 27 | *Berm Bottom Width* | 20 | FT | | $ - |
| 28 | *Distance to CL Berm - Width* | 10 | FT | | $ - |
| 29 | *Berm Centerline Length (for perimeter calcs)* | 88 | FT | | $ - |
| 30 | *Berm Centerline Width (for perimeter calcs)* | 61 | FT | | $ - |
| 31 | *Berm perimeter (at CL Length)* | 245 | FT | | $ - |
| 32 | *Berm Area/LF* | 45 | SF/FT | | $ - |
| 33 | Imported Fill for Berm | 408 | CY | $ 44 | $ 17,967 |
| 34 | Embankment Compaction | 408 | CY | $ 22 | $ 8,983 |
| 35 | | | | | $ - |
| 36 | **Spillway Assumptions KCSWDM Table 4.2.2A** | | | | $ - |
| 37 | RipRap Lining for Overflow | 5 | CY | $ 346 | $ 1,845 |
| 38 | *Width* | 6 | FT | | $ - |
| 39 | *Length* | 12 | FT | | $ - |
| 40 | *RipRap Depth* | 2 | FT | | $ - |
| 41 | *Slope Run:Rise* | 3 | :1 | | $ - |
| 42 | | | | | $ - |
| 43 | **Pond Excavation and Liner** | | | | $ - |
| 44 | Facility Excavation to Berm and Waste | 406 | CY | $ 79 | $ 32,113 |
| 45 | | | | | $ - |
| 46 | | | | | $ - |
| 47 | **Outlet Pipe** | | | | $ - |
| 48 | Pipe - 12" Diameter | 100 | LF | $ 140 | $ 14,000 |
| 49 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 50 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 51 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 52 | Control Structure | 1 | EA | $ 24,860 | $ 24,860 |
| 53 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 54 | Pipe Discharge Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 55 | Debris Barrier | 1 | EA | $ 14,808 | $ 14,808 |
| 56 | | | | | $ - |
| 57 | **Conveyance Pipe** | | | | $ - |
| 58 | Pipe - 12" Diameter | 100 | LF | $ 140 | $ 14,000 |
| 59 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 60 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 61 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 62 | Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 63 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 64 | | | | | $ - |
| 65 | **Site Removals and Restoration** | | | | $ - |
| 66 | Access Gate (16 ft wide gate) | 1 | EA | $ 3,085 | $ 3,085 |
| 67 | Access Roadway (12'W X 200'L) to site (4" HMA/4" CSBC) and gate | 267 | SY | $ 71 | $ 18,933 |
| 68 | Disking or tilling of compacted soil (180'W X 140'L est. disturbance) | 1,972 | SY | $ 4 | $ 7,278 |
| 69 | Seeding, mulching and compost (Emergent, Riparian & Upland) | 1,972 | SY | $ 10 | $ 19,409 |
| 70 | Plantings (Emergent & Riparian) est. @ 25% of the seeded area | 493 | SY | $ 19 | $ 9,369 |
| 71 | | | | | $ - |
| 72 | **High Rate Underground Filter** | | | $ - | $ - |
| 73 | Filterra Unit 4'X6' (complete) | 1 | EA | $ 22,165 | $ 22,165 |
| 74 | Structural Excavation to Waste (10'W X12'L X 5'D) + (50'LX5'WX6'D) | 78 | CY | $ 79 | $ 6,123 |
| 75 | Imported Structural Fill | 73 | CY | $ 44 | $ 3,247 |
| 76 | Crushed Base | 1 | CY | $ 64 | $ 64 |
| 77 | Inlet Drain w/Energy Dissipating Rocks | 1 | EA | $ 1,481 | $ 1,481 |
| 78 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 79 | Pipe 8" dia. | 50 | LF | $ 80 | $ 4,000 |
| 80 | Trench Box Shoring (Shallow) | 390 | SF | $ 10 | $ 3,838 |
| 81 | | | | $ - | $ - |
| 82 | **Restoration High Rate Underground Filter** | | | $ - | $ - |
| 83 | Landscaping, planting, and restoration (Filter and 8" Pipe) | 39 | SY | $ 59 | $ 2,296 |
| 84 | Street Tree | 1 | EA | $ 720 | $ 720 |
| 85 | | | | | $ - |
| 86 | | | | | $ - |
| 87 | **Additional Costs** | | | | $ - |
| 88 | Removals at 4 % Construction Costs | 4.0% | LS | $ 311,761 | $ 12,470 |
| 89 | TESC at 2% of Construction | 2% | LS | $ 324,231 | $ 6,485 |
| | | | | | $ - |
| | | | | | $ - |
| | ***Item Subtotal Construction Costs (Year 2023)*** | | | | $ 330,716 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 33,072 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 363,788 |
| ***Direct: Subtotal Construction Costs*** | | | ***$ 363,800*** |

**Description: WQBE_13E_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Property**

An infiltration pond is a basin that stores and infiltrates stormwater runoff. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Cost Estimating Assumptions:**

General

The installation is assumed to be on private property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.
Construction occurs outside of the right-of-way and no traffic control or street use permits are required.
Trench Box shoring for pipe installation.

**Infiltration Pond**

The infiltration pond is designed in accordance with KC SW Manual Section 5.2.2 and is generally as described below:
It is assumed that stormwater will be pre-treated prior to conveyance to this facility and that a pre-settling pond will not be required.
The infiltration pond has a bottom area of 1,479 s.f. and a storage depth of 4 feet deep (48 inches).
The pond storage volume is generally located below grade.
The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 27.4 ft. wide and 54.0 ft. long.
The pond is constructed with 3:1 side slopes.
The design includes 1' of freeboard.
Infiltration pond is located on outwash soils.
An emergency overflow spillway is included.
The spillway is riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.
Emergency Spillway is 12 ft. long w/ a slope of 3:1, H:V.
The infiltration pond includes a compacted berm that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content.
A Type 2 minimum 72" dia. flow restrictor (weir) is included with shear gate, and frame and grate for secondary inlet.
Approximately 200 feet of 12-inch diameter pipes are included.
Dewatering is not required.
A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.
Property is assumed to be existing open space without building or pavement removal.
Fencing is not required, but a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced to help restrict vehicular access.
Disturbed areas are seeded and it is assumed that a portion of the area has plantings.
The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.

**High Rate Underground Filter**

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6"thick.
The facility treatment area is 24 sf (4'X6') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.
A total of 50 LF of 8" storm pipe is required to connect to the deep UIC well.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_13F_Infiltration Pond Outwash Soil with High Rate Underground Filter System With Property Cost | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Infiltration Pond (1479 sf bottom area @ 4 ft. Storage Depth) with High Rate Underground Filter (24 s.f. bottom area) | 1 | EA | $ 363,800 | $ 363,800 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 363,800*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 72,760 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 436,560*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 43,656 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 480,216*** |
| | | | | Construction Sales Tax | $ 49,222 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 529,400*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 105,648 |
| | | | | Construction Management | $ 48,022 |
| | | | | Permitting & Support | $ 4,802 |
| 10602 | s.f. Land Area | Medium | Land Purchase/ROW Acquisition | | $ 852,719 |
| 4000 | s.f. Land Area | Low | Permanent Easements | | $ 40,400 |
| | | | | WTD Staff Costs & Non-WTD Support | $ 28,813 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,080,403*** |
| | | | | Project Contingency | $ 482,941 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 1,563,300*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 2,092,700*** |

**Description: WQBE_13F_Infiltration Pond Outwash Soil with High Rate Underground Filter System with Property Cost (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 2,092,700** | |
| Capital cost | $ 2,092,700 | $/Unit |
| Total Direct O&M/Year | $ 5,439 | |
| Direct O&M cost | $ 5,439 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 11,100 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 2,243,700** | **$/unit** |
| **Annual O&M Cost** | **$ 6,600** | **$/year** |
| Annualized Cost | $1,870 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| Vacuum Truck Equipment + Labor | 2023 dollars | $ 360 | $/year |
| Grass seeding & Annual Plan Replacement | 2023 dollars | $ 766 | $/year |
| Chain Saw Rental | 2023 dollars | $ 56 | $/year |
| Subtotal | | $ 1,182 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash, Debris, and Sediment | 12 | hr | |
| Remove Dead, Diseased, or Dying Trees | 12 | hr | |
| Remediation of erosion | 12 | hr | |
| Plant health | 4 | hr | |
| **Total hours per year** | 40 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 2,176 | |
| Labor cost, burdened | O/H 150.0% | $ 5,439 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 56,234 | | $ 258,763 | **$2,429,897** | **########** | | | |
| 0 | 1.000 | **$ 2,092,700** | | | $2,092,700 | ######## | $ 2,092,700 | $ 2,092,700 | $ 2,243,726 |
| 1 | 0.950 | $1,182 | $ - | $ 5,439 | $ 6,621 | $ 6,291 | $ 2,099,321 | $ 2,098,991 | $ 151,026 |
| 2 | 0.903 | $ 1,217 | $ - | $ 5,602 | $ 6,820 | $ 6,156 | $ 2,106,141 | $ 2,105,147 | $ 144,735 |
| 3 | 0.858 | $ 1,254 | $ - | $ 5,770 | $ 7,024 | $ 6,025 | $ 2,113,165 | $ 2,111,172 | $ 138,579 |
| 4 | 0.815 | $ 1,292 | $ - | $ 5,943 | $ 7,235 | $ 5,896 | $ 2,120,400 | $ 2,117,067 | $ 132,554 |
| 5 | 0.774 | $ 1,330 | $ - | $ 6,122 | $ 7,452 | $ 5,770 | $ 2,127,852 | $ 2,122,837 | $ 126,658 |
| 6 | 0.736 | $ 1,370 | $ - | $ 6,305 | $ 7,676 | $ 5,646 | $ 2,135,527 | $ 2,128,484 | $ 120,888 |
| 7 | 0.699 | $ 1,411 | $ - | $ 6,494 | $ 7,906 | $ 5,526 | $ 2,143,433 | $ 2,134,010 | $ 115,242 |
| 8 | 0.664 | $ 1,454 | $ - | $ 6,689 | $ 8,143 | $ 5,408 | $ 2,151,576 | $ 2,139,417 | $ 109,716 |
| 9 | 0.631 | $ 1,497 | $ - | $ 6,890 | $ 8,387 | $ 5,292 | $ 2,159,963 | $ 2,144,709 | $ 104,309 |
| 10 | 0.599 | $ 1,542 | $ 11,100 | $ 7,097 | $ 19,739 | $ 11,833 | $ 2,179,702 | $ 2,156,542 | $ 99,016 |
| 11 | 0.570 | $ 1,589 | $ - | $ 7,310 | $ 8,898 | $ 5,068 | $ 2,188,600 | $ 2,161,611 | $ 87,183 |
| 12 | 0.541 | $ 1,636 | $ - | $ 7,529 | $ 9,165 | $ 4,960 | $ 2,197,765 | $ 2,166,570 | $ 82,115 |
| 13 | 0.514 | $ 1,685 | $ - | $ 7,755 | $ 9,440 | $ 4,854 | $ 2,207,205 | $ 2,171,424 | $ 77,155 |
| 14 | 0.489 | $ 1,736 | $ - | $ 7,987 | $ 9,723 | $ 4,750 | $ 2,216,929 | $ 2,176,174 | $ 72,301 |
| 15 | 0.464 | $ 1,788 | $ - | $ 8,227 | $ 10,015 | $ 4,649 | $ 2,226,943 | $ 2,180,823 | $ 67,551 |
| 16 | 0.441 | $ 1,842 | $ - | $ 8,474 | $ 10,315 | $ 4,549 | $ 2,237,259 | $ 2,185,372 | $ 62,903 |
| 17 | 0.419 | $ 1,897 | $ - | $ 8,728 | $ 10,625 | $ 4,452 | $ 2,247,883 | $ 2,189,824 | $ 58,354 |
| 18 | 0.398 | $ 1,954 | $ - | $ 8,990 | $ 10,944 | $ 4,357 | $ 2,258,827 | $ 2,194,181 | $ 53,902 |
| 19 | 0.378 | $ 2,012 | $ - | $ 9,260 | $ 11,272 | $ 4,264 | $ 2,270,099 | $ 2,198,444 | $ 49,545 |
| 20 | 0.359 | $ 2,073 | $ 11,100 | $ 9,537 | $ 22,710 | $ 8,162 | $ 2,292,809 | $ 2,206,606 | $ 45,282 |
| 21 | 0.341 | $ 2,135 | $ - | $ 9,823 | $ 11,958 | $ 4,083 | $ 2,304,767 | $ 2,210,689 | $ 37,120 |
| 22 | 0.324 | $ 2,199 | $ - | $ 10,118 | $ 12,317 | $ 3,996 | $ 2,317,084 | $ 2,214,685 | $ 33,037 |
| 23 | 0.308 | $ 2,265 | $ - | $ 10,422 | $ 12,687 | $ 3,911 | $ 2,329,771 | $ 2,218,595 | $ 29,041 |
| 24 | 0.293 | $ 2,333 | $ - | $ 10,734 | $ 13,067 | $ 3,827 | $ 2,342,838 | $ 2,222,422 | $ 25,130 |
| 25 | 0.278 | $ 2,403 | $ - | $ 11,056 | $ 13,459 | $ 3,745 | $ 2,356,297 | $ 2,226,167 | $ 21,303 |
| 26 | 0.264 | $ 2,475 | $ - | $ 11,388 | $ 13,863 | $ 3,665 | $ 2,370,160 | $ 2,229,832 | $ 17,558 |
| 27 | 0.251 | $ 2,549 | $ - | $ 11,730 | $ 14,279 | $ 3,587 | $ 2,384,438 | $ 2,233,419 | $ 13,893 |
| 28 | 0.239 | $ 2,626 | $ - | $ 12,082 | $ 14,707 | $ 3,510 | $ 2,399,146 | $ 2,236,929 | $ 10,307 |
| 29 | 0.227 | $ 2,704 | $ - | $ 12,444 | $ 15,148 | $ 3,435 | $ 2,414,294 | $ 2,240,364 | $ 6,797 |
| 30 | 0.215 | $ 2,785 | $ - | $ 12,817 | $ 15,603 | $ 3,362 | $ 2,429,897 | $ 2,243,726 | $ 3,362 |

**Description: WQBE_13F_Infiltration Pond Outwash Soil with High Rate Underground Filter System with Property Cost**

An infiltration pond is a basin that stores and infiltrates stormwater runoff. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions (Pond):**

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by
6 trash, sediment and debris removal performed annually by a crew of two over a 3 hour workday.
Removal of dead, diseased or dying trees annually by a crew of four using hand tools and a
12 chainsaw as needed (3 hour work day). Assume annual cost of $56 for chainsaw rental.
Stabilization of eroded berms, slopes, embankments, and animal borrows. Assume annual visit of 2 crew members, 4 hour work day. Grass seed mix as needed to stabilize at an estimated cost of
8 $113 per year.

**O&M Estimating Assumptions (Filter):**

Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year.
6 Assume use of vacuum truck.
Biannually 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man
4 hours. Assumed annual cost of $113 for mulch.
Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 1 hour per visit.
4 Total of 4 man hours.
Annual plant replacement allowance of $540. Will allow for the replacement of approximately 10 shrubs or other medium sized plant material.
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Capital Replacement Assumptions (Pond):**

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Replacement will also include replacement of access gate every ten years. Items will include those highlighted in blue on the cost estimate sheet.

**Capital Replacement Assumptions (Filter):**

No capital replacement within 30-year life per Filterra Owner's Manual.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Andrew Staples (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_13F_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Private Property with Property Cost | | | **Version:** | 2 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Infiltration Pond on Private Property With Property Cost** | | | | $ - |
| 2 | ***Pond Assumptions*** | | | | $ - |
| 3 | *Pond Bottom Area* | 1,479 | SF | | $ - |
| 4 | *Pond Top Area* | 4,009 | SF | | $ - |
| 5 | *Pond Top Area* | | | | $ - |
| 6 | *Pond Bottom Length* | 54.0 | FT | | $ - |
| 7 | *Pond Top Length* | 78 | FT | | $ - |
| 8 | *Pond Bottom Width* | 27.4 | FT | | $ - |
| 9 | *Pond Top Width* | 51 | | | $ - |
| 10 | *Pond Exc. Depth* | 4 | FT | | $ - |
| 11 | *Slope Run/Rise* | 3 | :1 | | $ - |
| 12 | *Slope Length* | 12 | FT | | $ - |
| 13 | *Freeboard (Ave.)* | 1 | FT | | $ - |
| 14 | | | | | $ - |
| 15 | | | | | $ - |
| 16 | ***Storage Volume*** | | | | $ - |
| 17 | *Pond Effective Storage Depth (Ave.)* | 3 | FT | | $ - |
| 18 | *Pond Storage Top Area* | 3,268 | SF | | $ - |
| 19 | *Storage Facility interior Area (Ave.)* | 2,374 | SF | | $ - |
| 20 | *Effective Storage Volume* | 9,495 | CF | | $ - |
| 21 | *Storage Volume* | 0.07 | MG | | $ - |
| 22 | | | | | $ - |
| 23 | ***Compacted Berm Assumptions (per KC Manual)*** | | | | $ - |
| 24 | *Berm Height (Average)* | 3.5 | FT | | $ - |
| 25 | *Berm slope Length@2:1 Slopes* | 7 | FT | | $ - |
| 26 | *Berm flat top Width* | 6 | FT | | $ - |
| 27 | *Berm Bottom Width* | 20 | FT | | $ - |
| 28 | *Distance to CL Berm - Width* | 10 | FT | | $ - |
| 29 | *Berm Centerline Length (for perimeter calcs)* | 88 | FT | | $ - |
| 30 | *Berm Centerline Width (for perimeter calcs)* | 61 | FT | | $ - |
| 31 | *Berm perimeter (at CL Length)* | 245 | FT | | $ - |
| 32 | *Berm Area/LF* | 45 | SF/FT | | $ - |
| 33 | Imported Fill for Berm | 408 | CY | $ 44 | $ 17,967 |
| 34 | Embankment Compaction | 408 | CY | $ 22 | $ 8,983 |
| 35 | | | | | $ - |
| 36 | **Spillway Assumptions KCSWDM Table 4.2.2A** | | | | $ - |
| 37 | RipRap Lining for Overflow | 5 | CY | $ 346 | $ 1,845 |
| 38 | *Width* | 6 | FT | | $ - |
| 39 | *Length* | 12 | FT | | $ - |
| 40 | *RipRap Depth* | 2 | FT | | $ - |
| 41 | *Slope Run:Rise* | 3 | :1 | | $ - |
| 42 | | | | | $ - |
| 43 | **Pond Excavation and Liner** | | | | $ - |
| 44 | Facility Excavation to Berm and Waste | 406 | CY | $ 79 | $ 32,113 |
| 45 | | | | | $ - |
| 46 | | | | | $ - |
| 47 | **Outlet Pipe** | | | | $ - |
| 48 | Pipe - 12" Diameter | 100 | LF | $ 140 | $ 14,000 |
| 49 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 50 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 51 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 52 | Control Structure | 1 | EA | $ 24,860 | $ 24,860 |
| 53 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 54 | Pipe Discharge Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 55 | Debris Barrier | 1 | EA | $ 14,808 | $ 14,808 |
| 56 | | | | | $ - |
| 57 | **Conveyance Pipe** | | | | $ - |
| 58 | Pipe - 12" Diameter | 100 | LF | $ 140 | $ 14,000 |
| 59 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 60 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 61 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 62 | Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 63 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 64 | | | | | $ - |
| 65 | **Site Removals and Restoration** | | | | $ - |
| 66 | Access Gate (16 ft wide gate) | 1 | EA | $ 3,085 | $ 3,085 |
| 67 | Access Roadway (12'W X 200'L) to site (4" HMA/4" CSBC) and gate | 267 | SY | $ 71 | $ 18,933 |
| 68 | Disking or tilling of compacted soil (180'W X 140'L est. disturbance) | 1,972 | SY | $ 4 | $ 7,278 |
| 69 | Seeding, mulching and compost (Emergent, Riparian & Upland) | 1,972 | SY | $ 10 | $ 19,409 |
| 70 | Plantings (Emergent & Riparian) est. @ 25% of the seeded area | 493 | SY | $ 19 | $ 9,369 |
| 71 | | | | | $ - |
| 72 | **High Rate Underground Filter** | | | $ - | $ - |
| 73 | Filterra Unit 4'X6' (complete) | 1 | EA | $ 22,165 | $ 22,165 |
| 74 | Structural Excavation to Waste (10'W X12'L X 5'D) + (50'LX5'WX6'D) | 78 | CY | $ 79 | $ 6,123 |
| 75 | Imported Structural Fill | 73 | CY | $ 44 | $ 3,247 |
| 76 | Crushed Base | 1 | CY | $ 64 | $ 64 |
| 77 | Inlet Drain w/Energy Dissipating Rocks | 1 | EA | $ 1,481 | $ 1,481 |
| 78 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 79 | Pipe 8" dia. | 50 | LF | $ 80 | $ 4,000 |
| 80 | Trench Box Shoring (Shallow) | 390 | SF | $ 10 | $ 3,838 |
| 81 | | | | $ - | $ - |
| 82 | **Restoration High Rate Underground Filter** | | | $ - | $ - |
| 83 | Landscaping, planting, and restoration (Filter and 8" Pipe) | 39 | SY | $ 59 | $ 2,296 |
| 84 | Street Tree | 1 | EA | $ 720 | $ 720 |
| 85 | | | | | $ - |
| 87 | **Additional Costs** | | | | $ - |
| 88 | Removals at 4 % Construction Costs | 4.0% | LS | $ 311,761 | $ 12,470 |
| 89 | TESC at 2% of Construction | 2% | LS | $ 324,231 | $ 6,485 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 330,716 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 33,072 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 363,788 |
| ***Direct: Subtotal Construction Costs*** | | | ***$ 363,800*** |

**Description: WQBE_13F_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Public Property**

An infiltration pond is a basin that stores and infiltrates stormwater runoff. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Cost Estimating Assumptions:**

General

The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to Medium.
Construction occurs outside of the right-of-way and no traffic control or street use permits are required.
Trench Box shoring for pipe installation.

Infiltration Pond

The infiltration pond is designed in accordance with KC SW Manual Section 5.2.2 and is generally as described below:
It is assumed that stormwater will be pre-treated prior to conveyance to this facility and that a pre-settling pond will not be required.
The infiltration pond has a bottom area of 1,479 s.f. and a storage depth of 4 feet deep (48 inches).
The pond storage volume is generally located below grade.
The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 27.4 ft. wide and 54.0 ft. long.
The pond is constructed with 3:1 side slopes.
The design includes 1' of freeboard.
Infiltration pond is located on outwash soils.
An emergency overflow spillway is included.
The spillway is riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.
Emergency Spillway is 12 ft. long w/ a slope of 3:1, H:V.
The infiltration pond includes a compacted berm that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content.
A Type 2 minimum 72" dia. flow restrictor (weir) is included with shear gate, and frame and grate for secondary inlet.
Approximately 200 feet of 12-inch diameter pipes are included.
Dewatering is not required.
A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.
Property is assumed to be existing open space without building or pavement removal.
Fencing is not required, but a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced to help restrict vehicular access.
Disturbed areas are seeded and it is assumed that a portion of the area has plantings.

**High Rate Underground Filter**

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6"thick.
The facility treatment area is 24 sf (4'X6') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.
A total of 50 LF of 8" storm pipe is required to connect to the deep UIC well.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_14A_Infiltration Vault Till Soil on Public Property | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Infiltration Vault - Till Soil (1836 sf bottom area @ 0.08 MG Storage) | 1 | EA | $ 1,554,500 | $ 1,554,500 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 1,554,500*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 310,900 |
| | | | | Street Use Permit (Y/N) N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 1,865,400*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 186,540 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 2,051,940*** |
| | | | | Construction Sales Tax | $ 210,324 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 2,262,300*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 451,427 |
| | | | | Construction Management | $ 205,194 |
| | | | | Permitting & Support | $ 20,519 |
| | s.f. Land Area | None | | Land Purchase/ROW Acquisition | $ - |
| | s.f. Land Area | None | | Permanent Easements | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 123,116 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 800,257*** |
| | | | | Project Contingency | $ 918,767 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 1,719,000*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 3,981,300*** |

**Description: WQBE 14A - Infiltration Vault Till Soil on Public Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 3,981,300** | |
| Capital cost | $ 3,981,300 | $/Unit |
| Total Direct O&M/Year | $ 4,351 | |
| Direct O&M cost | $ 4,351 | $/Unit |
| Capital Replacement Costs (20 year equipment) | $ 56,900 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 4,104,000** | **$/unit** |
| **Annual O&M Cost** | **$ 4,800** | **$/year** |
| Annualized Cost | $750 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Cement Patching | 2023 dollars | $ 113 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $473 | |
| Labor | | | |
| Remove Trash, Debris, and Sediment | 16 | hr | |
| Inspection and joint repair, crack repair | 16 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| **Total hours per year** | 32 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 1,740 | |
| Labor cost, burdened | O/H 150.0% | $ 4,351 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 22,503 | | $ 207,010 | **$4,267,713** | **$ 4,104,034** | | | |
| 0 | 1.000 | **$ 3,981,300** | | | $3,981,300 | $ 3,981,300 | $ 3,981,300 | $ 3,981,300 | $ 4,104,034 |
| 1 | 0.950 | $473 | $ - | $ 4,351 | $ 4,824 | $ 4,584 | $ 3,986,124 | $ 3,985,884 | $ 122,734 |
| 2 | 0.903 | $ 487 | $ - | $ 4,482 | $ 4,969 | $ 4,486 | $ 3,991,093 | $ 3,990,369 | $ 118,151 |
| 3 | 0.858 | $ 502 | $ - | $ 4,616 | $ 5,118 | $ 4,390 | $ 3,996,211 | $ 3,994,759 | $ 113,665 |
| 4 | 0.815 | $ 517 | $ - | $ 4,755 | $ 5,272 | $ 4,296 | $ 4,001,483 | $ 3,999,055 | $ 109,276 |
| 5 | 0.774 | $ 532 | $ - | $ 4,897 | $ 5,430 | $ 4,204 | $ 4,006,912 | $ 4,003,259 | $ 104,980 |
| 6 | 0.736 | $ 548 | $ - | $ 5,044 | $ 5,593 | $ 4,114 | $ 4,012,505 | $ 4,007,373 | $ 100,776 |
| 7 | 0.699 | $ 565 | $ - | $ 5,196 | $ 5,760 | $ 4,026 | $ 4,018,265 | $ 4,011,399 | $ 96,662 |
| 8 | 0.664 | $ 582 | $ - | $ 5,351 | $ 5,933 | $ 3,940 | $ 4,024,198 | $ 4,015,339 | $ 92,635 |
| 9 | 0.631 | $ 599 | $ - | $ 5,512 | $ 6,111 | $ 3,856 | $ 4,030,310 | $ 4,019,195 | $ 88,695 |
| 10 | 0.599 | $ 617 | $ - | $ 5,677 | $ 6,294 | $ 3,773 | $ 4,036,604 | $ 4,022,968 | $ 84,839 |
| 11 | 0.570 | $ 636 | $ - | $ 5,848 | $ 6,483 | $ 3,693 | $ 4,043,087 | $ 4,026,661 | $ 81,066 |
| 12 | 0.541 | $ 655 | $ - | $ 6,023 | $ 6,678 | $ 3,614 | $ 4,049,765 | $ 4,030,275 | $ 77,373 |
| 13 | 0.514 | $ 674 | $ - | $ 6,204 | $ 6,878 | $ 3,537 | $ 4,056,643 | $ 4,033,812 | $ 73,759 |
| 14 | 0.489 | $ 695 | $ - | $ 6,390 | $ 7,085 | $ 3,461 | $ 4,063,728 | $ 4,037,273 | $ 70,223 |
| 15 | 0.464 | $ 715 | $ - | $ 6,582 | $ 7,297 | $ 3,387 | $ 4,071,025 | $ 4,040,660 | $ 66,762 |
| 16 | 0.441 | $ 737 | $ - | $ 6,779 | $ 7,516 | $ 3,315 | $ 4,078,541 | $ 4,043,974 | $ 63,375 |
| 17 | 0.419 | $ 759 | $ - | $ 6,982 | $ 7,741 | $ 3,244 | $ 4,086,282 | $ 4,047,218 | $ 60,060 |
| 18 | 0.398 | $ 782 | $ - | $ 7,192 | $ 7,974 | $ 3,174 | $ 4,094,256 | $ 4,050,392 | $ 56,816 |
| 19 | 0.378 | $ 805 | $ - | $ 7,408 | $ 8,213 | $ 3,107 | $ 4,102,469 | $ 4,053,499 | $ 53,642 |
| 20 | 0.359 | $ 829 | $ 56,900 | $ 7,630 | $ 65,359 | $ 23,489 | $ 4,167,828 | $ 4,076,988 | $ 50,535 |
| 21 | 0.341 | $ 854 | $ - | $ 7,859 | $ 8,713 | $ 2,975 | $ 4,176,541 | $ 4,079,963 | $ 27,046 |
| 22 | 0.324 | $ 880 | $ - | $ 8,095 | $ 8,974 | $ 2,912 | $ 4,185,516 | $ 4,082,875 | $ 24,071 |
| 23 | 0.308 | $ 906 | $ - | $ 8,337 | $ 9,244 | $ 2,849 | $ 4,194,759 | $ 4,085,724 | $ 21,160 |
| 24 | 0.293 | $ 934 | $ - | $ 8,587 | $ 9,521 | $ 2,788 | $ 4,204,280 | $ 4,088,512 | $ 18,310 |
| 25 | 0.278 | $ 962 | $ - | $ 8,845 | $ 9,807 | $ 2,729 | $ 4,214,087 | $ 4,091,241 | $ 15,522 |
| 26 | 0.264 | $ 990 | $ - | $ 9,110 | $ 10,101 | $ 2,670 | $ 4,224,188 | $ 4,093,911 | $ 12,793 |
| 27 | 0.251 | $ 1,020 | $ - | $ 9,384 | $ 10,404 | $ 2,613 | $ 4,234,591 | $ 4,096,525 | $ 10,123 |
| 28 | 0.239 | $ 1,051 | $ - | $ 9,665 | $ 10,716 | $ 2,557 | $ 4,245,307 | $ 4,099,082 | $ 7,510 |
| 29 | 0.227 | $ 1,082 | $ - | $ 9,955 | $ 11,037 | $ 2,503 | $ 4,256,345 | $ 4,101,585 | $ 4,952 |
| 30 | 0.215 | $ 1,115 | $ - | $ 10,254 | $ 11,369 | $ 2,449 | $ 4,267,713 | $ 4,104,034 | $ 2,449 |

**Description: WQBE 14A - Infiltration Vault Till Soil on Public Property**

Box-shaped underground facility that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day,
16 assume use of vactor truck.
Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an 8 hour
16 work day. Assume annual cost of $113 for cement patching mix.
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Capital Replacement Assumptions:**

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_14A_Infiltration Vault Till Soil on Public Property | | | **Version:** | 2 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Infiltration Vault on Property** | | | | $ - |
| 2 | ***Vault Assumptions*** | | | | $ - |
| 3 | *Exterior Length* | 54 | FT | | $ - |
| 4 | *Interior Length* | 51 | FT | | $ - |
| 5 | *Exterior Width* | 39 | FT | | $ - |
| 6 | *Interior Width* | 36 | FT | | $ - |
| 7 | *Interior Structure Height (Ave.)* | 7.5 | FT | | $ - |
| 8 | *Storage Depth (Ave)* | 6.0 | FT | | $ - |
| 9 | *Sediment Storage Depth* | 0.5 | FT | | $ - |
| 10 | *Freeboard (Ave.)* | 1.0 | FT | | $ - |
| 11 | *Storage Facility Exterior Footprint Area* | 2,106 | SF | | $ - |
| 12 | | | | | $ - |
| 13 | ***Storage Volume*** | | | | $ - |
| 14 | *Storage Facility interior Area* | 1,836 | SF | | $ - |
| 15 | *Effective Storage Volume (11,016 cf target)* | 11,016 | CF | | $ - |
| 16 | *Vault Storage Volume* | 0.08 | MG | | $ - |
| 17 | | | | | $ - |
| 18 | ***Structure Concrete Assumptions*** | | | | $ - |
| 19 | *Exterior Wall thickness* | 1.5 | FT | | $ - |
| 20 | *Top Slab Thickness* | 2 | FT | | $ - |
| 21 | *Flow Spreader Slab thickness* | 2 | FT | | $ - |
| 22 | *Center column footprint area (2'x2')* | 4 | SF | | $ - |
| 23 | *Center Column Spacing* | 5 | FT | | $ - |
| 24 | *Concrete Reinforcing Rebar* | 225 | LB/CY | | $ - |
| 25 | *Crushed Base Thickness* | 1 | FT | | $ - |
| 26 | | | | | $ - |
| 27 | **Concrete Structure** | | | | $ - |
| 28 | Vault Interior Columns at Midspan | 11 | CY | $ 650 | $ 7,222 |
| 29 | Slab under Flow Control/discharge (est. 6'W X 10'L X 2'D) | 4 | CY | $ 320 | $ 1,422 |
| 30 | Stormwater Flow Spreader Sump w/Lip Bottom Slab - 2' D x 2XL X 36W' | 5 | CY | $ 320 | $ 1,707 |
| 31 | Exterior Wall Concrete | 78 | CY | $ 1,250 | $ 96,875 |
| 32 | Top Slab Concrete | 156 | CY | $ 1,250 | $ 195,000 |
| 33 | Concrete Reinforcing Rebar | 57,238 | LBS | $ 1.38 | $ 78,988 |
| 34 | Crushed Base | 78 | CY | $ 64 | $ 4,992 |
| 35 | | | | | $ - |
| 36 | ***Shoring and Excavation Assumptions*** | | | | $ - |
| 37 | *Construction Room* | 3 | FT | | $ - |
| 38 | *Tank Bury Depth* | 2 | FT | | $ - |
| 39 | *Total Excavation Depth* | 13 | FT | | $ - |
| 40 | *Excavation Length* | 64 | FT | | $ - |
| 41 | *Excavation Width* | 49 | FT | | $ - |
| 42 | | | | | $ - |
| 43 | **Soil Excavation and Disposal** | | | | $ - |
| 44 | Excavation | 1,452 | CY | $ 79 | $ 114,696 |
| 48 | Imported Structure Backfill | 633 | CY | $ 44 | $ 27,845 |
| 49 | | | | | $ - |
| 50 | **Solder Pile Shoring** | | | | $ - |
| 51 | *Solder Pile Shaft Depth (3 x Exc. Depth)* | 38 | FT | | $ - |
| 52 | *Solder Pile Shaft Thickness* | 2 | FT | | $ - |
| 53 | *Center to Center Shaft Spacing* | 6 | FT | | $ - |
| 54 | *Rebar in Shaft* | 114 | LB/CY | | $ - |
| 55 | *Shoring Wall Perimeter* | 218 | FT | | $ - |
| 56 | *Number of Shafts* | 36 | EA | | $ - |
| 57 | Drill Solder Pile Shafts | 157 | CY | $ 262 | $ 41,155 |
| 58 | Set Solder Pile and CDF | 157 | CY | $ 391 | $ 61,418 |
| 59 | Purchase and Salvage Solder Piles | 153,900 | LB | $ 0.7 | $ 107,730 |
| 60 | Tie Backs - one per soldier pile except corners | 32 | EA | $ 2,477 | $ 79,264 |
| 61 | Timber Lagging | 9,831 | BF | $ 9 | $ 88,479 |
| 62 | | | | | $ - |
| 63 | **Gates and Access** | | | | $ - |
| 64 | Flow Restrictor | 1 | EA | $ 24,600 | $ 24,600 |
| 65 | Confined Space Safety | 1 | LS | $ 32,595 | $ 32,595 |
| 66 | Access Hatches | 2 | EA | $ 13,038 | $ 26,076 |
| 67 | | | | | $ - |
| 68 | **Conveyance Pipe** | | | | $ - |
| 69 | 12" Storm Pipe (upstream and discharge) | 200 | LF | $ 140 | $ 28,000 |
| 70 | Trench Excavation to waste (8'W X 15'D) | 889 | CY | $ 79 | $ 70,222 |
| 71 | Trench Box Shoring | 6,000 | SF | $ 10 | $ 60,000 |
| 72 | 48" Diameter Maintenance holes | 4 | EA | $ 10,640 | $ 42,560 |
| 73 | Imported Backfill | 883 | CY | $ 44 | $ 38,855 |
| 74 | Dewater Trench - Sumps | 200 | LF | $ 139 | $ 27,800 |
| 75 | Demolish Surface incl. room for construction (@20' wide) | 444 | SY | $ 14 | $ 6,222 |
| 76 | Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100') | 444 | SY | $ 71 | $ 31,556 |
| 77 | | | | | $ - |
| 78 | **Site Removals and Restoration** | | | | $ - |
| 79 | Disking or tilling of compacted soil (assumed 1.5 times structure footprint) | 523 | SY | $ 4 | $ 2,091 |
| 80 | Seeding, mulching and compost | 523 | SY | $ 10 | $ 5,227 |
| 81 | Demolish Existing Surface | 348 | SY | $ 14 | $ 4,878 |
| 82 | Pavement Remove and Restoration (Vault) - 4" HMA/4"CSBC | 348 | SY | $ 71 | $ 24,740 |
| 83 | Removals at 4 % Construction Costs | 4.0% | LS | $ 1,332,215 | $ 53,289 |
| 84 | TESC at 2% of Construction | 2% | LS | $ 1,385,503 | $ 27,710 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 1,413,214 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 141,321 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 1,554,535 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 1,554,500*** |

**Description: WQBE 14A - Infiltration Vault Till Soil on Public Property**

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

**Cost Estimating Assumptions:**

The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.
The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.
The vault is assumed to be sited on till soils.
It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.
The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.08 MG.

The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.
The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1836 square feet and a maximum storage depth of 6 feet deep.
Vault has interior dimensions of 36'W x 51'L with an average interior height of 7.5'.
The minimum vault height is 7' deep at the shallowest end.
The vault side slopes are a minimum of 5% towards the center of the vault.

Infiltration is achieved through the native soils at the bottom of the structure.
A minimum of 0.5 feet for sediment storage and a minimum of 1 foot of freeboard depth are assumed.
Exterior and interior wall thickness is 1.5 feet.
Top slab thickness is 2 feet.
The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.
The side walls extend to 1 feet below the vault floor.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth
The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
There will be two maintenance hole access locations with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.
Shoring and lagging is required for construction of the structure.
A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.
Trench Box shoring is used.
The storage vault, facility inlet and outlet pipes are sited beneath a parking area.
It is assumed that the tank restoration will consist of parking lot restoration with4" HMA/4" CSTC.
It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
Allowance fore removals estimated at 4% of the construction costs.
The facility is located on property and traffic control is not required.
A street use permit is not required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR) |
| **Description:** | WQBE_14B_Infiltration Vault Outwash Soil on Public Property | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Infiltration Vault - Outwash Soil (1156 sf bottom area @ 0.05 MG Storage) | 1 | EA | $ 1,285,100 | $ 1,285,100 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 1,285,100*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 257,020 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 1,542,120*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 154,212 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 1,696,332*** |
| | | | | Construction Sales Tax | $ 173,874 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 1,870,200*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 373,193 |
| | | | | Construction Management | $ 169,633 |
| | | | | Permitting & Support | $ 16,963 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 101,780 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 661,569*** |
| | | | | Project Contingency | $ 759,531 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 1,421,100*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 3,291,300*** |

**Description: WQBE_14B_Infiltration Vault Outwash Soil on Public Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 3,291,300** | |
| Capital cost | $ 3,291,300 | $/Unit |
| Total Direct O&M/Year | $ 4,351 | |
| Direct O&M cost | $ 4,351 | $/Unit |
| Capital Replacement Costs (20 year equipment) | $ 56,900 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 3,414,000** | **$/unit** |
| **Annual O&M Cost** | **$ 4,800** | **$/year** |
| Annualized Cost | $750 | |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Cement Patching | 2023 dollars | $ 113 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $473 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash, Debris, and Sediment | 16 | hr | |
| Inspection and joint repair, crack repair | 16 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| **Total hours per year** | 32 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 1,740 | |
| Labor cost, burdened | O/H 150.0% | $ 4,351 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 22,503 | | $ 207,010 | **$3,577,713** | **$ 3,414,034** | | | |
| 0 | 1.000 | **$ 3,291,300** | | | $3,291,300 | $ 3,291,300 | $ 3,291,300 | $ 3,291,300 | $ 3,414,034 |
| 1 | 0.950 | $473 | $ - | $ 4,351 | $ 4,824 | $ 4,584 | $ 3,296,124 | $ 3,295,884 | $ 122,734 |
| 2 | 0.903 | $ 487 | $ - | $ 4,482 | $ 4,969 | $ 4,486 | $ 3,301,093 | $ 3,300,369 | $ 118,151 |
| 3 | 0.858 | $ 502 | $ - | $ 4,616 | $ 5,118 | $ 4,390 | $ 3,306,211 | $ 3,304,759 | $ 113,665 |
| 4 | 0.815 | $ 517 | $ - | $ 4,755 | $ 5,272 | $ 4,296 | $ 3,311,483 | $ 3,309,055 | $ 109,276 |
| 5 | 0.774 | $ 532 | $ - | $ 4,897 | $ 5,430 | $ 4,204 | $ 3,316,912 | $ 3,313,259 | $ 104,980 |
| 6 | 0.736 | $ 548 | $ - | $ 5,044 | $ 5,593 | $ 4,114 | $ 3,322,505 | $ 3,317,373 | $ 100,776 |
| 7 | 0.699 | $ 565 | $ - | $ 5,196 | $ 5,760 | $ 4,026 | $ 3,328,265 | $ 3,321,399 | $ 96,662 |
| 8 | 0.664 | $ 582 | $ - | $ 5,351 | $ 5,933 | $ 3,940 | $ 3,334,198 | $ 3,325,339 | $ 92,635 |
| 9 | 0.631 | $ 599 | $ - | $ 5,512 | $ 6,111 | $ 3,856 | $ 3,340,310 | $ 3,329,195 | $ 88,695 |
| 10 | 0.599 | $ 617 | $ - | $ 5,677 | $ 6,294 | $ 3,773 | $ 3,346,604 | $ 3,332,968 | $ 84,839 |
| 11 | 0.570 | $ 636 | $ - | $ 5,848 | $ 6,483 | $ 3,693 | $ 3,353,087 | $ 3,336,661 | $ 81,066 |
| 12 | 0.541 | $ 655 | $ - | $ 6,023 | $ 6,678 | $ 3,614 | $ 3,359,765 | $ 3,340,275 | $ 77,373 |
| 13 | 0.514 | $ 674 | $ - | $ 6,204 | $ 6,878 | $ 3,537 | $ 3,366,643 | $ 3,343,812 | $ 73,759 |
| 14 | 0.489 | $ 695 | $ - | $ 6,390 | $ 7,085 | $ 3,461 | $ 3,373,728 | $ 3,347,273 | $ 70,223 |
| 15 | 0.464 | $ 715 | $ - | $ 6,582 | $ 7,297 | $ 3,387 | $ 3,381,025 | $ 3,350,660 | $ 66,762 |
| 16 | 0.441 | $ 737 | $ - | $ 6,779 | $ 7,516 | $ 3,315 | $ 3,388,541 | $ 3,353,974 | $ 63,375 |
| 17 | 0.419 | $ 759 | $ - | $ 6,982 | $ 7,741 | $ 3,244 | $ 3,396,282 | $ 3,357,218 | $ 60,060 |
| 18 | 0.398 | $ 782 | $ - | $ 7,192 | $ 7,974 | $ 3,174 | $ 3,404,256 | $ 3,360,392 | $ 56,816 |
| 19 | 0.378 | $ 805 | $ - | $ 7,408 | $ 8,213 | $ 3,107 | $ 3,412,469 | $ 3,363,499 | $ 53,642 |
| 20 | 0.359 | $ 829 | $ 56,900 | $ 7,630 | $ 65,359 | $ 23,489 | $ 3,477,828 | $ 3,386,988 | $ 50,535 |
| 21 | 0.341 | $ 854 | $ - | $ 7,859 | $ 8,713 | $ 2,975 | $ 3,486,541 | $ 3,389,963 | $ 27,046 |
| 22 | 0.324 | $ 880 | $ - | $ 8,095 | $ 8,974 | $ 2,912 | $ 3,495,516 | $ 3,392,875 | $ 24,071 |
| 23 | 0.308 | $ 906 | $ - | $ 8,337 | $ 9,244 | $ 2,849 | $ 3,504,759 | $ 3,395,724 | $ 21,160 |
| 24 | 0.293 | $ 934 | $ - | $ 8,587 | $ 9,521 | $ 2,788 | $ 3,514,280 | $ 3,398,512 | $ 18,310 |
| 25 | 0.278 | $ 962 | $ - | $ 8,845 | $ 9,807 | $ 2,729 | $ 3,524,087 | $ 3,401,241 | $ 15,522 |
| 26 | 0.264 | $ 990 | $ - | $ 9,110 | $ 10,101 | $ 2,670 | $ 3,534,188 | $ 3,403,911 | $ 12,793 |
| 27 | 0.251 | $ 1,020 | $ - | $ 9,384 | $ 10,404 | $ 2,613 | $ 3,544,591 | $ 3,406,525 | $ 10,123 |
| 28 | 0.239 | $ 1,051 | $ - | $ 9,665 | $ 10,716 | $ 2,557 | $ 3,555,307 | $ 3,409,082 | $ 7,510 |
| 29 | 0.227 | $ 1,082 | $ - | $ 9,955 | $ 11,037 | $ 2,503 | $ 3,566,345 | $ 3,411,585 | $ 4,952 |
| 30 | 0.215 | $ 1,115 | $ - | $ 10,254 | $ 11,369 | $ 2,449 | $ 3,577,713 | $ 3,414,034 | $ 2,449 |

**Description: WQBE_14B_Infiltration Vault Outwash Soil on Public Property**
Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.
**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**
Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work
16 day, assume use of vactor truck.
Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an
16 8 hour work day. Assume annual cost of $113 for cement patching mix.
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.
**Capital Replacement Assumptions:**
Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_14B_Infiltration Vault Outwash Soil on Public Property | | | **Version:** | 2 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Infiltration Vault on Property** | | | | $ - |
| 2 | ***Vault Assumptions*** | | | | $ - |
| 3 | *Exterior Length* | 37 | FT | | $ - |
| 4 | *Interior Length* | 34 | FT | | $ - |
| 5 | *Exterior Width* | 37 | FT | | $ - |
| 6 | *Interior Width* | 34 | FT | | $ - |
| 7 | *Interior Structure Height (Ave.)* | 7.5 | FT | | $ - |
| 8 | *Storage Depth (Ave)* | 6.0 | FT | | $ - |
| 9 | *Sediment Storage Depth* | 0.5 | FT | | $ - |
| 10 | *Freeboard (Ave.)* | 1.0 | FT | | $ - |
| 11 | *Storage Facility Exterior Footprint Area* | 1,369 | SF | | $ - |
| 12 | | | | | $ - |
| 13 | ***Storage Volume*** | | | | $ - |
| 14 | *Storage Facility interior Area* | 1,156 | SF | | $ - |
| 15 | *Effective Storage Volume (15.500 cf target)* | 6,936 | CF | | $ - |
| 16 | *Vault Storage Volume* | 0.05 | MG | | $ - |
| 17 | | | | | $ - |
| 18 | ***Structure Concrete Assumptions*** | | | | $ - |
| 19 | *Exterior Wall thickness* | 1.5 | FT | | $ - |
| 20 | *Top Slab Thickness* | 2 | FT | | $ - |
| 21 | *Flow Spreader Slab thickness* | 2 | FT | | $ - |
| 22 | *Center column footprint area (2'x2')* | 4 | SF | | $ - |
| 23 | *Center Column Spacing* | 5 | FT | | $ - |
| 24 | *Concrete Reinforcing Rebar* | 225 | LB/CY | | $ - |
| 25 | *Crushed Base Thickness* | 1 | FT | | $ - |
| 26 | | | | | $ - |
| 27 | **Concrete Structure** | | | | $ - |
| 28 | Vault Interior Columns at Midspan | 8 | CY | $ 650 | $ 5,056 |
| 29 | Slab under Flow Control/discharge (est. 6'W X 10'L X 2'D) | 4 | CY | $ 320 | $ 1,422 |
| 30 | Stormwater Flow Spreader Sump w/Lip Bottom Slab - 2' D x 2XL X 36W' | 5 | CY | $ 320 | $ 1,612 |
| 31 | Exterior Wall Concrete | 62 | CY | $ 1,250 | $ 77,083 |
| 32 | Top Slab Concrete | 101 | CY | $ 1,250 | $ 126,759 |
| 33 | Concrete Reinforcing Rebar | 40,575 | LBS | $ 1.38 | $ 55,994 |
| 34 | Crushed Base | 51 | CY | $ 64 | $ 3,245 |
| 35 | | | | | $ - |
| 36 | ***Shoring and Excavation Assumptions*** | | | | $ - |
| 37 | *Construction Room* | 3 | FT | | $ - |
| 38 | *Tank Bury Depth* | 2 | FT | | $ - |
| 39 | *Total Excavation Depth* | 13 | FT | | $ - |
| 40 | *Excavation Length* | 47 | FT | | $ - |
| 41 | *Excavation Width* | 47 | FT | | $ - |
| 42 | | | | | $ - |
| 43 | **Soil Excavation and Disposal** | | | | $ - |
| 44 | Excavation to waste | 1,023 | CY | $ 79 | $ 80,792 |
| 48 | Imported Structure Backfill | 490 | CY | $ 44 | $ 21,573 |
| 49 | | | | | $ - |
| 50 | **Solder Pile Shoring** | | | | $ - |
| 51 | *Solder Pile Shaft Depth (3 x Exc. Depth)* | 38 | FT | | $ - |
| 52 | *Solder Pile Shaft Thickness* | 2 | FT | | $ - |
| 53 | *Center to Center Shaft Spacing* | 6 | FT | | $ - |
| 54 | *Rebar in Shaft* | 114 | LB/CY | | $ - |
| 55 | *Shoring Wall Perimeter* | 180 | FT | | $ - |
| 56 | *Number of Shafts* | 30 | EA | | $ - |
| 57 | Drill Solder Pile Shafts | 131 | CY | $ 262 | $ 34,296 |
| 58 | Set Solder Pile and CDF | 131 | CY | $ 391 | $ 51,182 |
| 59 | Purchase and Salvage Solder Piles | 128,250 | LB | $ 0.7 | $ 89,775 |
| 60 | Tie Backs - one per soldier pile except corners | 26 | EA | $ 2,477 | $ 64,402 |
| 61 | Timber Lagging (64'W X 70'L @ approx. 20'H) | 8,178 | BF | $ 9 | $ 73,602 |
| 62 | | | | | $ - |
| 63 | **Gates and Access** | | | | $ - |
| 64 | Flow Restrictor | 1 | EA | $ 24,600 | $ 24,600 |
| 65 | Confined Space Safety | 1 | LS | $ 32,595 | $ 32,595 |
| 66 | Access Hatches | 2 | EA | $ 13,038 | $ 26,076 |
| 67 | | | | | $ - |
| 68 | **Conveyance Pipe** | | | | $ - |
| 69 | 12" Storm Pipe (upstream and discharge) | 200 | LF | $ 140 | $ 28,000 |
| 70 | Trench Excavation to waste (8'W X 15'D) | 889 | CY | $ 79 | $ 70,222 |
| 71 | Trench Box Shoring | 6,000 | SF | $ 10 | $ 60,000 |
| 72 | 48" Diameter Maintenance holes | 4 | EA | $ 10,640 | $ 42,560 |
| 73 | Imported Backfill | 883 | CY | $ 44 | $ 38,855 |
| 74 | Dewater Trench - Sumps | 200 | LF | $ 139 | $ 27,800 |
| 75 | Demolish Surface incl. room for construction (@20' wide) | 444 | SY | $ 14 | $ 6,222 |
| 76 | Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100') | 444 | SY | $ 71 | $ 31,556 |
| 77 | | | | | $ - |
| 78 | **Site Removals and Restoration** | | | | $ - |
| 79 | Disking or tilling of compacted soil (assumed 1.5 times structure footprint) | 368 | SY | $ 4 | $ 1,473 |
| 80 | Seeding, mulching and compost | 368 | SY | $ 10 | $ 3,682 |
| 81 | Demolish Existing Surface | 245 | SY | $ 14 | $ 3,436 |
| 82 | Pavement Remove and Restoration (Vault) - 4" HMA/4"CSBC | 245 | SY | $ 71 | $ 17,427 |
| 83 | | | | | $ - |
| 84 | Removals at 4 % Construction Costs | 4.0% | LS | $ 1,101,296 | $ 44,052 |
| 85 | TESC at 2% of Construction | 2% | LS | $ 1,145,347 | $ 22,907 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 1,168,254 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 116,825 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 1,285,080 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 1,285,100*** |

**Description: WQBE 14B - Infiltration Vault Outwash Soil on Public Property**
Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

**Cost Estimating Assumptions:**
The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.
The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.
The vault is assumed to be sited on Outwash soils.
It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.
The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.05 MG.
The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.
The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1156 square feet and a maximum storage depth of 6 feet deep.
Vault has interior dimensions of 34'W x 34'L with an average interior height of 7.5'.
The minimum vault height is 7' deep at the shallowest end.
The vault side slopes are a minimum of 5% towards the center of the vault.
Infiltration is achieved through the native soils at the bottom of the structure.
A minimum of 0.5 feet for sediment storage and a minimum of 1 feet of freeboard depth are assumed.
Exterior and interior wall thickness is 1.5 feet.
Top slab thickness is 2 feet.
The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.
The side walls extend to 1 feet below the vault floor.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth
The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
There will be two maintenance hole access locations with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.
Shoring and lagging is required for construction of the structure.
A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.
Trench Box shoring is used.
The storage vault, facility inlet and outlet pipes are sited beneath a parking area.
It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and traffic control is not required.
A street use permit is not required.

**Planning Basis Assumptions:**
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**
All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**
This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_14C_Infiltration Vault Till Soil in ROW | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Infiltration Vault - Till Soil (1836 sf bottom area @ 0.08 MG Storage) in ROW | 1 | EA | $ 1,731,038 | $ 1,731,038 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 1,731,038*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 346,208 |
| | | | Street Use Permit (Y/N) | Y | $ 90,000 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 2,167,246*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 207,725 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 2,374,970*** |
| | | | | Construction Sales Tax | $ 234,209 |
| | | | | Outside Agency Construction | $ 173,104 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 2,782,300*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 522,493 |
| | | | | Construction Management | $ 237,497 |
| | | | | Permitting & Support | $ 23,750 |
| | s.f. Land Area | None | | Land Purchase/ROW Acquisition | $ - |
| | s.f. Land Area | None | | Permanent Easements | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 142,498 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 926,238*** |
| | | | | Project Contingency | $ 1,112,562 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 2,038,800*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 4,821,100*** |

**Description: WQBE 14C- Infiltration Vault Till Soil in ROW (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 4,821,100** | |
| Capital cost | $ 4,821,100 | $/Unit |
| Total Direct O&M/Year | $ 4,351 | |
| Direct O&M cost | $ 4,351 | $/Unit |
| Capital Replacement Costs (20 year equipment) | $ 56,858 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 4,943,800** | **$/unit** |
| **Annual O&M Cost** | **$ 4,800** | **$/year** |
| Annualized Cost | $750 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Cement Patching | 2023 dollars | $ 113 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $473 | |
| Labor | | | |
| Remove Trash, Debris, and Sediment | 16 | hr | |
| Inspection and joint repair, crack repair | 16 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| **Total hours per year** | 32 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 1,740 | |
| Labor cost, burdened | O/H 150.0% | $ 4,351 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 22,503 | | $ 207,010 | **$5,107,472** | **$ 4,943,819** | | | |
| 0 | 1.000 | **$ 4,821,100** | | | $4,821,100 | $ 4,821,100 | $ 4,821,100 | $ 4,821,100 | $ 4,943,819 |
| 1 | 0.950 | $473 | $ - | $ 4,351 | $ 4,824 | $ 4,584 | $ 4,825,924 | $ 4,825,684 | $ 122,719 |
| 2 | 0.903 | $ 487 | $ - | $ 4,482 | $ 4,969 | $ 4,486 | $ 4,830,893 | $ 4,830,169 | $ 118,136 |
| 3 | 0.858 | $ 502 | $ - | $ 4,616 | $ 5,118 | $ 4,390 | $ 4,836,011 | $ 4,834,559 | $ 113,650 |
| 4 | 0.815 | $ 517 | $ - | $ 4,755 | $ 5,272 | $ 4,296 | $ 4,841,283 | $ 4,838,855 | $ 109,261 |
| 5 | 0.774 | $ 532 | $ - | $ 4,897 | $ 5,430 | $ 4,204 | $ 4,846,712 | $ 4,843,059 | $ 104,965 |
| 6 | 0.736 | $ 548 | $ - | $ 5,044 | $ 5,593 | $ 4,114 | $ 4,852,305 | $ 4,847,173 | $ 100,761 |
| 7 | 0.699 | $ 565 | $ - | $ 5,196 | $ 5,760 | $ 4,026 | $ 4,858,065 | $ 4,851,199 | $ 96,647 |
| 8 | 0.664 | $ 582 | $ - | $ 5,351 | $ 5,933 | $ 3,940 | $ 4,863,998 | $ 4,855,139 | $ 92,620 |
| 9 | 0.631 | $ 599 | $ - | $ 5,512 | $ 6,111 | $ 3,856 | $ 4,870,110 | $ 4,858,995 | $ 88,680 |
| 10 | 0.599 | $ 617 | $ - | $ 5,677 | $ 6,294 | $ 3,773 | $ 4,876,404 | $ 4,862,768 | $ 84,824 |
| 11 | 0.570 | $ 636 | $ - | $ 5,848 | $ 6,483 | $ 3,693 | $ 4,882,887 | $ 4,866,461 | $ 81,051 |
| 12 | 0.541 | $ 655 | $ - | $ 6,023 | $ 6,678 | $ 3,614 | $ 4,889,565 | $ 4,870,075 | $ 77,358 |
| 13 | 0.514 | $ 674 | $ - | $ 6,204 | $ 6,878 | $ 3,537 | $ 4,896,443 | $ 4,873,612 | $ 73,744 |
| 14 | 0.489 | $ 695 | $ - | $ 6,390 | $ 7,085 | $ 3,461 | $ 4,903,528 | $ 4,877,073 | $ 70,208 |
| 15 | 0.464 | $ 715 | $ - | $ 6,582 | $ 7,297 | $ 3,387 | $ 4,910,825 | $ 4,880,460 | $ 66,747 |
| 16 | 0.441 | $ 737 | $ - | $ 6,779 | $ 7,516 | $ 3,315 | $ 4,918,341 | $ 4,883,774 | $ 63,360 |
| 17 | 0.419 | $ 759 | $ - | $ 6,982 | $ 7,741 | $ 3,244 | $ 4,926,082 | $ 4,887,018 | $ 60,045 |
| 18 | 0.398 | $ 782 | $ - | $ 7,192 | $ 7,974 | $ 3,174 | $ 4,934,056 | $ 4,890,192 | $ 56,801 |
| 19 | 0.378 | $ 805 | $ - | $ 7,408 | $ 8,213 | $ 3,107 | $ 4,942,269 | $ 4,893,299 | $ 53,627 |
| 20 | 0.359 | $ 829 | $ 56,858 | $ 7,630 | $ 65,318 | $ 23,474 | $ 5,007,587 | $ 4,916,773 | $ 50,521 |
| 21 | 0.341 | $ 854 | $ - | $ 7,859 | $ 8,713 | $ 2,975 | $ 5,016,300 | $ 4,919,748 | $ 27,046 |
| 22 | 0.324 | $ 880 | $ - | $ 8,095 | $ 8,974 | $ 2,912 | $ 5,025,274 | $ 4,922,660 | $ 24,071 |
| 23 | 0.308 | $ 906 | $ - | $ 8,337 | $ 9,244 | $ 2,849 | $ 5,034,518 | $ 4,925,509 | $ 21,160 |
| 24 | 0.293 | $ 934 | $ - | $ 8,587 | $ 9,521 | $ 2,788 | $ 5,044,039 | $ 4,928,297 | $ 18,310 |
| 25 | 0.278 | $ 962 | $ - | $ 8,845 | $ 9,807 | $ 2,729 | $ 5,053,845 | $ 4,931,026 | $ 15,522 |
| 26 | 0.264 | $ 990 | $ - | $ 9,110 | $ 10,101 | $ 2,670 | $ 5,063,946 | $ 4,933,697 | $ 12,793 |
| 27 | 0.251 | $ 1,020 | $ - | $ 9,384 | $ 10,404 | $ 2,613 | $ 5,074,350 | $ 4,936,310 | $ 10,123 |
| 28 | 0.239 | $ 1,051 | $ - | $ 9,665 | $ 10,716 | $ 2,557 | $ 5,085,066 | $ 4,938,867 | $ 7,510 |
| 29 | 0.227 | $ 1,082 | $ - | $ 9,955 | $ 11,037 | $ 2,503 | $ 5,096,103 | $ 4,941,370 | $ 4,952 |
| 30 | 0.215 | $ 1,115 | $ - | $ 10,254 | $ 11,369 | $ 2,449 | $ 5,107,472 | $ 4,943,819 | $ 2,449 |

**Description: WQBE 14C - Infiltration Vault Till Soil in ROW**
Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

**Life-Cycle Cost Model Input Assumptions:**
Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**
16 Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day, assume use of vactor truck.
16 Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an 8 hour work day. Assume annual cost of $113 for cement patching mix.
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.
**Capital Replacement Assumptions:**
Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_14C_Infiltration Vault Till Soil in ROW | | | **Version:** | 2 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Infiltration Vault in ROW** | | | | $ - |
| 2 | ***Vault Assumptions*** | | | | $ - |
| 3 | *Exterior Length* | 54 | FT | | $ - |
| 4 | *Interior Length* | 51 | FT | | $ - |
| 5 | *Exterior Width* | 39 | FT | | $ - |
| 6 | *Interior Width* | 36 | FT | | $ - |
| 7 | *Interior Structure Height (Ave.)* | 7.5 | FT | | $ - |
| 8 | *Storage Depth (Ave)* | 6.0 | FT | | $ - |
| 9 | *Sediment Storage Depth* | 0.5 | FT | | $ - |
| 10 | *Freeboard (Ave.)* | 1.0 | FT | | $ - |
| 11 | *Storage Facility Exterior Footprint Area* | 2,106 | SF | | $ - |
| 12 | | | | | $ - |
| 13 | ***Storage Volume*** | | | | $ - |
| 14 | *Storage Facility interior Area* | 1,836 | SF | | $ - |
| 15 | *Effective Storage Volume (11,016 cf target)* | 11,016 | CF | | $ - |
| 16 | *Vault Storage Volume* | 0.08 | MG | | $ - |
| 17 | | | | | $ - |
| 18 | ***Structure Concrete Assumptions*** | | | | $ - |
| 19 | *Exterior Wall thickness* | 1.5 | FT | | $ - |
| 20 | *Top Slab Thickness* | 2 | FT | | $ - |
| 21 | *Flow Spreader Slab thickness* | 2 | FT | | $ - |
| 22 | *Center column footprint area (2'x2')* | 4 | SF | | $ - |
| 23 | *Center Column Spacing* | 5 | FT | | $ - |
| 24 | *Concrete Reinforcing Rebar* | 225 | LB/CY | | $ - |
| 25 | *Crushed Base Thickness* | 1 | FT | | $ - |
| 26 | | | | | $ - |
| 27 | **Concrete Structure** | | | | $ - |
| 28 | Vault Interior Columns at Midspan | 11 | CY | $ 650 | $ 7,222 |
| 29 | Slab under Flow Control/discharge (est. 6'W X 10'L X 2'D) | 4 | CY | $ 320 | $ 1,422 |
| 30 | Stormwater Flow Spreader Sump w/Lip Bottom Slab - 2' D x 2XL X 36W' | 5 | CY | $ 320 | $ 1,707 |
| 31 | Exterior Wall Concrete | 78 | CY | $ 1,250 | $ 96,875 |
| 32 | Top Slab Concrete | 156 | CY | $ 1,250 | $ 195,000 |
| 33 | Concrete Reinforcing Rebar | 57,238 | LBS | $ 1.38 | $ 78,988 |
| 34 | Crushed Base | 78 | CY | $ 64 | $ 4,992 |
| 35 | | | | | $ - |
| 36 | ***Shoring and Excavation Assumptions*** | | | | $ - |
| 37 | *Construction Room* | 3 | FT | | $ - |
| 38 | *Tank Bury Depth* | 2 | FT | | $ - |
| 39 | *Total Excavation Depth* | 13 | FT | | $ - |
| 40 | *Excavation Length* | 64 | FT | | $ - |
| 41 | *Excavation Width* | 49 | FT | | $ - |
| 42 | | | | | $ - |
| 43 | **Soil Excavation and Disposal** | | | | $ - |
| 44 | Excavation | 1,452 | CY | $ 79 | $ 114,696 |
| 48 | Imported Structure Backfill | 633 | CY | $ 44 | $ 27,845 |
| 49 | | | | | $ - |
| 50 | **Solder Pile Shoring** | | | | $ - |
| 51 | *Solder Pile Shaft Depth (3 x Exc. Depth)* | 38 | FT | | $ - |
| 52 | *Solder Pile Shaft Thickness* | 2 | FT | | $ - |
| 53 | *Center to Center Shaft Spacing* | 6 | FT | | $ - |
| 54 | *Rebar in Shaft* | 114 | LB/CY | | $ - |
| 55 | *Shoring Wall Perimeter* | 218 | FT | | $ - |
| 56 | *Number of Shafts* | 36 | EA | | $ - |
| 57 | Drill Solder Pile Shafts | 157 | CY | $ 262 | $ 41,155 |
| 58 | Set Solder Pile and CDF | 157 | CY | $ 391 | $ 61,418 |
| 59 | Purchase and Salvage Solder Piles | 153,900 | LB | $ 0.7 | $ 107,730 |
| 60 | Tie Backs - one per soldier pile except corners | 32 | EA | $ 2,477 | $ 79,264 |
| 61 | Timber Lagging | 9,831 | BF | $ 9 | $ 88,479 |
| 62 | | | | | $ - |
| 63 | **Gates and Access** | | | | $ - |
| 64 | Flow Restrictor | 1 | EA | $ 24,600 | $ 24,600 |
| 65 | Confined Space Safety | 1 | LS | $ 32,595 | $ 32,595 |
| 66 | Access Hatches | 2 | EA | $ 13,038 | $ 26,076 |
| 67 | | | | | $ - |
| 68 | **Conveyance Pipe** | | | | $ - |
| 69 | 12" Storm Pipe (upstream and discharge) | 200 | LF | $ 140 | $ 28,000 |
| 70 | Trench Excavation to waste (8'W X 15'D) | 889 | CY | $ 79 | $ 70,222 |
| 71 | Trench Box Shoring | 6,000 | SF | $ 10 | $ 60,000 |
| 72 | 48" Diameter Maintenance holes | 4 | EA | $ 10,640 | $ 42,560 |
| 73 | Imported Backfill | 883 | CY | $ 44 | $ 38,855 |
| 74 | Dewater Trench - Sumps | 200 | LF | $ 139 | $ 27,800 |
| 75 | Demolish Surface incl. room for construction (@20' wide) | 444 | SY | $ 14 | $ 6,222 |
| 76 | Road Restoration (for pipe) - 6" HMA/6"CSBC x 20' W X 100' | 444 | SY | $ 110 | $ 48,889 |
| 77 | | | | | $ - |
| 78 | **Site Removals and Restoration** | | | | $ - |
| 79 | Demolish Existing Surface | 348 | SY | $ 14 | $ 4,878 |
| 80 | Road Restoration - 6" HMA/6"CSBC (for Vault -71'X56') | 348 | SY | $ 110 | $ 38,329 |
| 81 | Sidewalk Est. one side x 5' Wide | 42 | SY | $ 125 | $ 5,208 |
| 82 | Planting Strip Est one side x 8' Wide | 67 | SY | $ 10 | $ 656 |
| 83 | Landscape/Lawn Restoration | 67 | SY | $ 59 | $ 3,936 |
| 84 | Irrigation System Repair est @ 10% Landscape/Lawn | 10% | LS | $ 3,936 | $ 394 |
| 85 | Trees both new and replacements Est @ 4 per 100' | 3 | EA | $ 720 | $ 2,160 |
| 86 | | | | | $ - |
| 87 | Traffic Control Arterial (HMA) | 6 | MO | $ 20,000 | $ 120,000 |
| 88 | Removals at 4 % Construction Costs | 4.0% | LS | $ 1,366,014 | $ 54,641 |
| 89 | TESC at 2% of Construction | 2% | LS | $ 1,542,815 | $ 30,856 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 1,573,671 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 157,367 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 1,731,038 |
| ***Direct: Subtotal Construction Costs*** | | | ***$ 1,731,038*** |

**Description: WQBE 14C - Infiltration Vault Till Soil in ROW**
Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

**Cost Estimating Assumptions:**
The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.
The vault is assumed to be sited on till soils.
It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.
The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.08 MG.
The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.
The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1836 square feet and a maximum storage depth of 6 feet deep.
Vault has interior dimensions of 36'W x 51'L with an average interior height of 7.5'.
The minimum vault height is 7' deep at the shallowest end.
The vault side slopes are a minimum of 5% towards the center of the vault.
Infiltration is achieved through the native soils at the bottom of the structure.
A minimum of 0.5 feet for sediment storage and a minimum of 1 feet of freeboard depth are assumed.
Exterior and interior wall thickness is 1.5 feet.
Top slab thickness is 2 feet.
The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.
The side walls extend to 1 feet below the vault floor.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth
The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
There will be two maintenance hole access locations with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.
Shoring and lagging is required for construction of the structure.
A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.
Trench Box shoring is used.
The storage vault, facility inlet and outlet pipes are sited beneath a parking area.
It is assumed that the tank restoration will consist of parking lot restoration with 4" HMA/4" CSTC.
It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located within the ROW and Traffic control is required.
Traffic conditions are assumed to be heavy.
A street use permit is required.
Installation is in right-of-way and does not include easements or acquisition

**Planning Basis Assumptions:**
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**
All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Due to the facility width, utility relocation work is estimated at 10% of the total construction costs.

**Estimating Assumptions:**
This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_14D_Infiltration Vault Outwash Soil In ROW | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Infiltration Vault - Outwash Soil (1156 sf bottom area @ 0.05 MG Storage) | 1 | EA | $ 1,409,669 | $ 1,409,669 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 1,409,669*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 281,934 |
| | | | Street Use Permit (Y/N) | Y | $ 90,000 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 1,781,602*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 169,160 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 1,950,763*** |
| | | | | Construction Sales Tax | $ 190,728 |
| | | | | Outside Agency Construction | $ 140,967 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 2,282,500*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 429,168 |
| | | | | Construction Management | $ 195,076 |
| | | | | Permitting & Support | $ 19,508 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 117,046 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 760,797*** |
| | | | | Project Contingency | $ 912,989 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 1,673,800*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 3,956,300*** |

**Description: WQBE_14D_Infiltration Vault Outwash Soil In ROW (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 3,956,300** | |
| Capital cost | $ 3,956,300 | $/Unit |
| Total Direct O&M/Year | $ 4,351 | |
| Direct O&M cost | $ 4,351 | $/Unit |
| Capital Replacement Costs (20 year equipment) | $ 56,858 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 4,079,000** | **$/unit** |
| **Annual O&M Cost** | **$ 4,800** | **$/year** |
| Annualized Cost | $750 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Cement Patching | 2023 dollars | $ 113 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $473 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash, Debris, and Sediment | 16 | hr | |
| Inspection and joint repair, crack repair | 16 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| **Total hours per year** | 32 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 1,740 | |
| Labor cost, burdened | O/H 150.0% | $ 4,351 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 22,503 | | $ 207,010 | **$4,242,672** | **$ 4,079,019** | | | |
| 0 | 1.000 | **$ 3,956,300** | | | $3,956,300 | $ 3,956,300 | $ 3,956,300 | $ 3,956,300 | $ 4,079,019 |
| 1 | 0.950 | $473 | $ - | $ 4,351 | $ 4,824 | $ 4,584 | $ 3,961,124 | $ 3,960,884 | $ 122,719 |
| 2 | 0.903 | $ 487 | $ - | $ 4,482 | $ 4,969 | $ 4,486 | $ 3,966,093 | $ 3,965,369 | $ 118,136 |
| 3 | 0.858 | $ 502 | $ - | $ 4,616 | $ 5,118 | $ 4,390 | $ 3,971,211 | $ 3,969,759 | $ 113,650 |
| 4 | 0.815 | $ 517 | $ - | $ 4,755 | $ 5,272 | $ 4,296 | $ 3,976,483 | $ 3,974,055 | $ 109,261 |
| 5 | 0.774 | $ 532 | $ - | $ 4,897 | $ 5,430 | $ 4,204 | $ 3,981,912 | $ 3,978,259 | $ 104,965 |
| 6 | 0.736 | $ 548 | $ - | $ 5,044 | $ 5,593 | $ 4,114 | $ 3,987,505 | $ 3,982,373 | $ 100,761 |
| 7 | 0.699 | $ 565 | $ - | $ 5,196 | $ 5,760 | $ 4,026 | $ 3,993,265 | $ 3,986,399 | $ 96,647 |
| 8 | 0.664 | $ 582 | $ - | $ 5,351 | $ 5,933 | $ 3,940 | $ 3,999,198 | $ 3,990,339 | $ 92,620 |
| 9 | 0.631 | $ 599 | $ - | $ 5,512 | $ 6,111 | $ 3,856 | $ 4,005,310 | $ 3,994,195 | $ 88,680 |
| 10 | 0.599 | $ 617 | $ - | $ 5,677 | $ 6,294 | $ 3,773 | $ 4,011,604 | $ 3,997,968 | $ 84,824 |
| 11 | 0.570 | $ 636 | $ - | $ 5,848 | $ 6,483 | $ 3,693 | $ 4,018,087 | $ 4,001,661 | $ 81,051 |
| 12 | 0.541 | $ 655 | $ - | $ 6,023 | $ 6,678 | $ 3,614 | $ 4,024,765 | $ 4,005,275 | $ 77,358 |
| 13 | 0.514 | $ 674 | $ - | $ 6,204 | $ 6,878 | $ 3,537 | $ 4,031,643 | $ 4,008,812 | $ 73,744 |
| 14 | 0.489 | $ 695 | $ - | $ 6,390 | $ 7,085 | $ 3,461 | $ 4,038,728 | $ 4,012,273 | $ 70,208 |
| 15 | 0.464 | $ 715 | $ - | $ 6,582 | $ 7,297 | $ 3,387 | $ 4,046,025 | $ 4,015,660 | $ 66,747 |
| 16 | 0.441 | $ 737 | $ - | $ 6,779 | $ 7,516 | $ 3,315 | $ 4,053,541 | $ 4,018,974 | $ 63,360 |
| 17 | 0.419 | $ 759 | $ - | $ 6,982 | $ 7,741 | $ 3,244 | $ 4,061,282 | $ 4,022,218 | $ 60,045 |
| 18 | 0.398 | $ 782 | $ - | $ 7,192 | $ 7,974 | $ 3,174 | $ 4,069,256 | $ 4,025,392 | $ 56,801 |
| 19 | 0.378 | $ 805 | $ - | $ 7,408 | $ 8,213 | $ 3,107 | $ 4,077,469 | $ 4,028,499 | $ 53,627 |
| 20 | 0.359 | $ 829 | $ 56,858 | $ 7,630 | $ 65,318 | $ 23,474 | $ 4,142,787 | $ 4,051,973 | $ 50,521 |
| 21 | 0.341 | $ 854 | $ - | $ 7,859 | $ 8,713 | $ 2,975 | $ 4,151,500 | $ 4,054,948 | $ 27,046 |
| 22 | 0.324 | $ 880 | $ - | $ 8,095 | $ 8,974 | $ 2,912 | $ 4,160,474 | $ 4,057,860 | $ 24,071 |
| 23 | 0.308 | $ 906 | $ - | $ 8,337 | $ 9,244 | $ 2,849 | $ 4,169,718 | $ 4,060,709 | $ 21,160 |
| 24 | 0.293 | $ 934 | $ - | $ 8,587 | $ 9,521 | $ 2,788 | $ 4,179,239 | $ 4,063,497 | $ 18,310 |
| 25 | 0.278 | $ 962 | $ - | $ 8,845 | $ 9,807 | $ 2,729 | $ 4,189,045 | $ 4,066,226 | $ 15,522 |
| 26 | 0.264 | $ 990 | $ - | $ 9,110 | $ 10,101 | $ 2,670 | $ 4,199,146 | $ 4,068,897 | $ 12,793 |
| 27 | 0.251 | $ 1,020 | $ - | $ 9,384 | $ 10,404 | $ 2,613 | $ 4,209,550 | $ 4,071,510 | $ 10,123 |
| 28 | 0.239 | $ 1,051 | $ - | $ 9,665 | $ 10,716 | $ 2,557 | $ 4,220,266 | $ 4,074,067 | $ 7,510 |
| 29 | 0.227 | $ 1,082 | $ - | $ 9,955 | $ 11,037 | $ 2,503 | $ 4,231,303 | $ 4,076,570 | $ 4,952 |
| 30 | 0.215 | $ 1,115 | $ - | $ 10,254 | $ 11,369 | $ 2,449 | $ 4,242,672 | $ 4,079,019 | $ 2,449 |

**Description: WQBE_14D_Infiltration Vault Outwash Soil In ROW**

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**

16 Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day, assume use of vactor truck.

16 Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an 8 hour work day. Assume annual cost of $113 for cement patching mix.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Capital Replacement Assumptions:**

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_14D_Infiltration Vault Outwash Soil In ROW | | | **Version:** | 2 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Infiltration Vault in ROW** | | | | $ - |
| 2 | ***Vault Assumptions*** | | | | $ - |
| 3 | *Exterior Length* | 37 | FT | | $ - |
| 4 | *Interior Length* | 34 | FT | | $ - |
| 5 | *Exterior Width* | 37 | FT | | $ - |
| 6 | *Interior Width* | 34 | FT | | $ - |
| 7 | *Interior Structure Height (Ave.)* | 7.5 | FT | | $ - |
| 8 | *Storage Depth (Ave)* | 6.0 | FT | | $ - |
| 9 | *Sediment Storage Depth* | 0.5 | FT | | $ - |
| 10 | *Freeboard (Ave.)* | 1.0 | FT | | $ - |
| 11 | *Storage Facility Exterior Footprint Area* | 1,369 | SF | | $ - |
| 12 | | | | | $ - |
| 13 | ***Storage Volume*** | | | | $ - |
| 14 | *Storage Facility interior Area* | 1,156 | SF | | $ - |
| 15 | *Effective Storage Volume (15.500 cf target)* | 6,936 | CF | | $ - |
| 16 | *Vault Storage Volume* | 0.05 | MG | | $ - |
| 17 | | | | | $ - |
| 18 | ***Structure Concrete Assumptions*** | | | | $ - |
| 19 | *Exterior Wall thickness* | 1.5 | FT | | $ - |
| 20 | *Top Slab Thickness* | 2 | FT | | $ - |
| 21 | *Flow Spreader Slab thickness* | 2 | FT | | $ - |
| 22 | *Center column footprint area (2'x2')* | 4 | SF | | $ - |
| 23 | *Center Column Spacing* | 5 | FT | | $ - |
| 24 | *Concrete Reinforcing Rebar* | 225 | LB/CY | | $ - |
| 25 | *Crushed Base Thickness* | 1 | FT | | $ - |
| 26 | | | | | $ - |
| 27 | **Concrete Structure** | | | | $ - |
| 28 | Vault Interior Columns at Midspan | 8 | CY | $ 650 | $ 5,056 |
| 29 | Slab under Flow Control/discharge (est. 6'W X 10'L X 2'D) | 4 | CY | $ 1,250 | $ 5,556 |
| 30 | Stormwater Flow Spreader Sump w/Lip Bottom Slab - 2' D x 2XL X 36W' | 5 | CY | $ 1,250 | $ 6,296 |
| 31 | Exterior Wall Concrete | 62 | CY | $ 1,250 | $ 77,083 |
| 32 | Top Slab Concrete | 101 | CY | $ 950 | $ 96,337 |
| 33 | Concrete Reinforcing Rebar | 40,575 | LBS | $ 1.38 | $ 55,994 |
| 34 | Crushed Base | 51 | CY | $ 64 | $ 3,245 |
| 35 | | | | | $ - |
| 36 | ***Shoring and Excavation Assumptions*** | | | | $ - |
| 37 | *Construction Room* | 3 | FT | | $ - |
| 38 | *Tank Bury Depth* | 2 | FT | | $ - |
| 39 | *Total Excavation Depth* | 13 | FT | | $ - |
| 40 | *Excavation Length* | 47 | FT | | $ - |
| 41 | *Excavation Width* | 47 | FT | | $ - |
| 42 | | | | | $ - |
| 43 | **Soil Excavation and Disposal** | | | | $ - |
| 44 | Excavation to waste | 1,023 | CY | $ 79 | $ 80,792 |
| 48 | Imported Structure Backfill | 490 | CY | $ 44 | $ 21,573 |
| 49 | | | | | $ - |
| 50 | **Solder Pile Shoring** | | | | $ - |
| 51 | *Solder Pile Shaft Depth (3 x Exc. Depth)* | 38 | FT | | $ - |
| 52 | *Solder Pile Shaft Thickness* | 2 | FT | | $ - |
| 53 | *Center to Center Shaft Spacing* | 6 | FT | | $ - |
| 54 | *Rebar in Shaft* | 114 | LB/CY | | $ - |
| 55 | *Shoring Wall Perimeter* | 180 | FT | | $ - |
| 56 | *Number of Shafts* | 30 | EA | | $ - |
| 57 | Drill Solder Pile Shafts | 131 | CY | $ 262 | $ 34,296 |
| 58 | Set Solder Pile and CDF | 131 | CY | $ 391 | $ 51,182 |
| 59 | Purchase and Salvage Solder Piles | 128,250 | LB | $ 0.7 | $ 89,775 |
| 60 | Tie Backs - one per soldier pile except corners | 26 | EA | $ 2,477 | $ 64,402 |
| 61 | Timber Lagging (64'W X 70'L @ approx. 20'H) | 8,178 | BF | $ 9 | $ 73,602 |
| 62 | | | | | $ - |
| 63 | **Gates and Access** | | | | $ - |
| 64 | Flow Restrictor | 1 | EA | $ 24,600 | $ 24,600 |
| 65 | Confined Space Safety | 1 | LS | $ 32,595 | $ 32,595 |
| 66 | Access Hatches | 2 | EA | $ 13,038 | $ 26,076 |
| 67 | | | | | $ - |
| 68 | **Conveyance Pipe** | | | | $ - |
| 69 | 12" Storm Pipe (upstream and discharge) | 200 | LF | $ 140 | $ 28,000 |
| 70 | Trench Excavation to waste (8'W X 15'D) | 889 | CY | $ 79 | $ 70,222 |
| 71 | Trench Box Shoring | 6,000 | SF | $ 10 | $ 60,000 |
| 72 | 48" Diameter Maintenance holes | 4 | EA | $ 10,640 | $ 42,560 |
| 73 | Imported Backfill | 883 | CY | $ 44 | $ 38,855 |
| 74 | Dewater Trench - Sumps | 200 | LF | $ 139 | $ 27,800 |
| 75 | Demolish Surface incl. room for construction (@20' wide) | 444 | SY | $ 14 | $ 6,222 |
| 76 | Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100') | 444 | SY | $ 71 | $ 31,556 |
| 77 | | | | | $ - |
| 78 | **Site Removals and Restoration** | | | | $ - |
| 79 | Demolish Existing Surface | 245 | SY | $ 14 | $ 3,436 |
| 80 | Road Restoration - 6" HMA/6"CSBC (for Vault -54'X54') | 245 | SY | $ 110 | $ 26,999 |
| 81 | Sidewalk Est. one side x 5' Wide | 31 | SY | $ 125 | $ 3,819 |
| 82 | Planting Strip Est one side x 8' Wide | 49 | SY | $ 10 | $ 481 |
| 83 | Landscape/Lawn Restoration | 49 | SY | $ 59 | $ 2,886 |
| 84 | Irrigation System Repair est @ 10% Landscape/Lawn | 10% | LS | $ 2,886 | $ 289 |
| 85 | Trees both new and replacements Est @ 4 per 100' | 2 | EA | $ 720 | $ 1,440 |
| 86 | | | | | $ - |
| 87 | Traffic Control Arterial (HMA) | 6 | MO | $ 20,000 | $ 120,000 |
| 88 | Removals at 4 % Construction Costs | 4.0% | LS | $ 1,084,109 | $ 43,364 |
| 89 | TESC at 2% of Construction | 2% | LS | $ 1,256,389 | $ 25,128 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | *Item Subtotal Construction Costs (Year 2023)* | $ 1,281,517 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 128,152 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| *Item Subtotal Construction Costs (Year 2023)* | | | $ 1,409,669 |
| ***Direct: Subtotal Construction Costs*** | | | ***$ 1,409,669*** |

**Description: WQBE 14D - Infiltration Vault Outwash Soil in ROW**
Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

**Cost Estimating Assumptions:**
The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.
Installation is in right-of-way and does not include easements or acquisition
The vault is assumed to be sited on Outwash soils.
It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.
The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.05 MG.
The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.
The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1156 square feet and a maximum storage depth of 6 feet deep.
Vault has interior dimensions of 34'W x 34'L with an average interior height of 7.5'.
The minimum vault height is 7' deep at the shallowest end.
The vault side slopes are a minimum of 5% towards the center of the vault.
Infiltration is achieved through the native soils at the bottom of the structure.
A minimum of 0.5 feet for sediment storage and a minimum of 0.5 feet of freeboard depth are assumed.
Exterior and interior wall thickness is 1.5 feet.
Top slab thickness is 2 feet.
The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.
The side walls extend to 1 feet below the vault floor.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth
The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
There will be two maintenance hole access locations with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.
Shoring and lagging is required for construction of the structure.
A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.
Trench Box shoring is used.
The storage vault, facility inlet and outlet pipes are sited beneath a parking area.
It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located within the ROW and Traffic control is required.
Traffic conditions are assumed to be heavy.
A street use permit is required.

**Planning Basis Assumptions:**
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**
All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Due to the facility width, utility relocation work is estimated at 10% of the total construction costs.

**Estimating Assumptions:**
This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_14E_Infiltration Vault Till Soil With Property Cost | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Infiltration Vault - Till Soil (1836 sf bottom area @ 0.08 MG Storage) | 1 | EA | $ 1,554,535 | $ 1,554,535 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 1,554,535*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 310,907 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 1,865,442*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 186,544 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 2,051,986*** |
| | | | | Construction Sales Tax | $ 210,329 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 2,262,300*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 451,437 |
| | | | | Construction Management | $ 205,199 |
| | | | | Permitting & Support | $ 20,520 |
| 3726 | s.f. Land Area | Medium | Land Purchase/ROW Acquisition | | $ 299,682 |
| 4000 | s.f. Land Area | Low | Permanent Easements | | $ 40,400 |
| | | | | WTD Staff Costs & Non-WTD Support | $ 123,119 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,140,357*** |
| | | | | Project Contingency | $ 1,020,797 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 2,161,200*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 4,423,500*** |

**Description: WQBE_14E_Infiltration Vault Till Soil With Property Cost (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 4,423,500** | |
| Capital cost | $ 4,423,500 | $/Unit |
| Total Direct O&M/Year | $ 4,351 | |
| Direct O&M cost | $ 4,351 | $/Unit |
| Capital Replacement Costs (20 year equipment) | $ 56,858 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 4,546,200** | **$/unit** |
| **Annual O&M Cost** | **$ 4,800** | **$/year** |
| Annualized Cost | $750 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Cement Patching | 2023 dollars | $ 113 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $473 | |
| Labor | | | |
| Remove Trash, Debris, and Sediment | 16 | hr | |
| Inspection and joint repair, crack repair | 16 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| **Total hours per year** | 32 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 1,740 | |
| Labor cost, burdened | O/H 150.0% | $ 4,351 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

**Description: WQBE_14E_Infiltration Vault Till Soil With Property Cost**
Box-shaped underground facility that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

**Life-Cycle Cost Model Input Assumptions:**
Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**
16 Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day, assume use of vactor truck.
16 Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an 8 hour work day. Assume annual cost of $113 for cement patching mix.
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Capital Replacement Assumptions:**
Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 22,503 | | $ 207,010 | **$4,709,872** | **$ 4,546,219** | | | |
| 0 | 1.000 | **$ 4,423,500** | | | $4,423,500 | $ 4,423,500 | $ 4,423,500 | $ 4,423,500 | $ 4,546,219 |
| 1 | 0.950 | $473 | $ - | $ 4,351 | $ 4,824 | $ 4,584 | $ 4,428,324 | $ 4,428,084 | $ 122,719 |
| 2 | 0.903 | $ 487 | $ - | $ 4,482 | $ 4,969 | $ 4,486 | $ 4,433,293 | $ 4,432,569 | $ 118,136 |
| 3 | 0.858 | $ 502 | $ - | $ 4,616 | $ 5,118 | $ 4,390 | $ 4,438,411 | $ 4,436,959 | $ 113,650 |
| 4 | 0.815 | $ 517 | $ - | $ 4,755 | $ 5,272 | $ 4,296 | $ 4,443,683 | $ 4,441,255 | $ 109,261 |
| 5 | 0.774 | $ 532 | $ - | $ 4,897 | $ 5,430 | $ 4,204 | $ 4,449,112 | $ 4,445,459 | $ 104,965 |
| 6 | 0.736 | $ 548 | $ - | $ 5,044 | $ 5,593 | $ 4,114 | $ 4,454,705 | $ 4,449,573 | $ 100,761 |
| 7 | 0.699 | $ 565 | $ - | $ 5,196 | $ 5,760 | $ 4,026 | $ 4,460,465 | $ 4,453,599 | $ 96,647 |
| 8 | 0.664 | $ 582 | $ - | $ 5,351 | $ 5,933 | $ 3,940 | $ 4,466,398 | $ 4,457,539 | $ 92,620 |
| 9 | 0.631 | $ 599 | $ - | $ 5,512 | $ 6,111 | $ 3,856 | $ 4,472,510 | $ 4,461,395 | $ 88,680 |
| 10 | 0.599 | $ 617 | $ - | $ 5,677 | $ 6,294 | $ 3,773 | $ 4,478,804 | $ 4,465,168 | $ 84,824 |
| 11 | 0.570 | $ 636 | $ - | $ 5,848 | $ 6,483 | $ 3,693 | $ 4,485,287 | $ 4,468,861 | $ 81,051 |
| 12 | 0.541 | $ 655 | $ - | $ 6,023 | $ 6,678 | $ 3,614 | $ 4,491,965 | $ 4,472,475 | $ 77,358 |
| 13 | 0.514 | $ 674 | $ - | $ 6,204 | $ 6,878 | $ 3,537 | $ 4,498,843 | $ 4,476,012 | $ 73,744 |
| 14 | 0.489 | $ 695 | $ - | $ 6,390 | $ 7,085 | $ 3,461 | $ 4,505,928 | $ 4,479,473 | $ 70,208 |
| 15 | 0.464 | $ 715 | $ - | $ 6,582 | $ 7,297 | $ 3,387 | $ 4,513,225 | $ 4,482,860 | $ 66,747 |
| 16 | 0.441 | $ 737 | $ - | $ 6,779 | $ 7,516 | $ 3,315 | $ 4,520,741 | $ 4,486,174 | $ 63,360 |
| 17 | 0.419 | $ 759 | $ - | $ 6,982 | $ 7,741 | $ 3,244 | $ 4,528,482 | $ 4,489,418 | $ 60,045 |
| 18 | 0.398 | $ 782 | $ - | $ 7,192 | $ 7,974 | $ 3,174 | $ 4,536,456 | $ 4,492,592 | $ 56,801 |
| 19 | 0.378 | $ 805 | $ - | $ 7,408 | $ 8,213 | $ 3,107 | $ 4,544,669 | $ 4,495,699 | $ 53,627 |
| 20 | 0.359 | $ 829 | $ 56,858 | $ 7,630 | $ 65,318 | $ 23,474 | $ 4,609,987 | $ 4,519,173 | $ 50,521 |
| 21 | 0.341 | $ 854 | $ - | $ 7,859 | $ 8,713 | $ 2,975 | $ 4,618,700 | $ 4,522,148 | $ 27,046 |
| 22 | 0.324 | $ 880 | $ - | $ 8,095 | $ 8,974 | $ 2,912 | $ 4,627,674 | $ 4,525,060 | $ 24,071 |
| 23 | 0.308 | $ 906 | $ - | $ 8,337 | $ 9,244 | $ 2,849 | $ 4,636,918 | $ 4,527,909 | $ 21,160 |
| 24 | 0.293 | $ 934 | $ - | $ 8,587 | $ 9,521 | $ 2,788 | $ 4,646,439 | $ 4,530,697 | $ 18,310 |
| 25 | 0.278 | $ 962 | $ - | $ 8,845 | $ 9,807 | $ 2,729 | $ 4,656,245 | $ 4,533,426 | $ 15,522 |
| 26 | 0.264 | $ 990 | $ - | $ 9,110 | $ 10,101 | $ 2,670 | $ 4,666,346 | $ 4,536,097 | $ 12,793 |
| 27 | 0.251 | $ 1,020 | $ - | $ 9,384 | $ 10,404 | $ 2,613 | $ 4,676,750 | $ 4,538,710 | $ 10,123 |
| 28 | 0.239 | $ 1,051 | $ - | $ 9,665 | $ 10,716 | $ 2,557 | $ 4,687,466 | $ 4,541,267 | $ 7,510 |
| 29 | 0.227 | $ 1,082 | $ - | $ 9,955 | $ 11,037 | $ 2,503 | $ 4,698,503 | $ 4,543,770 | $ 4,952 |
| 30 | 0.215 | $ 1,115 | $ - | $ 10,254 | $ 11,369 | $ 2,449 | $ 4,709,872 | $ 4,546,219 | $ 2,449 |

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_14E_Infiltration Vault Till Soil With Property Cost | | | **Version:** | 2 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Infiltration Vault on Property** | | | | $ - |
| 2 | ***Vault Assumptions*** | | | | $ - |
| 3 | *Exterior Length* | 54 | FT | | $ - |
| 4 | *Interior Length* | 51 | FT | | $ - |
| 5 | *Exterior Width* | 39 | FT | | $ - |
| 6 | *Interior Width* | 36 | FT | | $ - |
| 7 | *Interior Structure Height (Ave.)* | 7.5 | FT | | $ - |
| 8 | *Storage Depth (Ave)* | 6.0 | FT | | $ - |
| 9 | *Sediment Storage Depth* | 0.5 | FT | | $ - |
| 10 | *Freeboard (Ave.)* | 1.0 | FT | | $ - |
| 11 | *Storage Facility Exterior Footprint Area* | 2,106 | SF | | $ - |
| 12 | | | | | $ - |
| 13 | ***Storage Volume*** | | | | $ - |
| 14 | *Storage Facility interior Area* | 1,836 | SF | | $ - |
| 15 | *Effective Storage Volume (11,016 cf target)* | 11,016 | CF | | $ - |
| 16 | *Vault Storage Volume* | 0.08 | MG | | $ - |
| 17 | | | | | $ - |
| 18 | ***Structure Concrete Assumptions*** | | | | $ - |
| 19 | *Exterior Wall thickness* | 1.5 | FT | | $ - |
| 20 | *Top Slab Thickness* | 2 | FT | | $ - |
| 21 | *Flow Spreader Slab thickness* | 2 | FT | | $ - |
| 22 | *Center column footprint area (2'x2')* | 4 | SF | | $ - |
| 23 | *Center Column Spacing* | 5 | FT | | $ - |
| 24 | *Concrete Reinforcing Rebar* | 225 | LB/CY | | $ - |
| 25 | *Crushed Base Thickness* | 1 | FT | | $ - |
| 26 | | | | | $ - |
| 27 | **Concrete Structure** | | | | $ - |
| 28 | Vault Interior Columns at Midspan | 11 | CY | $ 650 | $ 7,222 |
| 29 | Slab under Flow Control/discharge (est. 6'W X 10'L X 2'D) | 4 | CY | $ 320 | $ 1,422 |
| 30 | Stormwater Flow Spreader Sump w/Lip Bottom Slab - 2' D x 2XL X 36W' | 5 | CY | $ 320 | $ 1,707 |
| 31 | Exterior Wall Concrete | 78 | CY | $ 1,250 | $ 96,875 |
| 32 | Top Slab Concrete | 156 | CY | $ 1,250 | $ 195,000 |
| 33 | Concrete Reinforcing Rebar | 57,238 | LBS | $ 1.38 | $ 78,988 |
| 34 | Crushed Base | 78 | CY | $ 64 | $ 4,992 |
| 35 | | | | | $ - |
| 36 | ***Shoring and Excavation Assumptions*** | | | | $ - |
| 37 | *Construction Room* | 3 | FT | | $ - |
| 38 | *Tank Bury Depth* | 2 | FT | | $ - |
| 39 | *Total Excavation Depth* | 13 | FT | | $ - |
| 40 | *Excavation Length* | 64 | FT | | $ - |
| 41 | *Excavation Width* | 49 | FT | | $ - |
| 42 | | | | | $ - |
| 43 | **Soil Excavation and Disposal** | | | | $ - |
| 44 | Mass Excavate, in the dry | 1,452 | CY | $ 79 | $ 114,696 |
| 48 | Imported Structure Backfill | 633 | CY | $ 44 | $ 27,845 |
| 49 | | | | | $ - |
| 50 | **Solder Pile Shoring** | | | | $ - |
| 51 | *Solder Pile Shaft Depth (3 x Exc. Depth)* | 38 | FT | | $ - |
| 52 | *Solder Pile Shaft Thickness* | 2 | FT | | $ - |
| 53 | *Center to Center Shaft Spacing* | 6 | FT | | $ - |
| 54 | *Rebar in Shaft* | 114 | LB/CY | | $ - |
| 55 | *Shoring Wall Perimeter* | 218 | FT | | $ - |
| 56 | *Number of Shafts* | 36 | EA | | $ - |
| 57 | Drill Solder Pile Shafts | 157 | CY | $ 262 | $ 41,155 |
| 58 | Set Solder Pile and CDF | 157 | CY | $ 391 | $ 61,418 |
| 59 | Purchase and Salvage Solder Piles | 153,900 | LB | $ 0.7 | $ 107,730 |
| 60 | Tie Backs - one per soldier pile except corners | 32 | EA | $ 2,477 | $ 79,264 |
| 61 | Timber Lagging | 9,831 | BF | $ 9 | $ 88,479 |
| 62 | | | | | $ - |
| 63 | **Gates and Access** | | | | $ - |
| 64 | Flow Restrictor | 1 | EA | $ 24,600 | $ 24,600 |
| 65 | Confined Space Safety | 1 | LS | $ 32,595 | $ 32,595 |
| 66 | Access Hatches | 2 | EA | $ 13,038 | $ 26,076 |
| 67 | | | | | $ - |
| 68 | **Conveyance Pipe** | | | | $ - |
| 69 | 12" Storm Pipe (upstream and discharge) | 200 | LF | $ 140 | $ 28,000 |
| 70 | Trench Excavation to waste (8'W X 15'D) | 889 | CY | $ 79 | $ 70,222 |
| 71 | Trench Box Shoring | 6,000 | SF | $ 10 | $ 60,000 |
| 72 | 48" Diameter Maintenance holes | 4 | EA | $ 10,640 | $ 42,560 |
| 73 | Imported Backfill | 883 | CY | $ 44 | $ 38,855 |
| 74 | Dewater Trench - Sumps | 200 | LF | $ 139 | $ 27,800 |
| 75 | Demolish Surface incl. room for construction (@20' wide) | 444 | SY | $ 14 | $ 6,222 |
| 76 | Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100') | 444 | SY | $ 71 | $ 31,556 |
| 77 | | | | | $ - |
| 78 | **Site Removals and Restoration** | | | | $ - |
| 79 | Disking or tilling of compacted soil (assumed 1.5 times structure footprint) | 523 | SY | $ 4 | $ 2,091 |
| 80 | Seeding, mulching and compost | 523 | SY | $ 10 | $ 5,227 |
| 81 | Demolish Existing Surface | 348 | SY | $ 14 | $ 4,878 |
| 82 | Pavement Remove and Restoration (Vault) - 4" HMA/4"CSBC | 348 | SY | $ 71 | $ 24,740 |
| 83 | Removals at 4 % Construction Costs | 4.0% | LS | $ 1,332,215 | $ 53,289 |
| 84 | TESC at 2% of Construction | 2% | LS | $ 1,385,503 | $ 27,710 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 1,413,214 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | General Conditions | 0% | | 1 | $ - |
| | Mobilization/Demobilization | 10% | | 1.1 | $ 141,321 |
| | Overhead & Profit (OHP) | 0% | | 1 | $ - |
| | Insurance | 0.0% | | 1 | $ - |
| | Bonding | 0.0% | | 1 | $ - |
| | Escalation Multiplier from ENR-CCI | 0% | | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 1,554,535 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 1,554,535*** |

**Description: WQBE 14E - Infiltration Vault Till Soil With Property Cost**
Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

**Cost Estimating Assumptions:**
The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.
The vault is assumed to be sited on till soils.
It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.
The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.08 MG.
The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.
The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1836 square feet and a maximum storage depth of 6 feet deep.
Vault has interior dimensions of 36'W x 51'L with an average interior height of 7.5'.
The minimum vault height is 7' deep at the shallowest end.
The vault side slopes are a minimum of 5% towards the center of the vault.
Infiltration is achieved through the native soils at the bottom of the structure.
A minimum of 0.5 feet for sediment storage and a minimum of 1 feet of freeboard depth are assumed.
Exterior and interior wall thickness is 1.5 feet.
Top slab thickness is 2 feet.
The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.
The side walls extend to 1 feet below the vault floor.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth
The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
There will be two maintenance hole access locations with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.
Shoring and lagging is required for construction of the structure.
A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.
Trench Box shoring is used.
The storage vault, facility inlet and outlet pipes are sited beneath a parking area.
It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and traffic control is not required.
A street use permit is not required.
The installation is assumed to be on property with easements and acquisition required.

**Planning Basis Assumptions:**
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**
All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**
This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_14F_Infiltration Vault Outwash Soil With Property Cost | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Infiltration Vault - Outwash Soil (1156 sf bottom area @ 0.05 MG Storage) | 1 | EA | $ 1,285,100 | $ 1,285,100 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 1,285,100*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 257,020 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 1,542,120*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 154,212 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 1,696,332*** |
| | | | | Construction Sales Tax | $ 173,874 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 1,870,200*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 373,193 |
| | | | | Construction Management | $ 169,633 |
| | | | | Permitting & Support | $ 16,963 |
| 3726 | s.f. Land Area | Medium | | Land Purchase/ROW Acquisition | $ 299,682 |
| 4000 | s.f. Land Area | Low | | Permanent Easements | $ 40,400 |
| | | | | WTD Staff Costs & Non-WTD Support | $ 101,780 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,001,652*** |
| | | | | Project Contingency | $ 861,555 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 1,863,200*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 3,733,400*** |

**Description: WQBE_14F_Infiltration Vault Outwash Soil With Property Cost (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 3,733,400** | |
| Capital cost | $ 3,733,400 | $/Unit |
| Total Direct O&M/Year | $ 4,351 | |
| Direct O&M cost | $ 4,351 | $/Unit |
| Capital Replacement Costs (20 year equipment) | $ 56,900 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 3,856,100** | **$/unit** |
| **Annual O&M Cost** | **$ 4,800** | **$/year** |
| Annualized Cost | $750 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Cement Patching | 2023 dollars | $ 113 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $473 | |
| Labor | | | |
| Remove Trash, Debris, and Sediment | 16 | hr | |
| Inspection and joint repair, crack repair | 16 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| **Total hours per year** | 32 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 1,740 | |
| Labor cost, burdened | O/H 150.0% | $ 4,351 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 22,503 | | $ 207,010 | **$4,019,813** | **$ 3,856,134** | | | |
| 0 | 1.000 | **$ 3,733,400** | | | $3,733,400 | $ 3,733,400 | $ 3,733,400 | $ 3,733,400 | $ 3,856,134 |
| 1 | 0.950 | $473 | $ - | $ 4,351 | $ 4,824 | $ 4,584 | $ 3,738,224 | $ 3,737,984 | $ 122,734 |
| 2 | 0.903 | $ 487 | $ - | $ 4,482 | $ 4,969 | $ 4,486 | $ 3,743,193 | $ 3,742,469 | $ 118,151 |
| 3 | 0.858 | $ 502 | $ - | $ 4,616 | $ 5,118 | $ 4,390 | $ 3,748,311 | $ 3,746,859 | $ 113,665 |
| 4 | 0.815 | $ 517 | $ - | $ 4,755 | $ 5,272 | $ 4,296 | $ 3,753,583 | $ 3,751,155 | $ 109,276 |
| 5 | 0.774 | $ 532 | $ - | $ 4,897 | $ 5,430 | $ 4,204 | $ 3,759,012 | $ 3,755,359 | $ 104,980 |
| 6 | 0.736 | $ 548 | $ - | $ 5,044 | $ 5,593 | $ 4,114 | $ 3,764,605 | $ 3,759,473 | $ 100,776 |
| 7 | 0.699 | $ 565 | $ - | $ 5,196 | $ 5,760 | $ 4,026 | $ 3,770,365 | $ 3,763,499 | $ 96,662 |
| 8 | 0.664 | $ 582 | $ - | $ 5,351 | $ 5,933 | $ 3,940 | $ 3,776,298 | $ 3,767,439 | $ 92,635 |
| 9 | 0.631 | $ 599 | $ - | $ 5,512 | $ 6,111 | $ 3,856 | $ 3,782,410 | $ 3,771,295 | $ 88,695 |
| 10 | 0.599 | $ 617 | $ - | $ 5,677 | $ 6,294 | $ 3,773 | $ 3,788,704 | $ 3,775,068 | $ 84,839 |
| 11 | 0.570 | $ 636 | $ - | $ 5,848 | $ 6,483 | $ 3,693 | $ 3,795,187 | $ 3,778,761 | $ 81,066 |
| 12 | 0.541 | $ 655 | $ - | $ 6,023 | $ 6,678 | $ 3,614 | $ 3,801,865 | $ 3,782,375 | $ 77,373 |
| 13 | 0.514 | $ 674 | $ - | $ 6,204 | $ 6,878 | $ 3,537 | $ 3,808,743 | $ 3,785,912 | $ 73,759 |
| 14 | 0.489 | $ 695 | $ - | $ 6,390 | $ 7,085 | $ 3,461 | $ 3,815,828 | $ 3,789,373 | $ 70,223 |
| 15 | 0.464 | $ 715 | $ - | $ 6,582 | $ 7,297 | $ 3,387 | $ 3,823,125 | $ 3,792,760 | $ 66,762 |
| 16 | 0.441 | $ 737 | $ - | $ 6,779 | $ 7,516 | $ 3,315 | $ 3,830,641 | $ 3,796,074 | $ 63,375 |
| 17 | 0.419 | $ 759 | $ - | $ 6,982 | $ 7,741 | $ 3,244 | $ 3,838,382 | $ 3,799,318 | $ 60,060 |
| 18 | 0.398 | $ 782 | $ - | $ 7,192 | $ 7,974 | $ 3,174 | $ 3,846,356 | $ 3,802,492 | $ 56,816 |
| 19 | 0.378 | $ 805 | $ - | $ 7,408 | $ 8,213 | $ 3,107 | $ 3,854,569 | $ 3,805,599 | $ 53,642 |
| 20 | 0.359 | $ 829 | $ 56,900 | $ 7,630 | $ 65,359 | $ 23,489 | $ 3,919,928 | $ 3,829,088 | $ 50,535 |
| 21 | 0.341 | $ 854 | $ - | $ 7,859 | $ 8,713 | $ 2,975 | $ 3,928,641 | $ 3,832,063 | $ 27,046 |
| 22 | 0.324 | $ 880 | $ - | $ 8,095 | $ 8,974 | $ 2,912 | $ 3,937,616 | $ 3,834,975 | $ 24,071 |
| 23 | 0.308 | $ 906 | $ - | $ 8,337 | $ 9,244 | $ 2,849 | $ 3,946,859 | $ 3,837,824 | $ 21,160 |
| 24 | 0.293 | $ 934 | $ - | $ 8,587 | $ 9,521 | $ 2,788 | $ 3,956,380 | $ 3,840,612 | $ 18,310 |
| 25 | 0.278 | $ 962 | $ - | $ 8,845 | $ 9,807 | $ 2,729 | $ 3,966,187 | $ 3,843,341 | $ 15,522 |
| 26 | 0.264 | $ 990 | $ - | $ 9,110 | $ 10,101 | $ 2,670 | $ 3,976,288 | $ 3,846,011 | $ 12,793 |
| 27 | 0.251 | $ 1,020 | $ - | $ 9,384 | $ 10,404 | $ 2,613 | $ 3,986,691 | $ 3,848,625 | $ 10,123 |
| 28 | 0.239 | $ 1,051 | $ - | $ 9,665 | $ 10,716 | $ 2,557 | $ 3,997,407 | $ 3,851,182 | $ 7,510 |
| 29 | 0.227 | $ 1,082 | $ - | $ 9,955 | $ 11,037 | $ 2,503 | $ 4,008,445 | $ 3,853,685 | $ 4,952 |
| 30 | 0.215 | $ 1,115 | $ - | $ 10,254 | $ 11,369 | $ 2,449 | $ 4,019,813 | $ 3,856,134 | $ 2,449 |

**Description: WQBE_14F_Infiltration Vault Outwash Soil With Property Cost**
Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

**Life-Cycle Cost Model Input Assumptions:**
Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**
Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work
16 day, assume use of vactor truck.
Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an
16 8 hour work day. Assume annual cost of $113 for cement patching mix.
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Capital Replacement Assumptions:**
Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_14F_Infiltration Vault Outwash Soil With Property Cost | | | **Version:** | 2 |
| | **CONSTRUCTION COSTS** | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Infiltration Vault on Property** | | | | $ - |
| 2 | ***Vault Assumptions*** | | | | $ - |
| 3 | *Exterior Length* | 37 | FT | | $ - |
| 4 | *Interior Length* | 34 | FT | | $ - |
| 5 | *Exterior Width* | 37 | FT | | $ - |
| 6 | *Interior Width* | 34 | FT | | $ - |
| 7 | *Interior Structure Height (Ave.)* | 7.5 | FT | | $ - |
| 8 | *Storage Depth (Ave)* | 6.0 | FT | | $ - |
| 9 | *Sediment Storage Depth* | 0.5 | FT | | $ - |
| 10 | *Freeboard (Ave.)* | 1.0 | FT | | $ - |
| 11 | *Storage Facility Exterior Footprint Area* | 1,369 | SF | | $ - |
| 12 | | | | | $ - |
| 13 | ***Storage Volume*** | | | | $ - |
| 14 | *Storage Facility interior Area* | 1,156 | SF | | $ - |
| 15 | *Effective Storage Volume (15.500 cf target)* | 6,936 | CF | | $ - |
| 16 | *Vault Storage Volume* | 0.05 | MG | | $ - |
| 17 | | | | | $ - |
| 18 | ***Structure Concrete Assumptions*** | | | | $ - |
| 19 | *Exterior Wall thickness* | 1.5 | FT | | $ - |
| 20 | *Top Slab Thickness* | 2 | FT | | $ - |
| 21 | *Flow Spreader Slab thickness* | 2 | FT | | $ - |
| 22 | *Center column footprint area (2'x2')* | 4 | SF | | $ - |
| 23 | *Center Column Spacing* | 5 | FT | | $ - |
| 24 | *Concrete Reinforcing Rebar* | 225 | LB/CY | | $ - |
| 25 | *Crushed Base Thickness* | 1 | FT | | $ - |
| 26 | | | | | $ - |
| 27 | **Concrete Structure** | | | | $ - |
| 28 | Vault Interior Columns at Midspan | 8 | CY | $ 650 | $ 5,056 |
| 29 | Slab under Flow Control/discharge (est. 6'W X 10'L X 2'D) | 4 | CY | $ 320 | $ 1,422 |
| 30 | Stormwater Flow Spreader Sump w/Lip Bottom Slab - 2' D x 2XL X 36W' | 5 | CY | $ 320 | $ 1,612 |
| 31 | Exterior Wall Concrete | 62 | CY | $ 1,250 | $ 77,083 |
| 32 | Top Slab Concrete | 101 | CY | $ 1,250 | $ 126,759 |
| 33 | Concrete Reinforcing Rebar | 40,575 | LBS | $ 1.38 | $ 55,994 |
| 34 | Crushed Base | 51 | CY | $ 64 | $ 3,245 |
| 35 | | | | | $ - |
| 36 | ***Shoring and Excavation Assumptions*** | | | | $ - |
| 37 | *Construction Room* | 3 | FT | | $ - |
| 38 | *Tank Bury Depth* | 2 | FT | | $ - |
| 39 | *Total Excavation Depth* | 13 | FT | | $ - |
| 40 | *Excavation Length* | 47 | FT | | $ - |
| 41 | *Excavation Width* | 47 | FT | | $ - |
| 42 | | | | | $ - |
| 43 | **Soil Excavation and Disposal** | | | | $ - |
| 44 | Excavation | 1,023 | CY | $ 79 | $ 80,792 |
| 48 | Imported Structure Backfill | 490 | CY | $ 44 | $ 21,573 |
| 49 | | | | | $ - |
| 50 | **Solder Pile Shoring** | | | | $ - |
| 51 | *Solder Pile Shaft Depth (3 x Exc. Depth)* | 38 | FT | | $ - |
| 52 | *Solder Pile Shaft Thickness* | 2 | FT | | $ - |
| 53 | *Center to Center Shaft Spacing* | 6 | FT | | $ - |
| 54 | *Rebar in Shaft* | 114 | LB/CY | | $ - |
| 55 | *Shoring Wall Perimeter* | 180 | FT | | $ - |
| 56 | *Number of Shafts* | 30 | EA | | $ - |
| 57 | Drill Solder Pile Shafts | 131 | CY | $ 262 | $ 34,296 |
| 58 | Set Solder Pile and CDF | 131 | CY | $ 391 | $ 51,182 |
| 59 | Purchase and Salvage Solder Piles | 128,250 | LB | $ 0.7 | $ 89,775 |
| 60 | Tie Backs - one per soldier pile except corners | 26 | EA | $ 2,477 | $ 64,402 |
| 61 | Timber Lagging (64'W X 70'L @ approx. 20'H) | 8,178 | BF | $ 9 | $ 73,602 |
| 62 | | | | | $ - |
| 63 | **Gates and Access** | | | | $ - |
| 64 | Flow Restrictor | 1 | EA | $ 24,600 | $ 24,600 |
| 65 | Confined Space Safety | 1 | LS | $ 32,595 | $ 32,595 |
| 66 | Access Hatches | 2 | EA | $ 13,038 | $ 26,076 |
| 67 | | | | | $ - |
| 68 | **Conveyance Pipe** | | | | $ - |
| 69 | 12" Storm Pipe (upstream and discharge) | 200 | LF | $ 140 | $ 28,000 |
| 70 | Trench Excavation to waste (8'W X 15'D) | 889 | CY | $ 79 | $ 70,222 |
| 71 | Trench Box Shoring | 6,000 | SF | $ 10 | $ 60,000 |
| 72 | 48" Diameter Maintenance holes | 4 | EA | $ 10,640 | $ 42,560 |
| 73 | Imported Backfill | 883 | CY | $ 44 | $ 38,855 |
| 74 | Dewater Trench - Sumps | 200 | LF | $ 139 | $ 27,800 |
| 75 | Demolish Surface incl. room for construction (@20' wide) | 444 | SY | $ 14 | $ 6,222 |
| 76 | Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100') | 444 | SY | $ 71 | $ 31,556 |
| 77 | | | | | $ - |
| 78 | **Site Removals and Restoration** | | | | $ - |
| 79 | Disking or tilling of compacted soil (assumed 1.5 times structure footprint) | 368 | SY | $ 4 | $ 1,473 |
| 80 | Seeding, mulching and compost | 368 | SY | $ 10 | $ 3,682 |
| 81 | Demolish Existing Surface | 245 | SY | $ 14 | $ 3,436 |
| 82 | Pavement Remove and Restoration (Vault) - 4" HMA/4"CSBC | 245 | SY | $ 71 | $ 17,427 |
| 83 | | | | | $ - |
| 84 | Removals at 4 % Construction Costs | 4.0% | LS | $ 1,101,296 | $ 44,052 |
| 85 | TESC at 2% of Construction | 2% | LS | $ 1,145,347 | $ 22,907 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 1,168,254 |
| | **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | |
| | General Conditions | 0% | | 1 | $ - |
| | Mobilization/Demobilization | 10% | | 1.1 | $ 116,825 |
| | Overhead & Profit (OHP) | 0% | | 1 | $ - |
| | Insurance | 0.0% | | 1 | $ - |
| | Bonding | 0.0% | | 1 | $ - |
| | Escalation Multiplier from ENR-CCI | 0% | | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 1,285,080 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 1,285,100*** |

**Description: WQBE 14F - Infiltration Vault Outwash Soil With Property Cost**
Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

**Cost Estimating Assumptions:**
The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.
The vault is assumed to be sited on Outwash soils.
It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.
The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.05 MG.
The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.
The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1156 square feet and a maximum storage depth of 6 feet deep.
Vault has interior dimensions of 34'W x 34'L with an average interior height of 7.5'.
The minimum vault height is 7' deep at the shallowest end.
The vault side slopes are a minimum of 5% towards the center of the vault.
Infiltration is achieved through the native soils at the bottom of the structure.
A minimum of 0.5 feet for sediment storage and a minimum of 1 feet of freeboard depth are assumed.
Exterior and interior wall thickness is 1.5 feet.
Top slab thickness is 2 feet.
The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.
The side walls extend to 1 feet below the vault floor.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth
The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
There will be two maintenance hole access locations with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.
Shoring and lagging is required for construction of the structure.
A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.
Trench Box shoring is used.
The storage vault, facility inlet and outlet pipes are sited beneath a parking area.
It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and traffic control is not required.
A street use permit is not required.
The installation is assumed to be on property with easements and acquisition required.

**Planning Basis Assumptions:**
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**
All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**
This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR) |
| **Description:** | WQBE_14G_Infiltration Vault Outwash Soil with High Rate Underground Filter System in ROW | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Infiltration Vault - Outwash Soil (1156 sf bottom area @ 6' Ave. Storage Depth) with High Rate Underground Filter (24 s.f. bottom area) in ROW | 1 | EA | $ 1,363,807 | $ 1,363,807 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 1,363,807*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 272,761 |
| | | | Street Use Permit (Y/N) | Y | $ 90,000 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 1,726,568*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 163,657 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 1,890,225*** |
| | | | | Construction Sales Tax | $ 184,523 |
| | | | | Outside Agency Construction | $ 136,381 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 2,211,100*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 415,849 |
| | | | | Construction Management | $ 189,022 |
| | | | | Permitting & Support | $ 18,902 |
| | s.f. Land Area | None | | Land Purchase/ROW Acquisition | $ - |
| | s.f. Land Area | None | | Permanent Easements | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 113,413 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 737,188*** |
| | | | | Project Contingency | $ 884,486 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 1,621,700*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 3,832,800*** |

**Description: WQBE_14G_Infiltration Vault Outwash Soil with High Rate Underground Filter System in ROW (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 3,832,800** | |
| Capital cost | $ 3,832,800 | $/Unit |
| Total Direct O&M/Year | $ 5,439 | |
| Direct O&M cost | $ 5,439 | $/Unit |
| Capital Replacement Costs (10 Years) | $ - | $/unit |
| Capital Replacement Costs (20 year equipment) | $ 56,858 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 3,992,400** | **$/unit** |
| **Annual O&M Cost** | **$ 6,600** | **$/year** |
| Annualized Cost | $1,790 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| Cement Patching | 2023 dollars | $ 113 | |
| Mulch Replacement and Plants | 2023 dollars | $ 653 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $ 1,126 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash, Debris, and Sediment | 16 | hr | |
| Inspection and joint repair, crack repair | 16 | hr | |
| Plant Health & Mulch replacement | 8 | hr | |
| | | | |
| **Total hours per year** | 40 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 2,176 | |
| Labor cost, burdened | O/H 150.0% | $ 5,439 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 53,570 | | $ 258,763 | **$4,201,991** | **$ 3,992,429** | | | |
| 0 | 1.000 | **$ 3,832,800** | | | $3,832,800 | $ 3,832,800 | $ 3,832,800 | $ 3,832,800 | $ 3,992,429 |
| 1 | 0.950 | $1,126 | $ - | $ 5,439 | $ 6,565 | $ 6,238 | $ 3,839,365 | $ 3,839,038 | $ 159,629 |
| 2 | 0.903 | $ 1,160 | $ - | $ 5,602 | $ 6,762 | $ 6,104 | $ 3,846,127 | $ 3,845,142 | $ 153,391 |
| 3 | 0.858 | $ 1,195 | $ - | $ 5,770 | $ 6,965 | $ 5,974 | $ 3,853,092 | $ 3,851,115 | $ 147,287 |
| 4 | 0.815 | $ 1,230 | $ - | $ 5,943 | $ 7,174 | $ 5,846 | $ 3,860,266 | $ 3,856,961 | $ 141,313 |
| 5 | 0.774 | $ 1,267 | $ - | $ 6,122 | $ 7,389 | $ 5,721 | $ 3,867,654 | $ 3,862,682 | $ 135,467 |
| 6 | 0.736 | $ 1,305 | $ - | $ 6,305 | $ 7,611 | $ 5,599 | $ 3,875,265 | $ 3,868,281 | $ 129,746 |
| 7 | 0.699 | $ 1,345 | $ - | $ 6,494 | $ 7,839 | $ 5,479 | $ 3,883,104 | $ 3,873,760 | $ 124,148 |
| 8 | 0.664 | $ 1,385 | $ - | $ 6,689 | $ 8,074 | $ 5,362 | $ 3,891,178 | $ 3,879,122 | $ 118,669 |
| 9 | 0.631 | $ 1,426 | $ - | $ 6,890 | $ 8,316 | $ 5,247 | $ 3,899,495 | $ 3,884,369 | $ 113,307 |
| 10 | 0.599 | $ 1,469 | $ - | $ 7,097 | $ 8,566 | $ 5,135 | $ 3,908,060 | $ 3,889,504 | $ 108,060 |
| 11 | 0.570 | $ 1,513 | $ - | $ 7,310 | $ 8,823 | $ 5,025 | $ 3,916,883 | $ 3,894,530 | $ 102,924 |
| 12 | 0.541 | $ 1,559 | $ - | $ 7,529 | $ 9,087 | $ 4,918 | $ 3,925,971 | $ 3,899,448 | $ 97,899 |
| 13 | 0.514 | $ 1,605 | $ - | $ 7,755 | $ 9,360 | $ 4,813 | $ 3,935,331 | $ 3,904,260 | $ 92,981 |
| 14 | 0.489 | $ 1,654 | $ - | $ 7,987 | $ 9,641 | $ 4,710 | $ 3,944,972 | $ 3,908,970 | $ 88,168 |
| 15 | 0.464 | $ 1,703 | $ - | $ 8,227 | $ 9,930 | $ 4,609 | $ 3,954,902 | $ 3,913,579 | $ 83,459 |
| 16 | 0.441 | $ 1,754 | $ - | $ 8,474 | $ 10,228 | $ 4,511 | $ 3,965,130 | $ 3,918,090 | $ 78,849 |
| 17 | 0.419 | $ 1,807 | $ - | $ 8,728 | $ 10,535 | $ 4,414 | $ 3,975,665 | $ 3,922,504 | $ 74,339 |
| 18 | 0.398 | $ 1,861 | $ - | $ 8,990 | $ 10,851 | $ 4,320 | $ 3,986,516 | $ 3,926,824 | $ 69,925 |
| 19 | 0.378 | $ 1,917 | $ - | $ 9,260 | $ 11,176 | $ 4,228 | $ 3,997,692 | $ 3,931,052 | $ 65,605 |
| 20 | 0.359 | $ 1,974 | $ 56,858 | $ 9,537 | $ 68,370 | $ 24,571 | $ 4,066,062 | $ 3,955,623 | $ 61,377 |
| 21 | 0.341 | $ 2,034 | $ - | $ 9,823 | $ 11,857 | $ 4,049 | $ 4,077,920 | $ 3,959,672 | $ 36,806 |
| 22 | 0.324 | $ 2,095 | $ - | $ 10,118 | $ 12,213 | $ 3,962 | $ 4,090,132 | $ 3,963,634 | $ 32,757 |
| 23 | 0.308 | $ 2,158 | $ - | $ 10,422 | $ 12,579 | $ 3,877 | $ 4,102,712 | $ 3,967,511 | $ 28,795 |
| 24 | 0.293 | $ 2,222 | $ - | $ 10,734 | $ 12,957 | $ 3,795 | $ 4,115,668 | $ 3,971,306 | $ 24,918 |
| 25 | 0.278 | $ 2,289 | $ - | $ 11,056 | $ 13,345 | $ 3,713 | $ 4,129,014 | $ 3,975,019 | $ 21,123 |
| 26 | 0.264 | $ 2,358 | $ - | $ 11,388 | $ 13,746 | $ 3,634 | $ 4,142,759 | $ 3,978,653 | $ 17,410 |
| 27 | 0.251 | $ 2,428 | $ - | $ 11,730 | $ 14,158 | $ 3,556 | $ 4,156,917 | $ 3,982,209 | $ 13,776 |
| 28 | 0.239 | $ 2,501 | $ - | $ 12,082 | $ 14,583 | $ 3,480 | $ 4,171,500 | $ 3,985,690 | $ 10,219 |
| 29 | 0.227 | $ 2,576 | $ - | $ 12,444 | $ 15,020 | $ 3,406 | $ 4,186,520 | $ 3,989,096 | $ 6,739 |
| 30 | 0.215 | $ 2,653 | $ - | $ 12,817 | $ 15,471 | $ 3,333 | $ 4,201,991 | $ 3,992,429 | $ 3,333 |

**Description: WQBE_14G_Infiltration Vault Outwash Soil with High Rate Underground Filter System in ROW**
Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

**Life-Cycle Cost Model Input Assumptions:**
Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions (vault):**
Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work
16 day, assume use of vactor truck.
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.
Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an
16 8 hour work day. Assume annual cost of $113 for cement patching mix.

**O&M Estimating Assumptions (filter):**
Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year. Assume use of vacuum truck. Trips consolidated with vault cleaning.
Biannually 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours.
8 Assumed annual cost of $113 for mulch.
Annual plant replacement allowance of $540. Will allow for the replacement of approximately 10 shrubs or other medium sized plant material.

**Capital Replacement Assumptions (vault):**
Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

**Capital Replacement Assumptions (filter):**
No capital replacement within 30-year life per Filterra Owner's Manual.

**Estimate - AACEI Class 10**

| | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR) |
| **Description:** | WQBE_14G_Infiltration Vault Outwash Soil with High Rate Underground Filter System in ROW | | | **Version:** | 2 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Infiltration Vault** | | | | $ - |
| 2 | ***Vault Assumptions*** | | | | $ - |
| 3 | *Exterior Length* | 37 | FT | | $ - |
| 4 | *Interior Length* | 34 | FT | | $ - |
| 5 | *Exterior Width* | 37 | FT | | $ - |
| 6 | *Interior Width* | 34 | FT | | $ - |
| 7 | *Interior Structure Height (Ave.)* | 7.5 | FT | | $ - |
| 8 | *Storage Depth (Ave)* | 6.0 | FT | | $ - |
| 9 | *Sediment Storage Depth* | 0.5 | FT | | $ - |
| 10 | *Freeboard (Ave.)* | 1.0 | FT | | $ - |
| 11 | *Storage Facility Exterior Footprint Area* | 1,369 | SF | | $ - |
| 12 | | | | | $ - |
| 13 | ***Storage Volume*** | | | | $ - |
| 14 | *Storage Facility interior Area* | 1,156 | SF | | $ - |
| 15 | *Effective Storage Volume (15.500 cf target)* | 6,936 | CF | | $ - |
| 16 | *Vault Storage Volume* | 0.05 | MG | | $ - |
| 17 | | | | | $ - |
| 18 | ***Structure Concrete Assumptions*** | | | | $ - |
| 19 | *Exterior Wall thickness* | 1.5 | FT | | $ - |
| 20 | *Top Slab Thickness* | 2 | FT | | $ - |
| 21 | *Flow Spreader Slab thickness* | 2 | FT | | $ - |
| 22 | *Center column footprint area (2'x2')* | 4 | SF | | $ - |
| 23 | *Center Column Spacing* | 5 | FT | | $ - |
| 24 | *Concrete Reinforcing Rebar* | 225 | LB/CY | | $ - |
| 25 | *Crushed Base Thickness* | 1 | FT | | $ - |
| 26 | | | | | $ - |
| 27 | **Concrete Structure** | | | | $ - |
| 28 | Vault Interior Columns at Midspan | 8 | CY | $ 650 | $ 5,056 |
| 29 | Slab under Flow Control/discharge (est. 6'W X 10'L X 2'D) | 4 | CY | $ 320 | $ 1,422 |
| 30 | Stormwater Flow Spreader Sump w/Lip Bottom Slab - 2' D x 2XL X 36W' | 5 | CY | $ 320 | $ 1,612 |
| 31 | Exterior Wall Concrete | 62 | CY | $ 1,250 | $ 77,083 |
| 32 | Top Slab Concrete | 101 | CY | $ 1,250 | $ 126,759 |
| 33 | Concrete Reinforcing Rebar | 40,575 | LBS | $ 1.38 | $ 55,994 |
| 34 | Crushed Base | 51 | CY | $ 64 | $ 3,245 |
| 35 | | | | | $ - |
| 36 | ***Shoring and Excavation Assumptions*** | | | | $ - |
| 37 | *Construction Room* | 3 | FT | | $ - |
| 38 | *Tank Bury Depth* | 2 | FT | | $ - |
| 39 | *Total Excavation Depth* | 13 | FT | | $ - |
| 40 | *Excavation Length* | 47 | FT | | $ - |
| 41 | *Excavation Width* | 47 | FT | | $ - |
| 42 | | | | | $ - |
| 43 | **Soil Excavation and Disposal** | | | | $ - |
| 44 | Excavation | 1,023 | CY | $ 79 | $ 80,792 |
| 48 | Imported Structure Backfill | 490 | CY | $ 44 | $ 21,573 |
| 49 | | | | | $ - |
| 50 | **Solder Pile Shoring** | | | | $ - |
| 51 | *Solder Pile Shaft Depth (3 x Exc. Depth)* | 38 | FT | | $ - |
| 52 | *Solder Pile Shaft Thickness* | 2 | FT | | $ - |
| 53 | *Center to Center Shaft Spacing* | 6 | FT | | $ - |
| 54 | *Rebar in Shaft* | 114 | LB/CY | | $ - |
| 55 | *Shoring Wall Perimeter* | 180 | FT | | $ - |
| 56 | *Number of Shafts* | 30 | EA | | $ - |
| 57 | Drill Solder Pile Shafts | 131 | CY | $ 262 | $ 34,296 |
| 58 | Set Solder Pile and CDF | 131 | CY | $ 391 | $ 51,182 |
| 59 | Purchase and Salvage Solder Piles | 128,250 | LB | $ 0.7 | $ 89,775 |
| 60 | Tie Backs - one per soldier pile except corners | 26 | EA | $ 2,477 | $ 64,402 |
| 61 | Timber Lagging (64'W X 70'L @ approx. 20'H) | 8,178 | BF | $ 9 | $ 73,602 |
| 62 | | | | | $ - |
| 63 | **Gates and Access** | | | | $ - |
| 64 | Flow Restrictor | 1 | EA | $ 24,600 | $ 24,600 |
| 65 | Confined Space Safety | 1 | LS | $ 32,595 | $ 32,595 |
| 66 | Access Hatches | 2 | EA | $ 13,038 | $ 26,076 |
| 67 | | | | | $ - |
| 68 | **Conveyance Pipe** | | | | $ - |
| 69 | 12" Storm Pipe (upstream and discharge) | 200 | LF | $ 140 | $ 28,000 |
| 70 | Trench Excavation to waste (8'W X 15'D) | 889 | CY | $ 79 | $ 70,222 |
| 71 | Trench Box Shoring | 6,000 | SF | $ 10 | $ 60,000 |
| 72 | 48" Diameter Maintenance holes | 4 | EA | $ 10,640 | $ 42,560 |
| 73 | Imported Backfill | 883 | CY | $ 44 | $ 38,855 |
| 74 | Dewater Trench - Sumps | 200 | LF | $ 139 | $ 27,800 |
| 75 | Demolish Surface incl. room for construction (@20' wide) | 444 | SY | $ 14 | $ 6,222 |
| 76 | Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100') | 444 | SY | $ 71 | $ 31,556 |
| 77 | | | | | $ - |
| 78 | **Removals and Restoration** | | | | $ - |
| 79 | Demolish Existing Surface | 245 | SY | $ 14 | $ 3,436 |
| 80 | Road Restoration - 6" HMA/6"CSBC | 245 | SY | $ 110 | $ 26,999 |
| 81 | Sidewalk Est. one side x 5' Wide | 31 | SY | $ 125 | $ 3,819 |
| 82 | Planting Strip Est one side x 8' Wide | 49 | SY | $ 10 | $ 481 |
| 83 | Landscape/Lawn Restoration | 49 | SY | $ 59 | $ 2,886 |
| 84 | Irrigation System Repair est @ 10% Landscape/Lawn | 10% | LS | $ 2,886 | $ 289 |
| 85 | Trees both new and replacements Est @ 4 per 100' | 2 | EA | $ 720 | $ 1,440 |
| 86 | | | | | $ - |
| 87 | **High Rate Underground Filter** | | | | $ - |
| 88 | Filterra Unit 4'X6' (complete) | 1 | EA | $ 22,165 | $ 22,165 |
| 89 | Structural Excavation to Waste (10'W X12'L X 5'D) + (50'LX5'WX6'D) | 78 | CY | $ 79 | $ 6,123 |
| 90 | Imported Structural Fill | 73 | CY | $ 44 | $ 3,227 |
| 91 | Crushed Base | 1 | CY | $ 64 | $ 64 |
| 92 | Inlet Drain w/Energy Dissipating Rocks | 1 | EA | $ 1,481 | $ 1,481 |
| 93 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 94 | DI CL 50 Pipe 8" dia. | 50 | LF | $ 160 | $ 8,000 |
| 95 | Trench Box Shoring (Shallow) | 390 | SF | $ 10 | $ 3,900 |
| 96 | | | | | |
| 97 | **High Rate Underground Filter Restoration** | | | | $ - |
| 98 | Pavement Patching HMA 6" HMA/6"CSBC | 36 | SY | $ 110 | $ 3,972 |
| 99 | Concrete Curb and Gutter | 15 | LF | $ 137 | $ 2,055 |
| 100 | Sidewalk 5' Wide | 8 | SY | $ 67 | $ 558 |
| 101 | Landscaping, planting, and restoration | 8 | SY | $ 59 | $ 492 |
| 102 | Street Tree | 1 | EA | $ 720 | $ 720 |
| 103 | | | | | $ - |
| 104 | Removals at 4 % Construction Costs | 4.0% | LS | $ 1,105,714 | $ 44,229 |
| 105 | TESC at 2% of Construction | 2% | LS | $ 1,215,514 | $ 24,310 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 1,239,824 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 123,982 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 1,363,807 |
| ***Direct: Subtotal Construction Costs*** | | | ***$ 1,363,807*** |

**Description: WQBE_14G_Infiltration Vault Outwash Soil with High Rate Underground Filter System in ROW**

An infiltration vault is an open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Cost Estimating Assumptions:**

**General**

The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and traffic control is not required.
A street use permit is not required.

**Infiltration Vault**

The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.
The vault is assumed to be sited on Outwash soils.
It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.
The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.05 MG.
The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.
The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1156 square feet and a maximum storage depth of 6 feet deep.
Vault has interior dimensions of 34'W x 34'L with an average interior height of 7.5'.
The minimum vault height is 7' deep at the shallowest end.
The vault side slopes are a minimum of 5% towards the center of the vault.
Infiltration is achieved through the native soils at the bottom of the structure.
A minimum of 0.5 feet for sediment storage and a minimum of 1 feet of freeboard depth are assumed.
Exterior and interior wall thickness is 1.5 feet.
Top slab thickness is 2 feet.
The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.
The side walls extend to 1 feet below the vault floor.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth
The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
There will be two maintenance hole access locations with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.
Shoring and lagging is required for construction of the structure.
A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.
Trench Box shoring is used.
The storage vault, facility inlet and outlet pipes are sited beneath a parking area.
It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.

**High Rate Underground Filter**

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6"thick.
The facility treatment area is 24 sf (4'X6') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.
A total of 50 LF of 8" storm pipe is required to connect to the deep UIC well.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.
The facility is located within the ROW and Traffic control is required. Traffic conditions are assumed to be heavy for the urban setting and light for the rural setting.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Due to the facility width, utility relocation work is estimated at 10% of the total construction costs.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System With Property Cost | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Infiltration Vault - Outwash Soil (1156 sf bottom area @ 6' Ave. Storage Depth) with High Rate Underground Filter (24 s.f. bottom area) | 1 | EA | $ 1,340,895 | $ 1,340,895 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 1,340,895*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 268,179 |
| | | | Street Use Permit (Y/N) | Y | $ 90,000 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 1,699,074*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 160,907 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 1,859,982*** |
| | | | | Construction Sales Tax | $ 181,423 |
| | | | | Outside Agency Construction | $ 134,090 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 2,175,500*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 409,196 |
| | | | | Construction Management | $ 185,998 |
| | | | | Permitting & Support | $ 18,600 |
| 3750 | s.f. Land Area | Medium | Land Purchase/ROW Acquisition | | $ 301,613 |
| 4000 | s.f. Land Area | Low | Permanent Easements | | $ 40,400 |
| | | | | WTD Staff Costs & Non-WTD Support | $ 111,599 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,067,405*** |
| | | | | Project Contingency | $ 972,872 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 2,040,300*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 4,215,800*** |

**Description: WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System with Property Cost**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 4,215,800** | |
| Capital cost | $ 4,215,800 | $/Unit |
| Total Direct O&M/Year | $ 5,439 | |
| Direct O&M cost | $ 5,439 | $/Unit |
| Capital Replacement Costs (10 Years) | $ - | $/unit |
| Capital Replacement Costs (20 year equipment) | $ 56,900 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 4,375,400** | **$/unit** |
| **Annual O&M Cost** | **$ 6,600** | **$/year** |
| Annualized Cost | $1,790 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| Cement Patching | 2023 dollars | $ 113 | |
| Mulch Replacement and Plants | 2023 dollars | $ 653 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |

Subtotal $ 1,126

Labor

| | | | |
|---|---|---|---|
| Remove Trash, Debris, and Sediment | 16 | hr | |
| Inspection and joint repair, crack repair | 16 | hr | |
| Plant Health & Mulch replacement | 8 | hr | |
| | | | |
| **Total hours per year** | 40 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 2,176 | |
| Labor cost, burdened | O/H 150.0% | $ 5,439 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 53,570 | | $ 258,763 | **$4,585,033** | **$ 4,375,444** | | | |
| 0 | 1.000 | **$ 4,215,800** | | | $4,215,800 | $ 4,215,800 | $ 4,215,800 | $ 4,215,800 | $ 4,375,444 |
| 1 | 0.950 | $1,126 | $ - | $ 5,439 | $ 6,565 | $ 6,238 | $ 4,222,365 | $ 4,222,038 | $ 159,644 |
| 2 | 0.903 | $ 1,160 | $ - | $ 5,602 | $ 6,762 | $ 6,104 | $ 4,229,127 | $ 4,228,142 | $ 153,406 |
| 3 | 0.858 | $ 1,195 | $ - | $ 5,770 | $ 6,965 | $ 5,974 | $ 4,236,092 | $ 4,234,115 | $ 147,302 |
| 4 | 0.815 | $ 1,230 | $ - | $ 5,943 | $ 7,174 | $ 5,846 | $ 4,243,266 | $ 4,239,961 | $ 141,328 |
| 5 | 0.774 | $ 1,267 | $ - | $ 6,122 | $ 7,389 | $ 5,721 | $ 4,250,654 | $ 4,245,682 | $ 135,482 |
| 6 | 0.736 | $ 1,305 | $ - | $ 6,305 | $ 7,611 | $ 5,599 | $ 4,258,265 | $ 4,251,281 | $ 129,761 |
| 7 | 0.699 | $ 1,345 | $ - | $ 6,494 | $ 7,839 | $ 5,479 | $ 4,266,104 | $ 4,256,760 | $ 124,163 |
| 8 | 0.664 | $ 1,385 | $ - | $ 6,689 | $ 8,074 | $ 5,362 | $ 4,274,178 | $ 4,262,122 | $ 118,684 |
| 9 | 0.631 | $ 1,426 | $ - | $ 6,890 | $ 8,316 | $ 5,247 | $ 4,282,495 | $ 4,267,369 | $ 113,322 |
| 10 | 0.599 | $ 1,469 | $ - | $ 7,097 | $ 8,566 | $ 5,135 | $ 4,291,060 | $ 4,272,504 | $ 108,074 |
| 11 | 0.570 | $ 1,513 | $ - | $ 7,310 | $ 8,823 | $ 5,025 | $ 4,299,883 | $ 4,277,530 | $ 102,939 |
| 12 | 0.541 | $ 1,559 | $ - | $ 7,529 | $ 9,087 | $ 4,918 | $ 4,308,971 | $ 4,282,448 | $ 97,914 |
| 13 | 0.514 | $ 1,605 | $ - | $ 7,755 | $ 9,360 | $ 4,813 | $ 4,318,331 | $ 4,287,260 | $ 92,996 |
| 14 | 0.489 | $ 1,654 | $ - | $ 7,987 | $ 9,641 | $ 4,710 | $ 4,327,972 | $ 4,291,970 | $ 88,183 |
| 15 | 0.464 | $ 1,703 | $ - | $ 8,227 | $ 9,930 | $ 4,609 | $ 4,337,902 | $ 4,296,579 | $ 83,474 |
| 16 | 0.441 | $ 1,754 | $ - | $ 8,474 | $ 10,228 | $ 4,511 | $ 4,348,130 | $ 4,301,090 | $ 78,864 |
| 17 | 0.419 | $ 1,807 | $ - | $ 8,728 | $ 10,535 | $ 4,414 | $ 4,358,665 | $ 4,305,504 | $ 74,354 |
| 18 | 0.398 | $ 1,861 | $ - | $ 8,990 | $ 10,851 | $ 4,320 | $ 4,369,516 | $ 4,309,824 | $ 69,939 |
| 19 | 0.378 | $ 1,917 | $ - | $ 9,260 | $ 11,176 | $ 4,228 | $ 4,380,692 | $ 4,314,052 | $ 65,620 |
| 20 | 0.359 | $ 1,974 | $ 56,900 | $ 9,537 | $ 68,412 | $ 24,586 | $ 4,449,104 | $ 4,338,638 | $ 61,392 |
| 21 | 0.341 | $ 2,034 | $ - | $ 9,823 | $ 11,857 | $ 4,049 | $ 4,460,961 | $ 4,342,686 | $ 36,806 |
| 22 | 0.324 | $ 2,095 | $ - | $ 10,118 | $ 12,213 | $ 3,962 | $ 4,473,174 | $ 4,346,649 | $ 32,757 |
| 23 | 0.308 | $ 2,158 | $ - | $ 10,422 | $ 12,579 | $ 3,877 | $ 4,485,753 | $ 4,350,526 | $ 28,795 |
| 24 | 0.293 | $ 2,222 | $ - | $ 10,734 | $ 12,957 | $ 3,795 | $ 4,498,710 | $ 4,354,321 | $ 24,918 |
| 25 | 0.278 | $ 2,289 | $ - | $ 11,056 | $ 13,345 | $ 3,713 | $ 4,512,055 | $ 4,358,034 | $ 21,123 |
| 26 | 0.264 | $ 2,358 | $ - | $ 11,388 | $ 13,746 | $ 3,634 | $ 4,525,801 | $ 4,361,668 | $ 17,410 |
| 27 | 0.251 | $ 2,428 | $ - | $ 11,730 | $ 14,158 | $ 3,556 | $ 4,539,959 | $ 4,365,224 | $ 13,776 |
| 28 | 0.239 | $ 2,501 | $ - | $ 12,082 | $ 14,583 | $ 3,480 | $ 4,554,542 | $ 4,368,705 | $ 10,219 |
| 29 | 0.227 | $ 2,576 | $ - | $ 12,444 | $ 15,020 | $ 3,406 | $ 4,569,562 | $ 4,372,111 | $ 6,739 |
| 30 | 0.215 | $ 2,653 | $ - | $ 12,817 | $ 15,471 | $ 3,333 | $ 4,585,033 | $ 4,375,444 | $ 3,333 |

**Description: WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System with Property Cost**

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions (vault):**

Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work
16 day, assume use of vactor truck.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an
16 8 hour work day. Assume annual cost of $113 for cement patching mix.

**O&M Estimating Assumptions (filter):**

Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year. Assume use of vacuum truck. Trips consolidated with vault cleaning.

Biannually 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours.
8 Assumed annual cost of $113 for mulch.

Annual plant replacement allowance of $540. Will allow for the replacement of approximately 10 shrubs or other medium sized plant material.

**Capital Replacement Assumptions (vault):**

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

**Capital Replacement Assumptions (filter):**

No capital replacement within 30-year life per Filterra Owner's Manual.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| Project Name: | King County Water Quality Benefits Evaluation | | | Date: | 6/7/2024 |
| Location: | King County, WA | | | Estimator: | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| Description: | WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System With Property Cost | | | Version: | 2 |
| CONSTRUCTION COSTS | | | | | |
| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
| 1 | **Infiltration Vault on Property** | | | | $ - |
| 2 | ***Vault Assumptions*** | | | | $ - |
| 3 | *Exterior Length* | 37 | FT | | $ - |
| 4 | *Interior Length* | 34 | FT | | $ - |
| 5 | *Exterior Width* | 37 | FT | | $ - |
| 6 | *Interior Width* | 34 | FT | | $ - |
| 7 | *Interior Structure Height (Ave.)* | 7.5 | FT | | $ - |
| 8 | *Storage Depth (Ave)* | 6.0 | FT | | $ - |
| 9 | *Sediment Storage Depth* | 0.5 | FT | | $ - |
| 10 | *Freeboard (Ave.)* | 1.0 | FT | | $ - |
| 11 | *Storage Facility Exterior Footprint Area* | 1,369 | SF | | $ - |
| 12 | | | | | $ - |
| 13 | ***Storage Volume*** | | | | $ - |
| 14 | *Storage Facility interior Area* | 1,156 | SF | | $ - |
| 15 | *Effective Storage Volume (15.500 cf target)* | 6,936 | CF | | $ - |
| 16 | *Vault Storage Volume* | 0.05 | MG | | $ - |
| 17 | | | | | $ - |
| 18 | ***Structure Concrete Assumptions*** | | | | $ - |
| 19 | *Exterior Wall thickness* | 1.5 | FT | | $ - |
| 20 | *Top Slab Thickness* | 2 | FT | | $ - |
| 21 | *Flow Spreader Slab thickness* | 2 | FT | | $ - |
| 22 | *Center column footprint area (2'x2')* | 4 | SF | | $ - |
| 23 | *Center Column Spacing* | 5 | FT | | $ - |
| 24 | *Concrete Reinforcing Rebar* | 225 | LB/CY | | $ - |
| 25 | *Crushed Base Thickness* | 1 | FT | | $ - |
| 26 | | | | | $ - |
| 27 | **Concrete Structure** | | | | $ - |
| 28 | Vault Interior Columns at Midspan | 8 | CY | $ 650 | $ 5,056 |
| 29 | Slab under Flow Control/discharge (est. 6'W X 10'L X 2'D) | 4 | CY | $ 320 | $ 1,422 |
| 30 | Stormwater Flow Spreader Sump w/Lip Bottom Slab - 2' D x 2XL X 36W' | 5 | CY | $ 320 | $ 1,612 |
| 31 | Exterior Wall Concrete | 62 | CY | $ 1,250 | $ 77,083 |
| 32 | Top Slab Concrete | 101 | CY | $ 1,250 | $ 126,759 |
| 33 | Concrete Reinforcing Rebar | 40,575 | LBS | $ 1.38 | $ 55,994 |
| 34 | Crushed Base | 51 | CY | $ 64 | $ 3,245 |
| 35 | | | | | $ - |
| 36 | ***Shoring and Excavation Assumptions*** | | | | $ - |
| 37 | *Construction Room* | 3 | FT | | $ - |
| 38 | *Tank Bury Depth* | 2 | FT | | $ - |
| 39 | *Total Excavation Depth* | 13 | FT | | $ - |
| 40 | *Excavation Length* | 47 | FT | | $ - |
| 41 | *Excavation Width* | 47 | FT | | $ - |
| 42 | | | | | $ - |
| 43 | **Soil Excavation and Disposal** | | | | $ - |
| 44 | Excavation | 1,023 | CY | $ 79 | $ 80,792 |
| 48 | Imported Structure Backfill | 490 | CY | $ 44 | $ 21,573 |
| 49 | | | | | $ - |
| 50 | **Solder Pile Shoring** | | | | $ - |
| 51 | *Solder Pile Shaft Depth (3 x Exc. Depth)* | 38 | FT | | $ - |
| 52 | *Solder Pile Shaft Thickness* | 2 | FT | | $ - |
| 53 | *Center to Center Shaft Spacing* | 6 | FT | | $ - |
| 54 | *Rebar in Shaft* | 114 | LB/CY | | $ - |
| 55 | *Shoring Wall Perimeter* | 180 | FT | | $ - |
| 56 | *Number of Shafts* | 30 | EA | | $ - |
| 57 | Drill Solder Pile Shafts | 131 | CY | $ 262 | $ 34,296 |
| 58 | Set Solder Pile and CDF | 131 | CY | $ 391 | $ 51,182 |
| 59 | Purchase and Salvage Solder Piles | 128,250 | LB | $ 0.7 | $ 89,775 |
| 60 | Tie Backs - one per soldier pile except corners | 26 | EA | $ 2,477 | $ 64,402 |
| 61 | Timber Lagging (64'W X 70'L @ approx. 20'H) | 8,178 | BF | $ 9 | $ 73,602 |
| 62 | | | | | $ - |
| 63 | **Gates and Access** | | | | $ - |
| 64 | Flow Restrictor | 1 | EA | $ 24,600 | $ 24,600 |
| 65 | Confined Space Safety | 1 | LS | $ 32,595 | $ 32,595 |
| 66 | Access Hatches | 2 | EA | $ 13,038 | $ 26,076 |
| 67 | | | | | $ - |
| 68 | **Conveyance Pipe** | | | | $ - |
| 69 | 12" Storm Pipe (upstream and discharge) | 200 | LF | $ 140 | $ 28,000 |
| 70 | Trench Excavation to waste (8'W X 15'D) | 889 | CY | $ 79 | $ 70,222 |
| 71 | Trench Box Shoring | 6,000 | SF | $ 10 | $ 60,000 |
| 72 | 48" Diameter Maintenance holes | 4 | EA | $ 10,640 | $ 42,560 |
| 73 | Imported Backfill | 883 | CY | $ 44 | $ 38,855 |
| 74 | Dewater Trench - Sumps | 200 | LF | $ 139 | $ 27,800 |
| 75 | Demolish Surface incl. room for construction (@20' wide) | 444 | SY | $ 14 | $ 6,222 |
| 76 | Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100') | 444 | SY | $ 71 | $ 31,556 |
| 77 | | | | | $ - |
| 78 | **Site Removals and Restoration** | | | | $ - |
| 79 | Disking or tilling of compacted soil (assumed 1.5 times structure footprint) | 368 | SY | $ 4 | $ 1,473 |
| 80 | Seeding, mulching and compost | 368 | SY | $ 10 | $ 3,682 |
| 81 | Demolish Existing Surface | 245 | SY | $ 14 | $ 3,436 |
| 82 | Pavement Remove and Restoration (Vault) - 4" HMA/4"CSBC | 245 | SY | $ 71 | $ 17,427 |
| 86 | | | | | $ - |
| 72 | **High Rate Underground Filter** | | | $ - | $ - |
| 73 | Filterra Unit 4'X6' (complete) | 1 | EA | $ 22,165 | $ 22,165 |
| 74 | Structural Excavation to Waste (10'W X12'L X 5'D) + (50'LX5'WX6'D) | 78 | CY | $ 79 | $ 6,123 |
| 75 | Imported Structural Fill | 73 | CY | $ 44 | $ 3,247 |
| 76 | Crushed Base | 1 | CY | $ 64 | $ 64 |
| 77 | Inlet Drain w/Energy Dissipating Rocks | 1 | EA | $ 1,481 | $ 1,481 |
| 78 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 79 | Pipe 8" dia. | 50 | LF | $ 80 | $ 4,000 |
| 80 | Trench Box Shoring (Shallow) | 390 | SF | $ 10 | $ 3,838 |
| 81 | | | | $ - | $ - |
| 82 | **Restoration High Rate Underground Filter** | | | $ - | $ - |
| 83 | Landscaping, planting, and restoration (Filter and 8" Pipe) | 39 | SY | $ 59 | $ 2,296 |
| 84 | Street Tree | 1 | EA | $ 720 | $ 720 |
| 103 | | | | | $ - |
| 104 | Removals at 4 % Construction Costs | 4.0% | LS | $ 1,149,129 | $ 45,965 |
| 105 | TESC at 2% of Construction | 2% | LS | $ 1,195,094 | $ 23,902 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | *Item Subtotal Construction Costs (Year 2023)* | $ 1,218,996 |
| DIRECT: CONSTRUCTION COST MARK-UPS | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 121,900 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | *Item Subtotal Construction Costs (Year 2023)* | $ 1,340,895 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 1,340,895*** |

**Description: WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System With Property Cost**

An infiltration vault is an open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Cost Estimating Assumptions:**

**General**

Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and traffic control is not required.
A street use permit is not required.
The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to Medium.

**Infiltration Vault**

The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.
The vault is assumed to be sited on Outwash soils.
It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.
The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.05 MG.
The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.
The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1156 square feet and a maximum storage depth of 6 feet deep.
Vault has interior dimensions of 34'W x 34'L with an average interior height of 7.5'.
The minimum vault height is 7' deep at the shallowest end.
The vault side slopes are a minimum of 5% towards the center of the vault.
Infiltration is achieved through the native soils at the bottom of the structure.
A minimum of 0.5 feet for sediment storage and a minimum of 1 feet of freeboard depth are assumed.
Exterior and interior wall thickness is 1.5 feet.
Top slab thickness is 2 feet.
The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.
The side walls extend to 1 feet below the vault floor.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth
The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
There will be two maintenance hole access locations with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.
Shoring and lagging is required for construction of the structure.
A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.
Trench Box shoring is used.
The storage vault, facility inlet and outlet pipes are sited beneath a parking area.
It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.

**High Rate Underground Filter**

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6"thick.
The facility treatment area is 24 sf (4'X6') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.
A total of 50 LF of 8" storm pipe is required to connect to the deep UIC well.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.
The facility is located within the ROW and Traffic control is required. Traffic conditions are assumed to be heavy for the urban setting and light for the rural setting.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_14I_Infiltration Vault Outwash Soil with High Rate Underground Filter System Without Property Cost | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Infiltration Vault - Outwash Soil (1156 sf bottom area @ 6' Ave. Storage Depth) with High Rate Underground Filter (24 s.f. bottom area) | 1 | EA | $ 1,340,895 | $ 1,340,895 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 1,340,895*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 268,179 |
| | | | Street Use Permit (Y/N) | Y | $ 90,000 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 1,699,074*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 160,907 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 1,859,982*** |
| | | | | Construction Sales Tax | $ 181,423 |
| | | | | Outside Agency Construction | $ 134,090 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 2,175,500*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 409,196 |
| | | | | Construction Management | $ 185,998 |
| | | | | Permitting & Support | $ 18,600 |
| 0 | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| 0 | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 111,599 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 725,393*** |
| | | | | Project Contingency | $ 870,268 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 1,595,700*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 3,771,200*** |

**Description: WQBE_14I_Infiltration Vault Outwash Soil with High Rate Underground Filter System without Property Cost**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 3,771,200** | |
| Capital cost | $ 3,771,200 | $/Unit |
| Total Direct O&M/Year | $ 5,439 | |
| Direct O&M cost | $ 5,439 | $/Unit |
| Capital Replacement Costs (10 Years) | $ - | $/unit |
| Capital Replacement Costs (20 year equipment) | $ 56,858 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 3,930,800** | **$/unit** |
| **Annual O&M Cost** | **$ 6,600** | **$/year** |
| Annualized Cost | $1,790 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| Cement Patching | 2023 dollars | $ 113 | |
| Mulch Replacement and Plants | 2023 dollars | $ 653 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |

Subtotal $ 1,126

Labor

| | | | |
|---|---|---|---|
| Remove Trash, Debris, and Sediment | 16 | hr | |
| Inspection and joint repair, crack repair | 16 | hr | |
| Plant Health & Mulch replacement | 8 | hr | |
| | | | |
| **Total hours per year** | 40 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 2,176 | |
| Labor cost, burdened | O/H 150.0% | $ 5,439 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 53,570 | | $ 258,763 | **$4,140,391** | **$ 3,930,829** | | | |
| 0 | 1.000 | **$ 3,771,200** | | | $3,771,200 | $ 3,771,200 | $ 3,771,200 | $ 3,771,200 | $ 3,930,829 |
| 1 | 0.950 | $1,126 | $ - | $ 5,439 | $ 6,565 | $ 6,238 | $ 3,777,765 | $ 3,777,438 | $ 159,629 |
| 2 | 0.903 | $ 1,160 | $ - | $ 5,602 | $ 6,762 | $ 6,104 | $ 3,784,527 | $ 3,783,542 | $ 153,391 |
| 3 | 0.858 | $ 1,195 | $ - | $ 5,770 | $ 6,965 | $ 5,974 | $ 3,791,492 | $ 3,789,515 | $ 147,287 |
| 4 | 0.815 | $ 1,230 | $ - | $ 5,943 | $ 7,174 | $ 5,846 | $ 3,798,666 | $ 3,795,361 | $ 141,313 |
| 5 | 0.774 | $ 1,267 | $ - | $ 6,122 | $ 7,389 | $ 5,721 | $ 3,806,054 | $ 3,801,082 | $ 135,467 |
| 6 | 0.736 | $ 1,305 | $ - | $ 6,305 | $ 7,611 | $ 5,599 | $ 3,813,665 | $ 3,806,681 | $ 129,746 |
| 7 | 0.699 | $ 1,345 | $ - | $ 6,494 | $ 7,839 | $ 5,479 | $ 3,821,504 | $ 3,812,160 | $ 124,148 |
| 8 | 0.664 | $ 1,385 | $ - | $ 6,689 | $ 8,074 | $ 5,362 | $ 3,829,578 | $ 3,817,522 | $ 118,669 |
| 9 | 0.631 | $ 1,426 | $ - | $ 6,890 | $ 8,316 | $ 5,247 | $ 3,837,895 | $ 3,822,769 | $ 113,307 |
| 10 | 0.599 | $ 1,469 | $ - | $ 7,097 | $ 8,566 | $ 5,135 | $ 3,846,460 | $ 3,827,904 | $ 108,060 |
| 11 | 0.570 | $ 1,513 | $ - | $ 7,310 | $ 8,823 | $ 5,025 | $ 3,855,283 | $ 3,832,930 | $ 102,924 |
| 12 | 0.541 | $ 1,559 | $ - | $ 7,529 | $ 9,087 | $ 4,918 | $ 3,864,371 | $ 3,837,848 | $ 97,899 |
| 13 | 0.514 | $ 1,605 | $ - | $ 7,755 | $ 9,360 | $ 4,813 | $ 3,873,731 | $ 3,842,660 | $ 92,981 |
| 14 | 0.489 | $ 1,654 | $ - | $ 7,987 | $ 9,641 | $ 4,710 | $ 3,883,372 | $ 3,847,370 | $ 88,168 |
| 15 | 0.464 | $ 1,703 | $ - | $ 8,227 | $ 9,930 | $ 4,609 | $ 3,893,302 | $ 3,851,979 | $ 83,459 |
| 16 | 0.441 | $ 1,754 | $ - | $ 8,474 | $ 10,228 | $ 4,511 | $ 3,903,530 | $ 3,856,490 | $ 78,849 |
| 17 | 0.419 | $ 1,807 | $ - | $ 8,728 | $ 10,535 | $ 4,414 | $ 3,914,065 | $ 3,860,904 | $ 74,339 |
| 18 | 0.398 | $ 1,861 | $ - | $ 8,990 | $ 10,851 | $ 4,320 | $ 3,924,916 | $ 3,865,224 | $ 69,925 |
| 19 | 0.378 | $ 1,917 | $ - | $ 9,260 | $ 11,176 | $ 4,228 | $ 3,936,092 | $ 3,869,452 | $ 65,605 |
| 20 | 0.359 | $ 1,974 | $ 56,858 | $ 9,537 | $ 68,370 | $ 24,571 | $ 4,004,462 | $ 3,894,023 | $ 61,377 |
| 21 | 0.341 | $ 2,034 | $ - | $ 9,823 | $ 11,857 | $ 4,049 | $ 4,016,320 | $ 3,898,072 | $ 36,806 |
| 22 | 0.324 | $ 2,095 | $ - | $ 10,118 | $ 12,213 | $ 3,962 | $ 4,028,532 | $ 3,902,034 | $ 32,757 |
| 23 | 0.308 | $ 2,158 | $ - | $ 10,422 | $ 12,579 | $ 3,877 | $ 4,041,112 | $ 3,905,911 | $ 28,795 |
| 24 | 0.293 | $ 2,222 | $ - | $ 10,734 | $ 12,957 | $ 3,795 | $ 4,054,068 | $ 3,909,706 | $ 24,918 |
| 25 | 0.278 | $ 2,289 | $ - | $ 11,056 | $ 13,345 | $ 3,713 | $ 4,067,414 | $ 3,913,419 | $ 21,123 |
| 26 | 0.264 | $ 2,358 | $ - | $ 11,388 | $ 13,746 | $ 3,634 | $ 4,081,159 | $ 3,917,053 | $ 17,410 |
| 27 | 0.251 | $ 2,428 | $ - | $ 11,730 | $ 14,158 | $ 3,556 | $ 4,095,317 | $ 3,920,609 | $ 13,776 |
| 28 | 0.239 | $ 2,501 | $ - | $ 12,082 | $ 14,583 | $ 3,480 | $ 4,109,900 | $ 3,924,090 | $ 10,219 |
| 29 | 0.227 | $ 2,576 | $ - | $ 12,444 | $ 15,020 | $ 3,406 | $ 4,124,920 | $ 3,927,496 | $ 6,739 |
| 30 | 0.215 | $ 2,653 | $ - | $ 12,817 | $ 15,471 | $ 3,333 | $ 4,140,391 | $ 3,930,829 | $ 3,333 |

**Description: WQBE_14I_Infiltration Vault Outwash Soil with High Rate Underground Filter System without Property Cost**

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions (vault):**

Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work
16 day, assume use of vactor truck.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an
16 8 hour work day. Assume annual cost of $113 for cement patching mix.

**O&M Estimating Assumptions (filter):**

Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year. Assume use of vacuum truck. Trips consolidated with vault cleaning.

Biannually 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours.
8 Assumed annual cost of $113 for mulch.

Annual plant replacement allowance of $540. Will allow for the replacement of approximately 10 shrubs or other medium sized plant material.

**Capital Replacement Assumptions (vault):**

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

**Capital Replacement Assumptions (filter):**

No capital replacement within 30-year life per Filterra Owner's Manual.

**Estimate - AACEI Class 10**

| | | | |
|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_14I_Infiltration Vault Outwash Soil with High Rate Underground Filter System Without Property Cost | **Version:** | 2 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Infiltration Vault on Property** | | | | $ - |
| 2 | ***Vault Assumptions*** | | | | $ - |
| 3 | *Exterior Length* | 37 | FT | | $ - |
| 4 | *Interior Length* | 34 | FT | | $ - |
| 5 | *Exterior Width* | 37 | FT | | $ - |
| 6 | *Interior Width* | 34 | FT | | $ - |
| 7 | *Interior Structure Height (Ave.)* | 7.5 | FT | | $ - |
| 8 | *Storage Depth (Ave)* | 6.0 | FT | | $ - |
| 9 | *Sediment Storage Depth* | 0.5 | FT | | $ - |
| 10 | *Freeboard (Ave.)* | 1.0 | FT | | $ - |
| 11 | *Storage Facility Exterior Footprint Area* | 1,369 | SF | | $ - |
| 12 | | | | | $ - |
| 13 | ***Storage Volume*** | | | | $ - |
| 14 | *Storage Facility interior Area* | 1,156 | SF | | $ - |
| 15 | *Effective Storage Volume (15.500 cf target)* | 6,936 | CF | | $ - |
| 16 | *Vault Storage Volume* | 0.05 | MG | | $ - |
| 17 | | | | | $ - |
| 18 | ***Structure Concrete Assumptions*** | | | | $ - |
| 19 | *Exterior Wall thickness* | 1.5 | FT | | $ - |
| 20 | *Top Slab Thickness* | 2 | FT | | $ - |
| 21 | *Flow Spreader Slab thickness* | 2 | FT | | $ - |
| 22 | *Center column footprint area (2'x2')* | 4 | SF | | $ - |
| 23 | *Center Column Spacing* | 5 | FT | | $ - |
| 24 | *Concrete Reinforcing Rebar* | 225 | LB/CY | | $ - |
| 25 | *Crushed Base Thickness* | 1 | FT | | $ - |
| 26 | | | | | $ - |
| 27 | **Concrete Structure** | | | | $ - |
| 28 | Vault Interior Columns at Midspan | 8 | CY | $ 650 | $ 5,056 |
| 29 | Slab under Flow Control/discharge (est. 6'W X 10'L X 2'D) | 4 | CY | $ 320 | $ 1,422 |
| 30 | Stormwater Flow Spreader Sump w/Lip Bottom Slab - 2' D x 2XL X 36W' | 5 | CY | $ 320 | $ 1,612 |
| 31 | Exterior Wall Concrete | 62 | CY | $ 1,250 | $ 77,083 |
| 32 | Top Slab Concrete | 101 | CY | $ 1,250 | $ 126,759 |
| 33 | Concrete Reinforcing Rebar | 40,575 | LBS | $ 1.38 | $ 55,994 |
| 34 | Crushed Base | 51 | CY | $ 64 | $ 3,245 |
| 35 | | | | | $ - |
| 36 | ***Shoring and Excavation Assumptions*** | | | | $ - |
| 37 | *Construction Room* | 3 | FT | | $ - |
| 38 | *Tank Bury Depth* | 2 | FT | | $ - |
| 39 | *Total Excavation Depth* | 13 | FT | | $ - |
| 40 | *Excavation Length* | 47 | FT | | $ - |
| 41 | *Excavation Width* | 47 | FT | | $ - |
| 42 | | | | | $ - |
| 43 | **Soil Excavation and Disposal** | | | | $ - |
| 44 | Excavation | 1,023 | CY | $ 79 | $ 80,792 |
| 48 | Imported Structure Backfill | 490 | CY | $ 44 | $ 21,573 |
| 49 | | | | | $ - |
| 50 | **Solder Pile Shoring** | | | | $ - |
| 51 | *Solder Pile Shaft Depth (3 x Exc. Depth)* | 38 | FT | | $ - |
| 52 | *Solder Pile Shaft Thickness* | 2 | FT | | $ - |
| 53 | *Center to Center Shaft Spacing* | 6 | FT | | $ - |
| 54 | *Rebar in Shaft* | 114 | LB/CY | | $ - |
| 55 | *Shoring Wall Perimeter* | 180 | FT | | $ - |
| 56 | *Number of Shafts* | 30 | EA | | $ - |
| 57 | Drill Solder Pile Shafts | 131 | CY | $ 262 | $ 34,296 |
| 58 | Set Solder Pile and CDF | 131 | CY | $ 391 | $ 51,182 |
| 59 | Purchase and Salvage Solder Piles | 128,250 | LB | $ 0.7 | $ 89,775 |
| 60 | Tie Backs - one per soldier pile except corners | 26 | EA | $ 2,477 | $ 64,402 |
| 61 | Timber Lagging (64'W X 70'L @ approx. 20'H) | 8,178 | BF | $ 9 | $ 73,602 |
| 62 | | | | | $ - |
| 63 | **Gates and Access** | | | | $ - |
| 64 | Flow Restrictor | 1 | EA | $ 24,600 | $ 24,600 |
| 65 | Confined Space Safety | 1 | LS | $ 32,595 | $ 32,595 |
| 66 | Access Hatches | 2 | EA | $ 13,038 | $ 26,076 |
| 67 | | | | | $ - |
| 68 | **Conveyance Pipe** | | | | $ - |
| 69 | 12" Storm Pipe (upstream and discharge) | 200 | LF | $ 140 | $ 28,000 |
| 70 | Trench Excavation to waste (8'W X 15'D) | 889 | CY | $ 79 | $ 70,222 |
| 71 | Trench Box Shoring | 6,000 | SF | $ 10 | $ 60,000 |
| 72 | 48" Diameter Maintenance holes | 4 | EA | $ 10,640 | $ 42,560 |
| 73 | Imported Backfill | 883 | CY | $ 44 | $ 38,855 |
| 74 | Dewater Trench - Sumps | 200 | LF | $ 139 | $ 27,800 |
| 75 | Demolish Surface incl. room for construction (@20' wide) | 444 | SY | $ 14 | $ 6,222 |
| 76 | Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100') | 444 | SY | $ 71 | $ 31,556 |
| 77 | | | | | $ - |
| 78 | **Site Removals and Restoration** | | | | $ - |
| 79 | Disking or tilling of compacted soil (assumed 1.5 times structure footprint) | 368 | SY | $ 4 | $ 1,473 |
| 80 | Seeding, mulching and compost | 368 | SY | $ 10 | $ 3,682 |
| 81 | Demolish Existing Surface | 245 | SY | $ 14 | $ 3,436 |
| 82 | Pavement Remove and Restoration (Vault) - 4" HMA/4"CSBC | 245 | SY | $ 71 | $ 17,427 |
| 86 | | | | | $ - |
| 72 | **High Rate Underground Filter** | | | $ - | $ - |
| 73 | Filterra Unit 4'X6' (complete) | 1 | EA | $ 22,165 | $ 22,165 |
| 74 | Structural Excavation to Waste (10'W X12'L X 5'D) + (50'LX5'WX6'D) | 78 | CY | $ 79 | $ 6,123 |
| 75 | Imported Structural Fill | 73 | CY | $ 44 | $ 3,247 |
| 76 | Crushed Base | 1 | CY | $ 64 | $ 64 |
| 77 | Inlet Drain w/Energy Dissipating Rocks | 1 | EA | $ 1,481 | $ 1,481 |
| 78 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 79 | Pipe 8" dia. | 50 | LF | $ 80 | $ 4,000 |
| 80 | Trench Box Shoring (Shallow) | 390 | SF | $ 10 | $ 3,838 |
| 81 | | | | $ - | $ - |
| 82 | **Restoration High Rate Underground Filter** | | | $ - | $ - |
| 83 | Landscaping, planting, and restoration (Filter and 8" Pipe) | 39 | SY | $ 59 | $ 2,296 |
| 84 | Street Tree | 1 | EA | $ 720 | $ 720 |
| 103 | | | | | $ - |
| 104 | Removals at 4 % Construction Costs | 4.0% | LS | $ 1,149,129 | $ 45,965 |
| 105 | TESC at 2% of Construction | 2% | LS | $ 1,195,094 | $ 23,902 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 1,218,996 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 121,900 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 1,340,895 |
| ***Direct: Subtotal Construction Costs*** | | | ***$ 1,340,895*** |

**Description: WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System Without Property Cost**

An infiltration vault is an open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

**Cost Estimating Assumptions:**

**General**

Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and traffic control is not required.
A street use permit is not required.
The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to Medium.

**Infiltration Vault**

The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.
The vault is assumed to be sited on Outwash soils.
It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.
The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.05 MG.
The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.
The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1156 square feet and a maximum storage depth of 6 feet deep.
Vault has interior dimensions of 34'W x 34'L with an average interior height of 7.5'.
The minimum vault height is 7' deep at the shallowest end.
The vault side slopes are a minimum of 5% towards the center of the vault.
Infiltration is achieved through the native soils at the bottom of the structure.
A minimum of 0.5 feet for sediment storage and a minimum of 1 feet of freeboard depth are assumed.
Exterior and interior wall thickness is 1.5 feet.
Top slab thickness is 2 feet.
The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.
The side walls extend to 1 feet below the vault floor.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth
The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
There will be two maintenance hole access locations with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.
Shoring and lagging is required for construction of the structure.
A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.
Trench Box shoring is used.
The storage vault, facility inlet and outlet pipes are sited beneath a parking area.
It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.

**High Rate Underground Filter**

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6"thick.
The facility treatment area is 24 sf (4'X6') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.
A total of 50 LF of 8" storm pipe is required to connect to the deep UIC well.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.
The facility is located within the ROW and Traffic control is required. Traffic conditions are assumed to be heavy for the urban setting and light for the rural setting.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 18A_ Wetpond on Public Property | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Wetpond (553 s.f. bottom area @ 4 ft. Storage Depth) | 1 | EA | $ 339,352 | $ 339,352 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 339,352*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 67,870 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 407,223*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 40,722 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 447,945*** |
| | | | | Construction Sales Tax | $ 45,914 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 493,900*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 98,548 |
| | | | | Construction Management | $ 44,795 |
| | | | | Permitting & Support | $ 4,479 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 26,877 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 174,699*** |
| | | | | Project Contingency | $ 200,580 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 375,300*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 869,200*** |

**Description: WQBE 18A_ Wetpond on Public Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 869,200** | |
| Capital cost | $ 869,200 | $/Unit |
| Total Direct O&M/Year | $ 1,632 | |
| Direct O&M cost | $ 1,632 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 13,124 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 929,200** | **$/unit** |
| **Annual O&M Cost** | **$ 2,200** | **$/year** |
| Annualized Cost | $960 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Erosion Repair Materials | 2023 dollars | $ 246 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $606 | |
| Labor | | | |
| Remove Trash, Debris, and Sediment | 4 | hr | |
| Removal of oil sheen | 2 | hr | |
| Remediation of erosion | 6 | hr | |
| | 0 | hr | |
| **Total hours per year** | 12 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 653 | |
| Labor cost, burdened | O/H 150.0% | $ 1,632 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 28,831 | | $ 77,629 | **$1,001,907** | **$ 929,229** | | | |
| 0 | 1.000 | **$ 869,200** | | | $869,200 | $ 869,200 | $ 869,200 | $ 869,200 | $ 929,229 |
| 1 | 0.950 | $606 | $ - | $ 1,632 | $ 2,238 | $ 2,126 | $ 871,438 | $ 871,326 | $ 60,029 |
| 2 | 0.903 | $ 624 | $ - | $ 1,681 | $ 2,305 | $ 2,081 | $ 873,743 | $ 873,407 | $ 57,903 |
| 3 | 0.858 | $ 643 | $ - | $ 1,731 | $ 2,374 | $ 2,036 | $ 876,117 | $ 875,443 | $ 55,822 |
| 4 | 0.815 | $ 662 | $ - | $ 1,783 | $ 2,445 | $ 1,993 | $ 878,562 | $ 877,435 | $ 53,786 |
| 5 | 0.774 | $ 682 | $ - | $ 1,836 | $ 2,519 | $ 1,950 | $ 881,080 | $ 879,386 | $ 51,793 |
| 6 | 0.736 | $ 703 | $ - | $ 1,892 | $ 2,594 | $ 1,908 | $ 883,674 | $ 881,294 | $ 49,843 |
| 7 | 0.699 | $ 724 | $ - | $ 1,948 | $ 2,672 | $ 1,868 | $ 886,346 | $ 883,161 | $ 47,935 |
| 8 | 0.664 | $ 745 | $ - | $ 2,007 | $ 2,752 | $ 1,828 | $ 889,098 | $ 884,989 | $ 46,067 |
| 9 | 0.631 | $ 768 | $ - | $ 2,067 | $ 2,835 | $ 1,789 | $ 891,933 | $ 886,778 | $ 44,240 |
| 10 | 0.599 | $ 791 | $ 13,124 | $ 2,129 | $ 16,043 | $ 9,618 | $ 907,976 | $ 896,395 | $ 42,451 |
| 11 | 0.570 | $ 814 | $ - | $ 2,193 | $ 3,007 | $ 1,713 | $ 910,984 | $ 898,108 | $ 32,834 |
| 12 | 0.541 | $ 839 | $ - | $ 2,259 | $ 3,098 | $ 1,676 | $ 914,081 | $ 899,784 | $ 31,121 |
| 13 | 0.514 | $ 864 | $ - | $ 2,326 | $ 3,190 | $ 1,640 | $ 917,271 | $ 901,425 | $ 29,444 |
| 14 | 0.489 | $ 890 | $ - | $ 2,396 | $ 3,286 | $ 1,605 | $ 920,558 | $ 903,030 | $ 27,804 |
| 15 | 0.464 | $ 917 | $ - | $ 2,468 | $ 3,385 | $ 1,571 | $ 923,942 | $ 904,601 | $ 26,199 |
| 16 | 0.441 | $ 944 | $ - | $ 2,542 | $ 3,486 | $ 1,537 | $ 927,429 | $ 906,139 | $ 24,627 |
| 17 | 0.419 | $ 972 | $ - | $ 2,618 | $ 3,591 | $ 1,505 | $ 931,019 | $ 907,643 | $ 23,090 |
| 18 | 0.398 | $ 1,002 | $ - | $ 2,697 | $ 3,699 | $ 1,472 | $ 934,718 | $ 909,116 | $ 21,585 |
| 19 | 0.378 | $ 1,032 | $ - | $ 2,778 | $ 3,810 | $ 1,441 | $ 938,528 | $ 910,557 | $ 20,113 |
| 20 | 0.359 | $ 1,063 | $ 13,124 | $ 2,861 | $ 17,047 | $ 6,127 | $ 955,575 | $ 916,683 | $ 18,672 |
| 21 | 0.341 | $ 1,095 | $ - | $ 2,947 | $ 4,042 | $ 1,380 | $ 959,616 | $ 918,063 | $ 12,545 |
| 22 | 0.324 | $ 1,127 | $ - | $ 3,035 | $ 4,163 | $ 1,351 | $ 963,779 | $ 919,414 | $ 11,165 |
| 23 | 0.308 | $ 1,161 | $ - | $ 3,127 | $ 4,288 | $ 1,322 | $ 968,067 | $ 920,735 | $ 9,815 |
| 24 | 0.293 | $ 1,196 | $ - | $ 3,220 | $ 4,416 | $ 1,293 | $ 972,483 | $ 922,029 | $ 8,493 |
| 25 | 0.278 | $ 1,232 | $ - | $ 3,317 | $ 4,549 | $ 1,266 | $ 977,032 | $ 923,295 | $ 7,200 |
| 26 | 0.264 | $ 1,269 | $ - | $ 3,416 | $ 4,685 | $ 1,239 | $ 981,717 | $ 924,533 | $ 5,934 |
| 27 | 0.251 | $ 1,307 | $ - | $ 3,519 | $ 4,826 | $ 1,212 | $ 986,543 | $ 925,745 | $ 4,696 |
| 28 | 0.239 | $ 1,346 | $ - | $ 3,624 | $ 4,971 | $ 1,186 | $ 991,514 | $ 926,932 | $ 3,483 |
| 29 | 0.227 | $ 1,386 | $ - | $ 3,733 | $ 5,120 | $ 1,161 | $ 996,633 | $ 928,093 | $ 2,297 |
| 30 | 0.215 | $ 1,428 | $ - | $ 3,845 | $ 5,273 | $ 1,136 | $ 1,001,907 | $ 929,229 | $ 1,136 |

**Description: WQBE 18A_ Wetpond on Public Property**

Constructed stormwater pond that retains a permanent pool of water ("wetpool") at least during the wet season. Wetpool volume is related to the pond's effectiveness in settling particulate pollutants.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**

4 Removal of trash, debris and sediment. Labor shall include 2 crew members, 1 visit per year, 2 hours per visit; assume use of vactor truck and 4 man hours each year.

2 Removal of visible oil sheen by using a vactor truck. Labor shall include 2 crew members, 1 visit per year, 1 hours per visit; 2 man hours each year.

6 Areas that have over 6 inches of erosion shall be repaired biannually or after a major storm event. 2 crew members, 3 visits per year, 1 hour per visit, 6 man hours per year. Assume annual cost of erosion repair materials of $246.

**Capital Replacement Assumptions:**

Replacement of items highlighted in blue on estimate sheet every 10 years (i.e. riprap pads, gates, etc.)

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 18A_ Wetpond on Public Property | | | **Version:** | 2 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | ***Pond Upper Cell #1 (Sediment)*** | 4 | FT Depth | $ - | $ - |
| 2 | ***Bottom Area @ 1/3 Volume of Wetpond Facility*** | 40 | SF | $ - | $ - |
| 3 | ***Top Area@ 3:1 Side Slopes*** | 928 | SF | $ - | $ - |
| 4 | Facility Excavation to Waste @ 4 ft 'D + Sub-exc. for Liner | 140 | CY | $ 79 | $ 11,095 |
| 5 | Imported Treatment Liner @ 2' thick | 69 | CY | $ 105 | $ 7,218 |
| 6 | | | | $ - | $ - |
| 7 | ***Wetpond Excavation Volume (16.7'W X 33.3'L X 4'D)*** | 4 | FT Depth | $ - | $ - |
| 8 | ***Bottom Area @ 3:1 Side Slopes*** | 553 | SF | $ - | $ - |
| 9 | ***Top Area@ 3:1 Side Slopes*** | 2329 | SF | $ - | $ - |
| 10 | Facility Excavation to Waste @ 4 ft 'D + Sub-exc. for Liner | 386 | CY | $ 79 | $ 30,494 |
| 11 | Imported Fill for Compacted Berm Embankment - Between First & Second Cell (@244 LF and 45 sq ft./ft cross section area) | 407 | CY | $ 44 | $ 17,893 |
| 12 | Embankment Compaction | 407 | CY | $ 22 | $ 8,947 |
| 13 | Imported Treatment Liner @ 2' thick | 173 | CY | $ 105 | $ 18,114 |
| 14 | Riprap Lining for Pre-settling and Infiltration Pond Overflow Spillways (6'WX12'LX2'D) | 11 | CY | $ 346 | $ 3,691 |
| 15 | Access Roadway to site (4" HMA/4" CSBC) | 267 | SY | $ 71 | $ 18,933 |
| 16 | Access Gate (16 ft wide gate) | 1 | EA | $ 3,085 | $ 3,085 |
| 17 | | | | $ - | $ - |
| 18 | **Outlet Pipe** | | | $ - | $ - |
| 19 | Pipe - 12" PVC | 100 | LF | $ 140 | $ 14,000 |
| 20 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 21 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 22 | Control Structure with grate, clean out drain, and gate | 1 | EA | $ 24,860 | $ 24,860 |
| 23 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 24 | Pipe Discharge Rock Lining Riprap (12' Long by 8' wide x 2 ft thick) | 7 | SF | $ 346 | $ 2,460 |
| 25 | Debris Barrier | 1 | EA | $ 14,808 | $ 14,808 |
| 26 | | | | $ - | $ - |
| 27 | **Inlet Pipe** | | | $ - | $ - |
| 28 | Pipe - 12" PVC | 100 | LF | $ 140 | $ 14,000 |
| 29 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 30 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 31 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 32 | Pipe Discharge Rock Lining Riprap (12' Long by 8' wide x 2 ft thick) | 7 | SF | $ 346 | $ 2,460 |
| 33 | Catch Basin Structure (spill control) | 1 | EA | $ 3,900 | $ 3,900 |
| 34 | | | | $ - | $ - |
| 35 | **Restoration** | | | $ - | $ - |
| 36 | Disking or tilling of compacted soil (assumed 100'X100' construction staging/stockpiling) | 1,556 | SY | $ 4 | $ 6,222 |
| 37 | Seeding, mulching and compost (Emergent, Riparian & Upland) facility + staging | 1,814 | SY | $ 10 | $ 18,143 |
| 38 | Plantings (Emergent & Riparian) | 454 | SY | $ 19 | $ 8,618 |
| 39 | Trees (both sides of the facility and opportunistic areas) | 15 | EA | $ 720 | $ 10,800 |
| 40 | | | | $ - | $ - |
| 41 | | | | | $ - |
| 42 | **Additional Costs** | | | | $ - |
| 43 | Removals @ 4% Construction Costs | 4.0% | LS | $ 290,820 | $ 11,633 |
| 44 | TESC @2% Construction Costs | 2% | LS | $ 302,453 | $ 6,049 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 308,502 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 30,850 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 339,352 |
| | | | | ***Direct: Subtotal Construction Costs*** | ***$ 339,352*** |

**Description: WQBE 18A_ Wetpond on Public Property**

Constructed stormwater pond that retains a permanent pool of water ("wetpool") at least during the wet season. Wetpool volume is related to the pond's effectiveness in settling particulate pollutants.

**Cost Estimating Assumptions:**

The Wetpond is designed in accordance with the King Co. Surface Water Design Manual (KC SWDM) Section 6.4.1 and is generally as described below:
The wetpond has a bottom area of 553 sf and has a storage depth of 4 feet deep (48 inches).
The pond storage volume is generally located below grade.
The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 33.3 ft. width and is 16.7 ft. in length.
The facility is assumed to be lined with a 2 ft. deep treatment liner in accordance with KC SWDM Section 6.2.4.
The length to width ratio is less than 4:1 and a dividing berm is required. In accordance with Section 6.4 design recommendations, the wetpool will have 2 cells, with the upper cell designed to accommodate sediment storage.
The first wetpool cell is sized to approximately 1/3 of the required storage volume of the second wet pool storage. The pool is designed to meet the 4 foot minimum required depth.
The pond is constructed with 3:1 side slopes.
The design includes 1 foot for freeboard.
A min 72" Dia. flow control maintenance hole with a cone grate, clean out drain and gate that meets the requirements of Section 6.1.4.2 and Section 5.1.4 is provided at the facility outlet.

A minimum of a 54" Type 2 CB spill control structure that meets the requirements of section 4.2.1 and section 5.1.4.A is assumed for the inflow pipe.
A spillway is provided between pond cell 1 and pond cell 2 and an emergency overflow spillway is included.
Both the pond and emergency spillways are 12 ft. long w/ a slope of 3:1, H:V.
The spillways are riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.
The infiltration pond includes a compacted berm that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content
Approximately 200 feet of 12-inch diameter pipe is included for upstream and downstream conveyance.
It is assumed that dewatering will not be required.
Trench Box shoring for pipe installation.
A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.
The area for the wetpond is assumed to be existing open space without building or pavement removal.
Fencing is not included in the estimate, a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced.
Disturbed areas are seeded and it is assumed that a portion of the area has plantings.
The pond is tree-lined along both sides (length) and at opportunistic locations per KC Section 6.4.
The pond is assumed to be located in either KC right of way (away from the roadsides) or in King Co. owned property. It is assumed that real estate acquisition and easements are NOT required.
Construction occurs outside of the right-of-way and no traffic control or street use permits are required.
The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 18B_ Wetpond with Property Cost | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Wetpond (553 s.f. bottom area @ 4 ft. Storage Depth) | 1 | EA | $ 339,352 | $ 339,352 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 339,352*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 67,870 |
| | | | | Street Use Permit (Y/N) N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 407,223*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 40,722 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 447,945*** |
| | | | | Construction Sales Tax | $ 45,914 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 493,900*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 98,548 |
| | | | | Construction Management | $ 44,795 |
| | | | | Permitting & Support | $ 4,479 |
| 7150 | s.f. Land Area | Medium | Land Purchase/ROW Acquisition | | $ 575,075 |
| 4000 | s.f. Land Area | Low | Permanent Easements | | $ 40,400 |
| | | | | WTD Staff Costs & Non-WTD Support | $ 26,877 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 790,173*** |
| | | | | Project Contingency | $ 385,222 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 1,175,400*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 1,669,300*** |

**Description: WQBE 18B_ Wetpond with Property Cost (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 1,669,300** | |
| Capital cost | $ 1,669,300 | $/Unit |
| Total Direct O&M/Year | $ 1,632 | |
| Direct O&M cost | $ 1,632 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 13,124 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 1,729,300** | **$/unit** |
| **Annual O&M Cost** | **$ 2,200** | **$/year** |
| Annualized Cost | $960 | $/year |

**Materials, Supplies, Other Costs**

| | | | | |
|---|---|---|---|---|
| | | $ - | $/year | |
| Erosion Repair Materials | 2023 dollars | $ 246 | $/year | |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year | |
| Subtotal | | $606 | | |
| Labor | | | | |
| Remove Trash, Debris, and Sediment | 4 | hr | | |
| Removal of oil sheen | 2 | hr | | |
| Remediation of erosion | 6 | hr | | |
| | 0 | hr | | |
| **Total hours per year** | 12 | | | |
| Raw Labor Rate/Hr | | $ 54 | | |
| Raw labor cost | (embedded) | $ 653 | | |
| Labor cost, burdened | O/H 150.0% | $ 1,632 | $ | 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | | |
| Life Cycle Period: | 30 | years | | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 28,831 | | $ 77,629 | **$1,802,007** | **$ 1,729,329** | | | |
| 0 | 1.000 | **$ 1,669,300** | | | $1,669,300 | $ 1,669,300 | $ 1,669,300 | $ 1,669,300 | $ 1,729,329 |
| 1 | 0.950 | $606 | $ - | $ 1,632 | $ 2,238 | $ 2,126 | $ 1,671,538 | $ 1,671,426 | $ 60,029 |
| 2 | 0.903 | $ 624 | $ - | $ 1,681 | $ 2,305 | $ 2,081 | $ 1,673,843 | $ 1,673,507 | $ 57,903 |
| 3 | 0.858 | $ 643 | $ - | $ 1,731 | $ 2,374 | $ 2,036 | $ 1,676,217 | $ 1,675,543 | $ 55,822 |
| 4 | 0.815 | $ 662 | $ - | $ 1,783 | $ 2,445 | $ 1,993 | $ 1,678,662 | $ 1,677,535 | $ 53,786 |
| 5 | 0.774 | $ 682 | $ - | $ 1,836 | $ 2,519 | $ 1,950 | $ 1,681,180 | $ 1,679,486 | $ 51,793 |
| 6 | 0.736 | $ 703 | $ - | $ 1,892 | $ 2,594 | $ 1,908 | $ 1,683,774 | $ 1,681,394 | $ 49,843 |
| 7 | 0.699 | $ 724 | $ - | $ 1,948 | $ 2,672 | $ 1,868 | $ 1,686,446 | $ 1,683,261 | $ 47,935 |
| 8 | 0.664 | $ 745 | $ - | $ 2,007 | $ 2,752 | $ 1,828 | $ 1,689,198 | $ 1,685,089 | $ 46,067 |
| 9 | 0.631 | $ 768 | $ - | $ 2,067 | $ 2,835 | $ 1,789 | $ 1,692,033 | $ 1,686,878 | $ 44,240 |
| 10 | 0.599 | $ 791 | $ 13,124 | $ 2,129 | $ 16,043 | $ 9,618 | $ 1,708,076 | $ 1,696,495 | $ 42,451 |
| 11 | 0.570 | $ 814 | $ - | $ 2,193 | $ 3,007 | $ 1,713 | $ 1,711,084 | $ 1,698,208 | $ 32,834 |
| 12 | 0.541 | $ 839 | $ - | $ 2,259 | $ 3,098 | $ 1,676 | $ 1,714,181 | $ 1,699,884 | $ 31,121 |
| 13 | 0.514 | $ 864 | $ - | $ 2,326 | $ 3,190 | $ 1,640 | $ 1,717,371 | $ 1,701,525 | $ 29,444 |
| 14 | 0.489 | $ 890 | $ - | $ 2,396 | $ 3,286 | $ 1,605 | $ 1,720,658 | $ 1,703,130 | $ 27,804 |
| 15 | 0.464 | $ 917 | $ - | $ 2,468 | $ 3,385 | $ 1,571 | $ 1,724,042 | $ 1,704,701 | $ 26,199 |
| 16 | 0.441 | $ 944 | $ - | $ 2,542 | $ 3,486 | $ 1,537 | $ 1,727,529 | $ 1,706,239 | $ 24,627 |
| 17 | 0.419 | $ 972 | $ - | $ 2,618 | $ 3,591 | $ 1,505 | $ 1,731,119 | $ 1,707,743 | $ 23,090 |
| 18 | 0.398 | $ 1,002 | $ - | $ 2,697 | $ 3,699 | $ 1,472 | $ 1,734,818 | $ 1,709,216 | $ 21,585 |
| 19 | 0.378 | $ 1,032 | $ - | $ 2,778 | $ 3,810 | $ 1,441 | $ 1,738,628 | $ 1,710,657 | $ 20,113 |
| 20 | 0.359 | $ 1,063 | $ 13,124 | $ 2,861 | $ 17,047 | $ 6,127 | $ 1,755,675 | $ 1,716,783 | $ 18,672 |
| 21 | 0.341 | $ 1,095 | $ - | $ 2,947 | $ 4,042 | $ 1,380 | $ 1,759,716 | $ 1,718,163 | $ 12,545 |
| 22 | 0.324 | $ 1,127 | $ - | $ 3,035 | $ 4,163 | $ 1,351 | $ 1,763,879 | $ 1,719,514 | $ 11,165 |
| 23 | 0.308 | $ 1,161 | $ - | $ 3,127 | $ 4,288 | $ 1,322 | $ 1,768,167 | $ 1,720,835 | $ 9,815 |
| 24 | 0.293 | $ 1,196 | $ - | $ 3,220 | $ 4,416 | $ 1,293 | $ 1,772,583 | $ 1,722,129 | $ 8,493 |
| 25 | 0.278 | $ 1,232 | $ - | $ 3,317 | $ 4,549 | $ 1,266 | $ 1,777,132 | $ 1,723,395 | $ 7,200 |
| 26 | 0.264 | $ 1,269 | $ - | $ 3,416 | $ 4,685 | $ 1,239 | $ 1,781,817 | $ 1,724,633 | $ 5,934 |
| 27 | 0.251 | $ 1,307 | $ - | $ 3,519 | $ 4,826 | $ 1,212 | $ 1,786,643 | $ 1,725,845 | $ 4,696 |
| 28 | 0.239 | $ 1,346 | $ - | $ 3,624 | $ 4,971 | $ 1,186 | $ 1,791,614 | $ 1,727,032 | $ 3,483 |
| 29 | 0.227 | $ 1,386 | $ - | $ 3,733 | $ 5,120 | $ 1,161 | $ 1,796,733 | $ 1,728,193 | $ 2,297 |
| 30 | 0.215 | $ 1,428 | $ - | $ 3,845 | $ 5,273 | $ 1,136 | $ 1,802,007 | $ 1,729,329 | $ 1,136 |

**Description: WQBE 18B_ Wetpond with Property Cost**

Constructed stormwater pond that retains a permanent pool of water ("wetpool") at least during the wet season. Wetpool volume is related to the pond's effectiveness in settling particulate pollutants.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**

4 Removal of trash, debris and sediment. Labor shall include 2 crew members, 1 visit per year, 2 hours per visit; assume use of vactor truck and 4 man hours each year.

2 Removal of visible oil sheen by using a vactor truck. Labor shall include 2 crew members, 1 visit per year, 1 hours per visit; 2 man hours each year.

6 Areas that have over 6 inches of erosion shall be repaired biannually or after a major storm event. 2 crew members, 3 visits per year, 1 hour per visit, 6 man hours per year. Assume annual cost of erosion repair materials of $246.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Capital Replacement Assumptions:**

Replacement of items highlighted in blue on estimate sheet every 10 years (i.e. riprap pads, gates, etc.)

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Ryan Oberg (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 18B_ Wetpond with Property Cost | | | **Version:** | 2 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | ***Pond Upper Cell #1 (Sediment)*** | 4 | FT Depth | $ - | $ - |
| 2 | ***Bottom Area @ 1/3 Volume of Wetpond Facility*** | 40 | SF | $ - | $ - |
| 3 | ***Top Area@ 3:1 Side Slopes*** | 928 | SF | $ - | $ - |
| 4 | Facility Excavation to Waste @ 4 ft 'D + Sub-exc. for Liner | 140 | CY | $ 79 | $ 11,095 |
| 5 | Imported Treatment Liner @ 2' thick | 69 | CY | $ 105 | $ 7,218 |
| 6 | | | | $ - | $ - |
| 7 | ***Wetpond Excavation Volume (16.7'W X 33.3'L X 4'D)*** | 4 | FT Depth | $ - | $ - |
| 8 | ***Bottom Area @ 3:1 Side Slopes*** | 553 | SF | $ - | $ - |
| 9 | ***Top Area@ 3:1 Side Slopes*** | 2329 | SF | $ - | $ - |
| 10 | Facility Excavation to Waste @ 4 ft 'D + Sub-exc. for Liner | 386 | CY | $ 79 | $ 30,494 |
| 11 | Imported Fill for Compacted Berm Embankment - Between First & Second Cell (@244 LF and 45 sq ft./ft cross section area) | 407 | CY | $ 44 | $ 17,893 |
| 12 | Embankment Compaction | 407 | CY | $ 22 | $ 8,947 |
| 13 | Imported Treatment Liner @ 2' thick | 173 | CY | $ 105 | $ 18,114 |
| 14 | Riprap Lining for Pre-settling and Infiltration Pond Overflow Spillways (6'WX12'LX2'D) | 11 | CY | $ 346 | $ 3,691 |
| 15 | Access Roadway to site (4" HMA/4" CSBC) | 267 | SY | $ 71 | $ 18,933 |
| 16 | Access Gate (16 ft wide gate) | 1 | EA | $ 3,085 | $ 3,085 |
| 17 | | | | $ - | $ - |
| 18 | **Outlet Pipe** | | | $ - | $ - |
| 19 | Pipe - 12" PVC | 100 | LF | $ 140 | $ 14,000 |
| 20 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 21 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 22 | Control Structure with grate, clean out drain, and gate | 1 | EA | $ 24,860 | $ 24,860 |
| 23 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 24 | Pipe Discharge Rock Lining Riprap (12' Long by 8' wide x 2 ft thick) | 7 | SF | $ 346 | $ 2,460 |
| 25 | Debris Barrier | 1 | EA | $ 14,808 | $ 14,808 |
| 26 | | | | $ - | $ - |
| 27 | **Inlet Pipe** | | | $ - | $ - |
| 28 | Pipe - 12" PVC | 100 | LF | $ 140 | $ 14,000 |
| 29 | 5' Wide Trench x 6'D to waste | 111 | CY | $ 79 | $ 8,778 |
| 30 | Trench Box Shoring (Shallow) | 1,200 | SF | $ 10 | $ 12,000 |
| 31 | Imported Backfill | 108 | CY | $ 44 | $ 4,761 |
| 32 | Pipe Discharge Rock Lining Riprap (12' Long by 8' wide x 2 ft thick) | 7 | SF | $ 346 | $ 2,460 |
| 33 | Catch Basin Structure (spill control) | 1 | EA | $ 3,900 | $ 3,900 |
| 34 | | | | $ - | $ - |
| 35 | **Restoration** | | | $ - | $ - |
| 36 | Disking or tilling of compacted soil (assumed 100'X100' construction staging/stockpiling) | 1,556 | SY | $ 4 | $ 6,222 |
| 37 | Seeding, mulching and compost (Emergent, Riparian & Upland) facility + staging | 1,814 | SY | $ 10 | $ 18,143 |
| 38 | Plantings (Emergent & Riparian) | 454 | SY | $ 19 | $ 8,618 |
| 39 | Trees (both sides of the facility and opportunistic areas) | 15 | EA | $ 720 | $ 10,800 |
| 40 | | | | $ - | $ - |
| 41 | | | | | $ - |
| 42 | **Additional Costs** | | | | $ - |
| 43 | Removals @ 4% Construction Costs | 4.0% | LS | $ 290,820 | $ 11,633 |
| 44 | TESC @2% Construction Costs | 2% | LS | $ 302,453 | $ 6,049 |
| | | | | | $ - |
| | ***Item Subtotal Construction Costs (Year 2023)*** | | | | $ 308,502 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | General Conditions | | 0% | 1 | $ - |
| | Mobilization/Demobilization | | 10% | 1.1 | $ 30,850 |
| | Overhead & Profit (OHP) | | 0% | 1 | $ - |
| | Insurance | | 0.0% | 1 | $ - |
| | Bonding | | 0.0% | 1 | $ - |
| | Escalation Multiplier from ENR-CCI | | 0% | 1.0000 | $ - |
| | ***Item Subtotal Construction Costs (Year 2023)*** | | | | $ 339,352 |
| | ***Direct: Subtotal Construction Costs (553 SF Area)*** | | | | ***$ 339,352*** |

**Description: WQBE 18B_ Wetpond with Property Cost**

Constructed stormwater pond that retains a permanent pool of water ("wetpool") at least during the wet season. Wetpool volume is related to the pond's effectiveness in settling particulate pollutants.

**Cost Estimating Assumptions:**

The Wetpond is designed in accordance with the King Co. Surface Water Design Manual (KC SWDM) Section 6.4.1 and is generally as described below:
The wetpond has a bottom area of 553 sf and has a storage depth of 4 feet deep (48 inches).
The pond storage volume is generally located below grade.
The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 33.3 ft. width and is 16.7 ft. in length.
The facility is assumed to be lined with a 2 ft. deep treatment liner in accordance with KC SWDM Section 6.2.4.
The length to width ratio is less than 4:1 and a dividing berm is required. In accordance with Section 6.4 design recommendations, the wetpool will have 2 cells, with the upper cell designed to accommodate sediment storage.
The first wetpool cell is sized to approximately 1/3 of the required storage volume of the second wet pool storage. The pool is designed to meet the 4 foot minimum required depth.
The pond is constructed with 3:1 side slopes.
The design includes 1 foot for freeboard.
A min 72" Dia. flow control maintenance hole with a cone grate, clean out drain and gate that meets the requirements of Section 6.1.4.2 and Section 5.1.4 is provided at the facility outlet.

A minimum of a 54" Type 2 CB spill control structure that meets the requirements of section 4.2.1 and section 5.1.4.A is assumed for the inflow pipe.
A spillway is provided between pond cell 1 and pond cell 2 and an emergency overflow spillway is included.
Both the pond and emergency spillways are 12 ft. long w/ a slope of 3:1, H:V.
The spillways are riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.
The infiltration pond includes a compacted berm that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content

Approximately 100 feet of 12-inch and 100 feet of 12-inch diameter pipes are included for upstream and downstream conveyance.
It is assumed that dewatering will not be required.
Trench Box shoring for pipe installation.
A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.
Property is assumed to be existing open space without building or pavement removal.
Fencing is not included in the estimate, a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced.
Disturbed areas are seeded and it is assumed that a portion of the area has plantings.
The pond is tree-lined along both sides (length) and at opportunistic locations per KC Section 6.4.
The pond is located on property and real estate acquisition and easements are required.
Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to Medium.

**Planning Basis Assumptions:**
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**
All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**
This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Andrew Staples (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_19A_WetVault on Public Property | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Wet Vault (1615 sf @ 4 ft. Storage Depth) | 1 | EA | $ 2,048,600 | $ 2,048,600 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 2,048,600*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 409,720 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 2,458,320*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 245,832 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 2,704,152*** |
| | | | | Construction Sales Tax | $ 277,176 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 2,981,300*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 594,913 |
| | | | | Construction Management | $ 270,415 |
| | | | | Permitting & Support | $ 27,042 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 162,249 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,054,619*** |
| | | | | Project Contingency | $ 1,210,776 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 2,265,400*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 5,246,700*** |

**Description: WQBE_19A_WetVault on Public Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 5,246,700** | |
| Capital cost | $ 5,246,700 | $/Unit |
| Total Direct O&M/Year | $ 2,720 | |
| Direct O&M cost | $ 2,720 | $/Unit |
| Capital Replacement Costs (20 year equipment) | $ 56,900 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 5,333,600** | **$/unit** |
| **Annual O&M Cost** | **$ 3,100** | **$/year** |
| Annualized Cost | $660 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Cement Patching | 2023 dollars | $ 56 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $416 | |
| Labor | | | |
| Vactor to remove sediment and debris | 4 | hr | |
| Inspection and joint repair, crack repair | 16 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| **Total hours per year** | 20 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 1,088 | |
| Labor cost, burdened | O/H 150.0% | $ 2,720 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 19,791 | | $ 129,381 | **$5,452,773** | **$ 5,333,630** | | | |
| 0 | 1.000 | **$ 5,246,700** | | | $5,246,700 | $ 5,246,700 | $ 5,246,700 | $ 5,246,700 | $ 5,333,630 |
| 1 | 0.950 | $416 | $ - | $ 2,720 | $ 3,136 | $ 2,979 | $ 5,249,836 | $ 5,249,679 | $ 86,930 |
| 2 | 0.903 | $ 428 | $ - | $ 2,801 | $ 3,230 | $ 2,915 | $ 5,253,065 | $ 5,252,595 | $ 83,950 |
| 3 | 0.858 | $ 441 | $ - | $ 2,885 | $ 3,326 | $ 2,853 | $ 5,256,392 | $ 5,255,448 | $ 81,035 |
| 4 | 0.815 | $ 455 | $ - | $ 2,972 | $ 3,426 | $ 2,792 | $ 5,259,818 | $ 5,258,240 | $ 78,182 |
| 5 | 0.774 | $ 468 | $ - | $ 3,061 | $ 3,529 | $ 2,732 | $ 5,263,347 | $ 5,260,972 | $ 75,390 |
| 6 | 0.736 | $ 482 | $ - | $ 3,153 | $ 3,635 | $ 2,674 | $ 5,266,982 | $ 5,263,646 | $ 72,657 |
| 7 | 0.699 | $ 497 | $ - | $ 3,247 | $ 3,744 | $ 2,617 | $ 5,270,726 | $ 5,266,263 | $ 69,983 |
| 8 | 0.664 | $ 512 | $ - | $ 3,345 | $ 3,856 | $ 2,561 | $ 5,274,582 | $ 5,268,824 | $ 67,367 |
| 9 | 0.631 | $ 527 | $ - | $ 3,445 | $ 3,972 | $ 2,506 | $ 5,278,554 | $ 5,271,330 | $ 64,806 |
| 10 | 0.599 | $ 543 | $ - | $ 3,548 | $ 4,091 | $ 2,453 | $ 5,282,645 | $ 5,273,783 | $ 62,300 |
| 11 | 0.570 | $ 559 | $ - | $ 3,655 | $ 4,214 | $ 2,400 | $ 5,286,859 | $ 5,276,183 | $ 59,847 |
| 12 | 0.541 | $ 576 | $ - | $ 3,764 | $ 4,340 | $ 2,349 | $ 5,291,199 | $ 5,278,531 | $ 57,447 |
| 13 | 0.514 | $ 593 | $ - | $ 3,877 | $ 4,470 | $ 2,299 | $ 5,295,670 | $ 5,280,830 | $ 55,098 |
| 14 | 0.489 | $ 611 | $ - | $ 3,994 | $ 4,605 | $ 2,249 | $ 5,300,274 | $ 5,283,080 | $ 52,799 |
| 15 | 0.464 | $ 629 | $ - | $ 4,113 | $ 4,743 | $ 2,201 | $ 5,305,017 | $ 5,285,281 | $ 50,550 |
| 16 | 0.441 | $ 648 | $ - | $ 4,237 | $ 4,885 | $ 2,154 | $ 5,309,902 | $ 5,287,435 | $ 48,349 |
| 17 | 0.419 | $ 668 | $ - | $ 4,364 | $ 5,032 | $ 2,108 | $ 5,314,933 | $ 5,289,544 | $ 46,194 |
| 18 | 0.398 | $ 688 | $ - | $ 4,495 | $ 5,183 | $ 2,063 | $ 5,320,116 | $ 5,291,607 | $ 44,086 |
| 19 | 0.378 | $ 708 | $ - | $ 4,630 | $ 5,338 | $ 2,019 | $ 5,325,454 | $ 5,293,626 | $ 42,023 |
| 20 | 0.359 | $ 729 | $ 56,900 | $ 4,769 | $ 62,398 | $ 22,425 | $ 5,387,852 | $ 5,316,051 | $ 40,004 |
| 21 | 0.341 | $ 751 | $ - | $ 4,912 | $ 5,663 | $ 1,934 | $ 5,393,515 | $ 5,317,984 | $ 17,579 |
| 22 | 0.324 | $ 774 | $ - | $ 5,059 | $ 5,833 | $ 1,892 | $ 5,399,348 | $ 5,319,877 | $ 15,645 |
| 23 | 0.308 | $ 797 | $ - | $ 5,211 | $ 6,008 | $ 1,852 | $ 5,405,356 | $ 5,321,729 | $ 13,753 |
| 24 | 0.293 | $ 821 | $ - | $ 5,367 | $ 6,188 | $ 1,812 | $ 5,411,544 | $ 5,323,541 | $ 11,901 |
| 25 | 0.278 | $ 846 | $ - | $ 5,528 | $ 6,374 | $ 1,774 | $ 5,417,918 | $ 5,325,315 | $ 10,089 |
| 26 | 0.264 | $ 871 | $ - | $ 5,694 | $ 6,565 | $ 1,736 | $ 5,424,483 | $ 5,327,050 | $ 8,315 |
| 27 | 0.251 | $ 897 | $ - | $ 5,865 | $ 6,762 | $ 1,699 | $ 5,431,245 | $ 5,328,749 | $ 6,579 |
| 28 | 0.239 | $ 924 | $ - | $ 6,041 | $ 6,965 | $ 1,662 | $ 5,438,210 | $ 5,330,411 | $ 4,881 |
| 29 | 0.227 | $ 952 | $ - | $ 6,222 | $ 7,174 | $ 1,627 | $ 5,445,384 | $ 5,332,038 | $ 3,219 |
| 30 | 0.215 | $ 980 | $ - | $ 6,409 | $ 7,389 | $ 1,592 | $ 5,452,773 | $ 5,333,630 | $ 1,592 |

**Description: WQBE_19A_WetVault on Public Property**

A wetvault is an underground structure similar to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**

4 Trash, debris and sediment shall be removed annually from areas in the wet vault where accumulation may occur. 2 crew members, 1 visit per year, 2 hours per visit; assume use of vactor truck, total of 4 man hours per year.

16 Vault inlets, outlets, cracks wider than 1/2 inch, shall be inspected and/or repaired annually. 2 crew members, 1 visit per year, 8 hours per visit, total of 16 man hours per year. Assume annual cost for cement patching mix of $56.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Capital Replacement Assumptions:**

Complete replacement of mechanical equipment every twenty years (outlet structure and baffle) and access hatch. Items will include those highlighted in blue on the cost estimate sheet .

| Estimate - AACEI Class 10 | | | |
|---|---|---|---|
| Project Name: | King County Water Quality Benefits Evaluation | Date: | 6/7/2024 |
| Location: | King County, WA | Estimator: | Troy Gibbs (HDR)<br>Andrew Staples (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| Description: | WQBE_19A_WetVault on Public Property | Version: | 2 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Wet Vault on Public Property** | | | | $ - |
| 2 | ***Vault Assumptions*** | | | | $ - |
| 3 | *Exterior Length* | 83 | FT | | $ - |
| 4 | *Interior Length* | 80 | FT | | $ - |
| 5 | *Sump Length* | 4 | FT | | $ - |
| 6 | *Sump Wall Width* | 20 | FT | | $ - |
| 7 | *Sump Interior Depth* | 4 | FT | | $ - |
| 8 | *Sump Wall Total Length* | 54 | FT | | $ - |
| 9 | *Exterior Width* | 23 | FT | | $ - |
| 10 | *Interior Width* | 20.2 | FT | | $ - |
| 11 | *Interior Structure Height (Ave.)* | 7.3 | FT | | $ - |
| 12 | *Storage Depth (Ave)* | 4.0 | FT | | $ - |
| 13 | *Sediment Storage Depth* | 1.0 | FT | | $ - |
| 14 | *Freeboard (Ave.)* | 2.3 | FT | | $ - |
| 15 | *Storage Facility Exterior Footprint Area* | 1,925 | SF | | $ - |
| 16 | | | | | $ - |
| 17 | ***Storage Volume*** | | | | $ - |
| 18 | *Storage Facility interior Area* | 1,615 | SF | | $ - |
| 19 | *Effective Storage Volume (15.500 cf target)* | 6,460 | CF | | $ - |
| 20 | *Vault Storage Volume* | 0.05 | MG | | $ - |
| 21 | | | | | $ - |
| 22 | ***Structure Concrete Assumptions*** | | | | $ - |
| 23 | *Exterior Wall thickness* | 1.5 | FT | | $ - |
| 24 | *Sump Wall Thickness* | 1.5 | FT | | $ - |
| 25 | *Top Slab Thickness* | 2 | FT | | $ - |
| 26 | *Foundation Slab thickness* | 3 | FT | | $ - |
| 27 | *Concrete Reinforcing Rebar* | 225 | LB/CY | | $ - |
| 28 | *Crushed Base Thickness* | 1 | FT | | $ - |
| 29 | | | | | $ - |
| 30 | **Concrete Structure** | | | | $ - |
| 31 | Vault Interior Walls Concrete @2' Thick (partial for supports) | 5 | CY | $ 650 | $ 3,293 |
| 32 | Sump Wall Concrete | 12 | CY | $ 1,250 | $ 15,104 |
| 33 | Exterior Wall Concrete | 86 | CY | $ 1,250 | $ 107,662 |
| 34 | Top Slab Concrete | 143 | CY | $ 1,250 | $ 178,200 |
| 35 | Foundation Slab Concrete | 214 | CY | $ 950 | $ 203,148 |
| 36 | Stormwater Treatment Rebar @ 225 lbs/cy | 103,428 | LBS | $ 1.38 | $ 142,731 |
| 37 | Crushed Base | 71 | CY | $ 64 | $ 4,562 |
| 38 | | | | | $ - |
| 39 | ***Shoring and Excavation Assumptions*** | | | | $ - |
| 40 | *Construction Room* | 3 | FT | | $ - |
| 41 | *Tank Bury Depth* | 2 | FT | | $ - |
| 42 | *Total Excavation Depth* | 15 | FT | | $ - |
| 43 | *Excavation Length* | 93 | FT | | $ - |
| 44 | *Excavation Width* | 33 | FT | | $ - |
| 45 | | | | | $ - |
| 46 | **Soil Excavation and Disposal** | | | | $ - |
| 47 | Excavation | 1,749 | CY | $ 79 | $ 138,170 |
| 51 | Imported Structure Backfill | 801 | CY | $ 44 | $ 35,242 |
| 52 | | | | | $ - |
| 53 | | | | | $ - |
| 54 | **Solder Pile Shoring** | | | | $ - |
| 55 | *Solder Pile Shaft Depth (3 x Exc. Depth)* | 46 | FT | | $ - |
| 56 | *Solder Pile Shaft Thickness* | 2 | FT | | $ - |
| 57 | *Center to Center Shaft Spacing* | 6 | FT | | $ - |
| 58 | *Rebar in Shaft* | 114 | LB/CY | | $ - |
| 59 | *Shoring Wall Perimeter* | 244 | FT | | $ - |
| 60 | *Number of Shafts* | 41 | EA | | $ - |
| 61 | Drill Solder Pile Shafts | 219 | CY | $ 262 | $ 57,370 |
| 62 | Set Solder Pile and CDF | 219 | CY | $ 391 | $ 85,617 |
| 63 | Purchase and Salvage Solder Piles | 214,537 | LB | $ 0.7 | $ 150,176 |
| 64 | Tie Backs - one per soldier pile except corners | 37 | EA | $ 2,477 | $ 91,649 |
| 65 | Timber Lagging (64'W X 70'L @ approx. 20'H) | 13,098 | BF | $ 9 | $ 117,884 |
| 66 | | | | | $ - |
| 67 | **Gates and Access** | | | | $ - |
| 68 | Flow Restrictor | 1 | EA | $ 24,600 | $ 24,600 |
| 69 | Confined Space Safety | 1 | LS | $ 32,595 | $ 32,595 |
| 70 | Access Hatches | 2 | EA | $ 13,038 | $ 26,076 |
| 71 | | | | | $ - |
| 72 | **Conveyance Pipe** | | | | $ - |
| 73 | 12" Storm Pipe (upstream and discharge) | 200 | LF | $ 140 | $ 28,000 |
| 74 | Trench Excavation to waste (8'W X 15'D) | 889 | CY | $ 79 | $ 70,222 |
| 75 | Trench Box Shoring | 6,000 | SF | $ 10 | $ 60,000 |
| 76 | 48" Diameter Maintenance holes | 4 | EA | $ 10,640 | $ 42,560 |
| 77 | Imported Backfill | 883 | CY | $ 44 | $ 38,855 |
| 78 | Dewater Trench - Sumps | 200 | LF | $ 139 | $ 27,800 |
| 79 | Demolish Surface incl. room for construction (@20' wide) | 444 | SY | $ 14 | $ 6,222 |
| 80 | Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100') | 444 | SY | $ 71 | $ 31,556 |
| 81 | | | | | $ - |
| 82 | | | | | $ - |
| 83 | **Site Removals and Restoration** | | | | $ - |
| 84 | Disking or tilling of compacted soil (assumed 100'X100') | 514 | SY | $ 4 | $ 2,058 |
| 85 | Seeding, mulching and compost | 514 | SY | $ 10 | $ 5,144 |
| 86 | Demolish Existing Surface | 343 | SY | $ 14 | $ 4,801 |
| 87 | Pavement Restoration (Vault) - 4" HMA/4"CSBC | 343 | SY | $ 71 | $ 24,349 |
| 88 | | | | | |
| 89 | Removals at 4% Construction Costs | 4.0% | LS | $ 1,755,646 | $ 70,226 |
| 90 | TESC at 2% of Construction | 2% | LS | $ 1,825,872 | $ 36,517 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 1,862,389 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 186,239 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 2,048,628 |
| | | ***Direct: Subtotal Construction Costs*** | ***$ 2,048,600*** |

**Description: WQBE 19A_WetVault on Public Property**

A wetvault is an underground structure similar to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants.

**Cost Estimating Assumptions:**

Wetvault design basis is per KCSWDM, "Wetvaults" (Chapter 6, Section 6.4.2).
It is assumed that no agency mitigation costs will be required.
The vault is an online storage facility and does not include flow control.
The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.

The vault is an underground cast in place concrete structure with an interior storage area of 1,615 s.f. and a maximum storage depth of 4 feet deep.

The vault is assumed to drain by gravity and has an effective storage of approximately 0.05 MG.
Vault has average interior dimensions of 20.2'W x 80'L x 7.3'H.
The minimum vault height is 7 feet deep at the shallowest end.

The vault floor side slopes are a minimum of 5% towards the center of the vault.

The vault is a flow through system with a minimum of 2 feet above the outlet flow control device (orifice) to retain oil within the vault.

An average of 1 foot of additional storage depth is provided for sediment storage.
Exterior and interior wall thickness is 1.5 feet.
Top slab thickness is 2 feet
Base/Ballast slab thickness is 3 feet (sized to counteract buoyancy)
There is a 1 foot layer of crushed base beneath the base/ballast slab.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth
The vault is positively anchored to the shoring piles.
Vault is designed for traffic loading.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
Two maintenance hole access with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.
Shoring and Lagging is required for construction of the structure.
A total of 200' of 12" diameter pipe is assumed for connection to the upstream and downstream mains.
The storage vault, facility inlet and outlet pipes are sited beneath a parking area.
Parking lot restoration is assumed to consist of 4" HMA / 4" CSTC.
Concrete curb, gutter, and sidewalk removal and restoration will not be required for the installation.
Removals are estimated at 4% of the item construction costs, in conformance with LTCP GSI cost estimates.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
Construction occurs outside of the right-of-way and no traffic control or street use permits are required.
The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Andrew Staples (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR) |
| **Description:** | WQBE 19B_WetVault in ROW | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Wet Vault (1615 sf @ 4 ft. Storage Depth) | 1 | EA | $ 2,091,200 | $ 2,091,200 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 2,091,200*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 418,240 |
| | | | Street Use Permit (Y/N) | Y | $ 90,000 |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 2,599,440*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 250,944 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 2,850,384*** |
| | | | | Construction Sales Tax | $ 282,939 |
| | | | | Outside Agency Construction | $ 209,120 |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 3,342,400*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 627,084 |
| | | | | Construction Management | $ 285,038 |
| | | | | Permitting & Support | $ 28,504 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 171,023 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,111,650*** |
| | | | | Project Contingency | $ 1,336,215 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 2,447,900*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 5,790,300*** |

**Description: WQBE 19B_WetVault in ROW (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 5,790,300** | |
| Capital cost | $ 5,790,300 | $/Unit |
| Total Direct O&M/Year | $ 2,720 | |
| Direct O&M cost | $ 2,720 | $/Unit |
| Capital Replacement Costs (20 year equipment) | $ 56,900 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 5,877,200** | **$/unit** |
| **Annual O&M Cost** | **$ 3,100** | **$/year** |
| Annualized Cost | $660 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Cement Patching | 2023 dollars | $ 56 | $/year |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year |
| Subtotal | | $416 | |
| Labor | | | |
| Vactor to remove sediment and debris | 4 | hr | |
| Inspection and joint repair, crack repair | 16 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| **Total hours per year** | 20 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 1,088 | |
| Labor cost, burdened | O/H 150.0% | $ 2,720 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 19,791 | | $ 129,381 | **$5,996,373** | **$ 5,877,230** | | | |
| 0 | 1.000 | **$ 5,790,300** | | | $5,790,300 | $ 5,790,300 | $ 5,790,300 | $ 5,790,300 | $ 5,877,230 |
| 1 | 0.950 | $416 | $ - | $ 2,720 | $ 3,136 | $ 2,979 | $ 5,793,436 | $ 5,793,279 | $ 86,930 |
| 2 | 0.903 | $ 428 | $ - | $ 2,801 | $ 3,230 | $ 2,915 | $ 5,796,665 | $ 5,796,195 | $ 83,950 |
| 3 | 0.858 | $ 441 | $ - | $ 2,885 | $ 3,326 | $ 2,853 | $ 5,799,992 | $ 5,799,048 | $ 81,035 |
| 4 | 0.815 | $ 455 | $ - | $ 2,972 | $ 3,426 | $ 2,792 | $ 5,803,418 | $ 5,801,840 | $ 78,182 |
| 5 | 0.774 | $ 468 | $ - | $ 3,061 | $ 3,529 | $ 2,732 | $ 5,806,947 | $ 5,804,572 | $ 75,390 |
| 6 | 0.736 | $ 482 | $ - | $ 3,153 | $ 3,635 | $ 2,674 | $ 5,810,582 | $ 5,807,246 | $ 72,657 |
| 7 | 0.699 | $ 497 | $ - | $ 3,247 | $ 3,744 | $ 2,617 | $ 5,814,326 | $ 5,809,863 | $ 69,983 |
| 8 | 0.664 | $ 512 | $ - | $ 3,345 | $ 3,856 | $ 2,561 | $ 5,818,182 | $ 5,812,424 | $ 67,367 |
| 9 | 0.631 | $ 527 | $ - | $ 3,445 | $ 3,972 | $ 2,506 | $ 5,822,154 | $ 5,814,930 | $ 64,806 |
| 10 | 0.599 | $ 543 | $ - | $ 3,548 | $ 4,091 | $ 2,453 | $ 5,826,245 | $ 5,817,383 | $ 62,300 |
| 11 | 0.570 | $ 559 | $ - | $ 3,655 | $ 4,214 | $ 2,400 | $ 5,830,459 | $ 5,819,783 | $ 59,847 |
| 12 | 0.541 | $ 576 | $ - | $ 3,764 | $ 4,340 | $ 2,349 | $ 5,834,799 | $ 5,822,131 | $ 57,447 |
| 13 | 0.514 | $ 593 | $ - | $ 3,877 | $ 4,470 | $ 2,299 | $ 5,839,270 | $ 5,824,430 | $ 55,098 |
| 14 | 0.489 | $ 611 | $ - | $ 3,994 | $ 4,605 | $ 2,249 | $ 5,843,874 | $ 5,826,680 | $ 52,799 |
| 15 | 0.464 | $ 629 | $ - | $ 4,113 | $ 4,743 | $ 2,201 | $ 5,848,617 | $ 5,828,881 | $ 50,550 |
| 16 | 0.441 | $ 648 | $ - | $ 4,237 | $ 4,885 | $ 2,154 | $ 5,853,502 | $ 5,831,035 | $ 48,349 |
| 17 | 0.419 | $ 668 | $ - | $ 4,364 | $ 5,032 | $ 2,108 | $ 5,858,533 | $ 5,833,144 | $ 46,194 |
| 18 | 0.398 | $ 688 | $ - | $ 4,495 | $ 5,183 | $ 2,063 | $ 5,863,716 | $ 5,835,207 | $ 44,086 |
| 19 | 0.378 | $ 708 | $ - | $ 4,630 | $ 5,338 | $ 2,019 | $ 5,869,054 | $ 5,837,226 | $ 42,023 |
| 20 | 0.359 | $ 729 | $ 56,900 | $ 4,769 | $ 62,398 | $ 22,425 | $ 5,931,452 | $ 5,859,651 | $ 40,004 |
| 21 | 0.341 | $ 751 | $ - | $ 4,912 | $ 5,663 | $ 1,934 | $ 5,937,115 | $ 5,861,584 | $ 17,579 |
| 22 | 0.324 | $ 774 | $ - | $ 5,059 | $ 5,833 | $ 1,892 | $ 5,942,948 | $ 5,863,477 | $ 15,645 |
| 23 | 0.308 | $ 797 | $ - | $ 5,211 | $ 6,008 | $ 1,852 | $ 5,948,956 | $ 5,865,329 | $ 13,753 |
| 24 | 0.293 | $ 821 | $ - | $ 5,367 | $ 6,188 | $ 1,812 | $ 5,955,144 | $ 5,867,141 | $ 11,901 |
| 25 | 0.278 | $ 846 | $ - | $ 5,528 | $ 6,374 | $ 1,774 | $ 5,961,518 | $ 5,868,915 | $ 10,089 |
| 26 | 0.264 | $ 871 | $ - | $ 5,694 | $ 6,565 | $ 1,736 | $ 5,968,083 | $ 5,870,650 | $ 8,315 |
| 27 | 0.251 | $ 897 | $ - | $ 5,865 | $ 6,762 | $ 1,699 | $ 5,974,845 | $ 5,872,349 | $ 6,579 |
| 28 | 0.239 | $ 924 | $ - | $ 6,041 | $ 6,965 | $ 1,662 | $ 5,981,810 | $ 5,874,011 | $ 4,881 |
| 29 | 0.227 | $ 952 | $ - | $ 6,222 | $ 7,174 | $ 1,627 | $ 5,988,984 | $ 5,875,638 | $ 3,219 |
| 30 | 0.215 | $ 980 | $ - | $ 6,409 | $ 7,389 | $ 1,592 | $ 5,996,373 | $ 5,877,230 | $ 1,592 |

**Description: WQBE 19B_WetVault in ROW**

A wetvault is an underground structure similar to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Trash, debris and sediment shall be removed annually from areas in the wet vault where accumulation may occur. 2 crew members, 1 visit per year, 2 hours per visit; assume use of vactor truck, total of 4
4 man hours per year.

Vault inlets, outlets, cracks wider than 1/2 inch, shall be inspected and/or repaired annually. 2 crew members, 1 visit per year, 8 hours per visit, total of 16 man hours per year. Assume annual cost for
16 cement patching mix of $56.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

**Capital Replacement Assumptions:**

Complete replacement of mechanical equipment every twenty years (outlet structure and baffle) and access hatch. Items will include those highlighted in blue on the cost estimate sheet .

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Andrew Staples (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE 19B_WetVault in ROW | | | **Version:** | 2 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | **Wet Vault in ROW** | | | | $ - |
| 2 | ***Vault Assumptions*** | | | | $ - |
| 3 | *Exterior Length* | 83 | FT | | $ - |
| 4 | *Interior Length* | 80 | FT | | $ - |
| 5 | *Sump Length* | 4 | FT | | $ - |
| 6 | *Sump Wall Width* | 20 | FT | | $ - |
| 7 | *Sump Interior Depth* | 4 | FT | | $ - |
| 8 | *Sump Wall Total Length* | 54 | FT | | $ - |
| 9 | *Exterior Width* | 23 | FT | | $ - |
| 10 | *Interior Width* | 20.2 | FT | | $ - |
| 11 | *Interior Structure Height (Ave.)* | 7.3 | FT | | $ - |
| 12 | *Storage Depth (Ave)* | 4.0 | FT | | $ - |
| 13 | *Sediment Storage Depth* | 1.0 | FT | | $ - |
| 14 | *Freeboard (Ave.)* | 2.3 | FT | | $ - |
| 15 | *Storage Facility Exterior Footprint Area* | 1,925 | SF | | $ - |
| 16 | | | | | $ - |
| 17 | ***Storage Volume*** | | | | $ - |
| 18 | *Storage Facility interior Area* | 1,615 | SF | | $ - |
| 19 | *Effective Storage Volume (15.500 cf target)* | 6,460 | CF | | $ - |
| 20 | *Vault Storage Volume* | 0.05 | MG | | $ - |
| 21 | | | | | $ - |
| 22 | ***Structure Concrete Assumptions*** | | | | $ - |
| 23 | *Exterior Wall thickness* | 1.5 | FT | | $ - |
| 24 | *Sump Wall Thickness* | 1.5 | FT | | $ - |
| 25 | *Top Slab Thickness* | 2 | FT | | $ - |
| 26 | *Foundation Slab thickness* | 3 | FT | | $ - |
| 27 | *Concrete Reinforcing Rebar* | 225 | LB/CY | | $ - |
| 28 | *Crushed Base Thickness* | 1 | FT | | $ - |
| 29 | | | | | $ - |
| 30 | **Concrete Structure** | | | | $ - |
| 31 | Vault Interior Walls Concrete @2' Thick (partial for supports) | 5 | CY | $ 650 | $ 3,293 |
| 32 | Sump Wall Concrete | 12 | CY | $ 1,250 | $ 15,104 |
| 33 | Exterior Wall Concrete | 86 | CY | $ 1,250 | $ 107,662 |
| 34 | Top Slab Concrete | 143 | CY | $ 1,250 | $ 178,200 |
| 35 | Foundation Slab Concrete | 214 | CY | $ 950 | $ 203,148 |
| 36 | Structure Rebar @ 225 lbs/cy | 103,428 | LBS | $ 1.38 | $ 142,731 |
| 37 | Crushed Base | 71 | CY | $ 64 | $ 4,562 |
| 38 | | | | | $ - |
| 39 | ***Shoring and Excavation Assumptions*** | | | | $ - |
| 40 | *Construction Room* | 3 | FT | | $ - |
| 41 | *Tank Bury Depth* | 2 | FT | | $ - |
| 42 | *Total Excavation Depth* | 15 | FT | | $ - |
| 43 | *Excavation Length* | 93 | FT | | $ - |
| 44 | *Excavation Width* | 33 | FT | | $ - |
| 45 | | | | | $ - |
| 46 | **Soil Excavation and Disposal** | | | | $ - |
| 47 | Excavation | 1,749 | CY | $ 79 | $ 138,170 |
| 51 | Imported Structure Backfill | 801 | CY | $ 44 | $ 35,242 |
| 52 | | | | | $ - |
| 53 | | | | | $ - |
| 54 | **Solder Pile Shoring** | | | | $ - |
| 55 | *Solder Pile Shaft Depth (3 x Exc. Depth)* | 46 | FT | | $ - |
| 56 | *Solder Pile Shaft Thickness* | 2 | FT | | $ - |
| 57 | *Center to Center Shaft Spacing* | 6 | FT | | $ - |
| 58 | *Rebar in Shaft* | 114 | LB/CY | | $ - |
| 59 | *Shoring Wall Perimeter* | 244 | FT | | $ - |
| 60 | *Number of Shafts* | 41 | EA | | $ - |
| 61 | Drill Solder Pile Shafts | 219 | CY | $ 262 | $ 57,370 |
| 62 | Set Solder Pile and CDF | 219 | CY | $ 391 | $ 85,617 |
| 63 | Purchase and Salvage Solder Piles | 214,537 | LB | $ 0.7 | $ 150,176 |
| 64 | Tie Backs - one per soldier pile except corners | 37 | EA | $ 2,477 | $ 91,649 |
| 65 | Timber Lagging (64'W X 70'L @ approx. 20'H) | 13,098 | BF | $ 9 | $ 117,884 |
| 66 | | | | | $ - |
| 67 | **Gates and Access** | | | | $ - |
| 68 | Flow Restrictor | 1 | EA | $ 24,600 | $ 24,600 |
| 69 | Confined Space Safety | 1 | LS | $ 32,595 | $ 32,595 |
| 70 | Access Hatches | 2 | EA | $ 13,038 | $ 26,076 |
| 71 | | | | | $ - |
| 72 | **Conveyance Pipe** | | | | $ - |
| 73 | 12" DI Storm Pipe (upstream and discharge) | 200 | LF | $ 210 | $ 42,000 |
| 74 | Trench Excavation to waste (8'W X 15'D) | 889 | CY | $ 79 | $ 70,222 |
| 75 | Trench Box Shoring | 6,000 | SF | $ 10 | $ 60,000 |
| 76 | 48" Diameter Maintenance Hole | 4 | EA | $ 10,640 | $ 42,560 |
| 77 | Imported Backfill | 883 | CY | $ 44 | $ 38,855 |
| 78 | Dewater Trench - Sumps | 200 | LF | $ 139 | $ 27,800 |
| 79 | Demolish Surface incl. room for construction (@20' wide) | 444 | SY | $ 14 | $ 6,222 |
| 80 | Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100') | 444 | SY | $ 71 | $ 31,556 |
| 81 | | | | | $ - |
| 82 | **Site Removals and Restoration** | | | | $ - |
| 83 | Road Restoration - 6" HMA/6"CSBC | 343 | SY | $ 110 | $ 37,723 |
| 84 | Sidewalk Est. one side x 5' Wide | 56 | SY | $ 125 | $ 6,944 |
| 85 | Planting Strip Est one side x 8' Wide | 89 | SY | $ 10 | $ 875 |
| 86 | Landscape/Lawn Restoration | 89 | SY | $ 59 | $ 5,248 |
| 87 | Irrigation System Repair est @ 10% Landscape/Lawn | 10% | LS | $ 5,248 | $ 525 |
| 88 | Trees both new and replacements Est @ 4 per 100' | 4 | EA | $ 720 | $ 2,880 |
| 89 | Demolish Existing Surface | 343 | SY | $ 14 | $ 4,640 |
| 90 | | | | | |
| 91 | Removals at 4% Construction Costs | 4.0% | LS | $ 1,792,129 | $ 71,685 |
| 92 | TESC at 2% of Construction | 2% | LS | $ 1,863,815 | $ 37,276 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 1,901,091 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 190,109 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 2,091,200 |
| ***Direct: Subtotal Construction Costs*** | | | ***$ 2,091,200*** |

**Description: WQBE 19B_WetVault in ROW**

A wetvault is an underground structure similar to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants.

**Cost Estimating Assumptions:**

Wetvault design basis is per KCSWDM, "Wetvaults" (Chapter 6, Section 6.4.2).
The vault is an online storage facility and does not include flow control.
The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.

The vault is an underground cast in place concrete structure with an interior storage area of 1,615 s.f. and a maximum storage depth of 4 feet deep.

The vault is assumed to drain by gravity and has an effective storage of approximately 0.05 MG.
Vault has average interior dimensions of 20.2'W x 80'L x 7.3'H.
The minimum vault height is 7 feet deep at the shallowest end.
The vault side slopes are a minimum of 5% towards the center of the vault.
The vault is a flow through system with a minimum of 2 feet above the outlet flow control device (orifice) to retain oil within the vault.
An average of 1 foot of additional storage depth is provided for sediment storage.
Exterior and interior wall thickness is 2=1.5 feet.
Top slab thickness is 2 feet
Base/Ballast slab thickness is 3 feet (sized to counteract buoyancy)
There is a 1 foot layer of crushed base beneath the base/ballast slab.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface. .
No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth
The vault is positively anchored to the shoring piles.
Vault is designed for traffic loading.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
Two maintenance hole access with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.

Shoring and Lagging is required for construction of the structure.
A total of 200' of 12" diameter pipe is assumed for connection to the upstream and downstream mains.
The storage vault, facility inlet and outlet pipes are sited beneath a the roadway in right-of-way.
Full width arterial roadway restoration is assumed, including the sidwalks and landscape areas on both sides of the roadway.
Removals are estimated at 4% of the item construction costs, in conformance with LTCP GSI cost estimates.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located in right-of-way and and traffic control is required.
A street use permit is required.
The installation is on public Right of Way and will not require easement and property acquisition.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Due to the facility width, utility relocation work is estimated at 10% of the total construction costs.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Troy Gibbs (HDR)<br>Andrew Staples (HDR)<br>Jeremy Hollingsworth (HDR)<br>Cindy Kinzer (HDR) |
| **Description:** | WQBE 19C_WetVault with Property Cost | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Wet Vault (1615 sf @ 4 ft. Storage Depth) | 1 | EA | $ 2,048,600 | $ 2,048,600 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 2,048,600*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 409,720 |
| | | | | Street Use Permit (Y/N) N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 2,458,320*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 245,832 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 2,704,152*** |
| | | | | Construction Sales Tax | $ 277,176 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 2,981,300*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 594,913 |
| | | | | Construction Management | $ 270,415 |
| | | | | Permitting & Support | $ 27,042 |
| 3822 | s.f. Land Area | Medium | Land Purchase/ROW Acquisition | | $ 307,403 |
| 4000 | s.f. Land Area | Low | Permanent Easements | | $ 40,400 |
| | | | | WTD Staff Costs & Non-WTD Support | $ 162,249 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,402,423*** |
| | | | | Project Contingency | $ 1,315,117 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 2,717,500*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 5,698,800*** |

Updated on: 06/07/24

Phase 2 Updated on: 5/6/21

| | | | | | | | PHASE 3 COSTS (2023 Dollars) | | | | | | | | PHASE 2 COSTS (2019 Dollars) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item No. | Action | Class | Complexity | Description | Sub-Action Number | Subcategory | Action Unit | Design Drainage Area | Total Direct Construction Cost | Property acquisition | Total Indirect Non-Construction Costs | Total Project Cost | O&M Costs (Annual) | Life Cycle Cost (NPV) | Action Unit | Total Direct Construction Cost | Property acquisition | Total Indirect Non-Construction Costs | Total Project Cost | O&M Costs (Annual) | Life Cycle Cost (NPV) |
| 22 | Regional Vegetated Media | Class 10 | Moderate | WQBE_22A_Regional Vegetated Media SW Facility on Public Property | 22A | On property without Acquisition | 5,940 SF | 17,249,760 SF | $4,021,600 | $0 | $3,672,400 | $7,694,000 | $11,300 | $8,006,000 | 5,940 SF | $2,965,000 | $0 | $3,073,000 | $6,038,000 | $12,000 | $6,562,000 |
| | | | | WQBE_22B_Regional Vegetated Media SW Facility With Property Cost | 22B | On Property with Acquisition | 5,940 SF | 17,249,760 SF | $4,021,600 | $583,580 | $4,431,000 | $8,452,600 | $11,300 | $8,764,600 | 5,940 SF | $2,965,000 | $910,760 | $4,259,000 | $7,224,000 | $12,000 | $7,741,000 |

| MANDATORY INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |
| Retail Sales Tax Rate | 10.25% | Current Rate within City of Seattle is 10.25%, 10.1% outside of Seattle |
| Allowance for Indeterminates (AFI), Dependenent Upon Project Phase | 25% | Complexity Inputs for AFI (High = 30%; Moderate = 25%; Routine = 20%; Low = 15%) |
| Construction Change Order Allowance | 10% | |
| Project Contingency | 30% | Complexity Inputs (Moderate, & Routine = 30%; Override for Low = 15%) |

| SECONDARY INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |
| Street Use Permit | $ 90,000 | In ROW only - Arterial @ $90,000/Unit; Non-Arterial @use $30000/unit |
| Outside Agency Construction | 2% | For Projects in ROW Utility coordination assumed to be at 2% construction cost. |

| PROJECT CATEGORY AND INDIRECT PROJECT INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |

**PROPERTY COST**

| Cost Category | $/sf |
| --- | --- |
| Low | $ 10.10 |
| Medium | $ 80.43 |
| High | $ 284.37 |
| None | $ - |

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Meaghan McGinn (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jeffrey Price (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_22A_Regional Vegetated Media SW Facility on Public Property | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Regional Vegetated Media SW Facility (5940 SF Area) | 1 | EA | $ 2,652,900 | $ 2,652,900 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 2,652,900*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 663,225 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 3,316,125*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 331,613 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 3,647,738*** |
| | | | | Construction Sales Tax | $ 373,893 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 4,021,600*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 1,021,367 |
| | | | | Construction Management | $ 474,206 |
| | | | | Permitting & Support | $ 72,955 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 328,296 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 1,896,824*** |
| | | | | Project Contingency | $ 1,775,527 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 3,672,400*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 7,694,000*** |

**Description: WQBE_22A_Regional Vegetated Media SW Facility on Public Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 7,694,000** | |
| Capital cost | $ 7,694,000 | $/Unit |
| Total Direct O&M/Year | $ 6,527 | |
| Direct O&M cost | $ 6,527 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 76,400 | $/unit |
| Discount rate (%) | 5.25 | |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 8,006,000** | **$/unit** |
| **Annual O&M Cost** | **$ 11,300** | **$/year** |
| Annualized Cost | $7,510 | $/year |

**Materials, Supplies, Other Costs**

| | | | | |
|---|---|---|---|---|
| Mulch | 2023 dollars | $ 2,215 | | |
| Annual plant replacement | 2023 dollars | $ 2,160 | $/year | |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year | |
| Subtotal | | $ 4,735 | | |
| Labor | | | | |
| Mulch Replacement | 16 | hr | | |
| Plant Health | 8 | hr | | |
| Removal of Debris with Vactor truck | 24 | hr | | |
| | 0 | hr | | |
| **Total hours per year** | 48 | | | |
| Raw Labor Rate/Hr | | $ 54 | | |
| Raw labor cost | (embedded) | $ 2,611 | | |
| Labor cost, burdened | O/H 150.0% | $ 6,527 | $ | 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | | |
| Life Cycle Period: | 30 | years | | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 225,270 | | $ 310,515 | **$8,382,585** | **$ 8,006,037** | | | |
| 0 | 1.000 | **$ 7,694,000** | | | $7,694,000 | $ 7,694,000 | $ 7,694,000 | $ 7,694,000 | $ 8,006,037 |
| 1 | 0.950 | $4,735 | $ - | $ 6,527 | $ 11,262 | $ 10,700 | $ 7,705,262 | $ 7,704,700 | $ 312,037 |
| 2 | 0.903 | $ 4,877 | $ - | $ 6,723 | $ 11,600 | $ 10,471 | $ 7,716,861 | $ 7,715,171 | $ 301,337 |
| 3 | 0.858 | $ 5,023 | $ - | $ 6,924 | $ 11,948 | $ 10,247 | $ 7,728,809 | $ 7,725,419 | $ 290,865 |
| 4 | 0.815 | $ 5,174 | $ - | $ 7,132 | $ 12,306 | $ 10,028 | $ 7,741,115 | $ 7,735,447 | $ 280,618 |
| 5 | 0.774 | $ 5,329 | $ - | $ 7,346 | $ 12,675 | $ 9,814 | $ 7,753,790 | $ 7,745,261 | $ 270,590 |
| 6 | 0.736 | $ 5,489 | $ - | $ 7,566 | $ 13,056 | $ 9,604 | $ 7,766,846 | $ 7,754,865 | $ 260,776 |
| 7 | 0.699 | $ 5,654 | $ - | $ 7,793 | $ 13,447 | $ 9,399 | $ 7,780,293 | $ 7,764,264 | $ 251,171 |
| 8 | 0.664 | $ 5,823 | $ - | $ 8,027 | $ 13,851 | $ 9,198 | $ 7,794,144 | $ 7,773,462 | $ 241,772 |
| 9 | 0.631 | $ 5,998 | $ - | $ 8,268 | $ 14,266 | $ 9,001 | $ 7,808,410 | $ 7,782,464 | $ 232,575 |
| 10 | 0.599 | $ 6,178 | $ 76,400 | $ 8,516 | $ 91,094 | $ 54,610 | $ 7,899,504 | $ 7,837,073 | $ 223,573 |
| 11 | 0.570 | $ 6,363 | $ - | $ 8,771 | $ 15,135 | $ 8,621 | $ 7,914,639 | $ 7,845,694 | $ 168,964 |
| 12 | 0.541 | $ 6,554 | $ - | $ 9,035 | $ 15,589 | $ 8,436 | $ 7,930,228 | $ 7,854,130 | $ 160,343 |
| 13 | 0.514 | $ 6,751 | $ - | $ 9,306 | $ 16,057 | $ 8,256 | $ 7,946,284 | $ 7,862,386 | $ 151,907 |
| 14 | 0.489 | $ 6,954 | $ - | $ 9,585 | $ 16,538 | $ 8,079 | $ 7,962,823 | $ 7,870,465 | $ 143,651 |
| 15 | 0.464 | $ 7,162 | $ - | $ 9,872 | $ 17,034 | $ 7,907 | $ 7,979,857 | $ 7,878,372 | $ 135,571 |
| 16 | 0.441 | $ 7,377 | $ - | $ 10,169 | $ 17,546 | $ 7,738 | $ 7,997,403 | $ 7,886,110 | $ 127,665 |
| 17 | 0.419 | $ 7,598 | $ - | $ 10,474 | $ 18,072 | $ 7,572 | $ 8,015,475 | $ 7,893,682 | $ 119,927 |
| 18 | 0.398 | $ 7,826 | $ - | $ 10,788 | $ 18,614 | $ 7,410 | $ 8,034,089 | $ 7,901,093 | $ 112,355 |
| 19 | 0.378 | $ 8,061 | $ - | $ 11,111 | $ 19,172 | $ 7,252 | $ 8,053,261 | $ 7,908,345 | $ 104,944 |
| 20 | 0.359 | $ 8,303 | $ 76,400 | $ 11,445 | $ 96,148 | $ 34,554 | $ 8,149,409 | $ 7,942,899 | $ 97,692 |
| 21 | 0.341 | $ 8,552 | $ - | $ 11,788 | $ 20,340 | $ 6,945 | $ 8,169,749 | $ 7,949,844 | $ 63,138 |
| 22 | 0.324 | $ 8,808 | $ - | $ 12,142 | $ 20,950 | $ 6,797 | $ 8,190,699 | $ 7,956,641 | $ 56,193 |
| 23 | 0.308 | $ 9,073 | $ - | $ 12,506 | $ 21,579 | $ 6,651 | $ 8,212,278 | $ 7,963,292 | $ 49,396 |
| 24 | 0.293 | $ 9,345 | $ - | $ 12,881 | $ 22,226 | $ 6,509 | $ 8,234,504 | $ 7,969,801 | $ 42,745 |
| 25 | 0.278 | $ 9,625 | $ - | $ 13,268 | $ 22,893 | $ 6,370 | $ 8,257,397 | $ 7,976,171 | $ 36,235 |
| 26 | 0.264 | $ 9,914 | $ - | $ 13,666 | $ 23,580 | $ 6,234 | $ 8,280,977 | $ 7,982,405 | $ 29,865 |
| 27 | 0.251 | $ 10,211 | $ - | $ 14,076 | $ 24,287 | $ 6,101 | $ 8,305,264 | $ 7,988,506 | $ 23,631 |
| 28 | 0.239 | $ 10,518 | $ - | $ 14,498 | $ 25,016 | $ 5,970 | $ 8,330,279 | $ 7,994,476 | $ 17,531 |
| 29 | 0.227 | $ 10,833 | $ - | $ 14,933 | $ 25,766 | $ 5,843 | $ 8,356,046 | $ 8,000,319 | $ 11,560 |
| 30 | 0.215 | $ 11,158 | $ - | $ 15,381 | $ 26,539 | $ 5,718 | $ 8,382,585 | $ 8,006,037 | $ 5,718 |

**Description: WQBE_22A_Regional Vegetated Media SW Facility on Public Property**

A large-scale vegetated media filtration facility designed to treat stormwater runoff from a large drainage area.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of foreign debris, silt and trash from filter surface shall occur biannually or after a major storm event. This will include 2 crew members, 3 visits per year, 4 hours per visit, vactor truck included. Total of 24 man
24 hours.

Biannually 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 4 hours per visit, 16 man hours per year, includes dump truck and backhoe loader. Total of 16 man hours.
16 Annual cost of $2215 for mulch.

Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 2 hours per visit. Total of 8
8 man hours.

Annual plant replacement allowance of $2,160. Will allow for the replacement of approximately 40 shrubs or other medium sized plant material.

**Capital Replacement Assumptions:**

Replacement of mulch, plantings, and pipe discahrge riprap every 10 years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Meaghan McGinn (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jeffrey Price (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_22A_Regional Vegetated Media SW Facility on Public Property | | | **Version:** | 2 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | ***Flow Spreader Concete Sump Box*** | 4 | FT Depth | $ - | $ - |
| 2 | ***Spreader Interior Dimensions 70'W X 3'L*** | 210 | SF | $ - | $ - |
| 3 | Facility Excavation to Waste @ 3 ft 'D | 93 | CY | $ 79 | $ 7,315 |
| 4 | Concrete Walls @ 0.67' | 11 | CY | $ 1,250 | $ 13,586 |
| 5 | Concrete Base (4.3'L X 71.3'W X 1'T) | 11 | CY | $ 950 | $ 10,787 |
| 6 | Structure Rebar @ 225 lbs/cy | 5,000 | LBS | $ 1.38 | $ 6,901 |
| 7 | Crushed Aggregate Base | 6 | CY | $ 64 | $ 363 |
| 8 | Trench Shoring Facility | 560 | SF | $ 10 | $ 5,600 |
| 9 | | | | $ - | $ - |
| 10 | ***Energy Dissipating Concrete Structure*** | 6 | FT Depth | $ - | $ - |
| 11 | ***Structure Interior Dimensions 10'L X 6'W*** | 210 | SF | $ - | $ - |
| 12 | Facility Excavation to Waste - Open Cut 2:1 SS (@ 12'D) | 235 | CY | $ 79 | $ 18,570 |
| 13 | Imported Structural Fill | 208 | CY | $ 44 | $ 9,133 |
| 14 | Concrete Walls @ 0.67'T | 5 | CY | $ 1,250 | $ 6,812 |
| 15 | Concrete Base (7.3'W X 11.3'L X 1.67'T) | 5 | CY | $ 950 | $ 4,847 |
| 16 | Outfall Slab (5'L X 7'W X 1.67'T) | 2 | CY | $ 320 | $ 693 |
| 17 | Concrete Top Slab (0.67'T) | 2 | CY | $ 1,250 | $ 2,559 |
| 18 | Structure Rebar @ 225 lbs/cy | 3,322 | LBS | $ 1.38 | $ 4,584 |
| 19 | Crushed Aggregate Base (structure+slab) | 2 | CY | $ 64 | $ 139 |
| 20 | | | | $ - | $ - |
| 21 | ***Regional Media Filter - Property*** | 5,940 | SF | $ - | $ - |
| 22 | ***Treatment Facility Bottom Area : 84.9'L X 70'W*** | | | $ - | $ - |
| 23 | ***Curbed, vertical sides - Top Area*** | 5,940 | SF | $ - | $ - |
| 24 | Structural Excavation to Waste - Open Cut 2:1 SS (@ 6'D) | 2,344 | CY | $ 79 | $ 185,157 |
| 25 | Imported Structural Fill | 1,069 | CY | $ 44 | $ 47,046 |
| 26 | Vault Concrete Walls (85.9'L X 71.5'W X 5'H @ 1'T) | 58 | CY | $ 1,250 | $ 72,639 |
| 27 | Vault Concrete Base (86.9'L X 72'W X 2'T) | 463 | CY | $ 320 | $ 148,309 |
| 28 | Vault Rebar @ 225 lbs/cy | 117,355 | LBS | $ 1.38 | $ 161,950 |
| 29 | Crushed Aggregate Base | 116 | CY | $ 64 | $ 7,415 |
| 30 | Proprietary Treatment Media (@ 1.5'D) | 330 | CY | $ 707 | $ 233,310 |
| 31 | Mulch Compost (@ 0.3'D) | 66 | CY | $ 86 | $ 5,676 |
| 32 | Flow Discharge 6" Spalls | 13 | CY | $ 74 | $ 959 |
| 33 | | | | $ - | $ - |
| 34 | **Underdrain** | 594 | LF | $ - | $ - |
| 35 | Underdrain Aggregate (10'W X 84.9'L X 1.5'D) | 330 | CY | $ 133 | $ 43,890 |
| 36 | Pipe 12" Slotted Drain, PVC | 594 | LF | $ 111 | $ 65,756 |
| 37 | | | | $ - | $ - |
| 38 | **Restoration and Landscaping** | | | $ - | $ - |
| 39 | Landscaping, Planting, and Restoration (100' X 90') | 1,000 | SY | $ 59 | $ 59,000 |
| 40 | Trees Along the Perimeter | 10 | EA | $ 720 | $ 7,200 |
| 41 | Irrigation System | 9,000 | SF | $ 1.2 | $ 10,800 |
| 42 | | | | $ - | $ - |
| 43 | **Inlet Pipe** | | | $ - | $ - |
| 44 | Pipe - 12" Diameter | 1,000 | LF | $ 140 | $ 140,000 |
| 45 | 5' Wide Trench x 6' D to waste | 1,111 | CY | $ 79 | $ 87,778 |
| 46 | Trench Box Shoring (Shallow) | 12,000 | SF | $ 10 | $ 120,000 |
| 47 | Imported Backfill | 1,082 | CY | $ 44 | $ 47,609 |
| 48 | Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 49 | 48" Maintenance Hole | 1 | EA | $ 10,640 | $ 10,640 |
| 50 | Seeding and Restoration | 889 | SY | $ 10 | $ 8,889 |
| 51 | | | | $ - | $ - |
| 52 | **Outlet Pipe** | | | $ - | $ - |
| 53 | Pipe - 8" Diameter | 1,000 | LF | $ 80 | $ 80,000 |
| 54 | 5' Wide Trench x 7'D to waste | 1,296 | CY | $ 79 | $ 102,407 |
| 55 | Trench Box Shoring (Shallow) | 14,000 | SF | $ 10 | $ 140,000 |
| 56 | Imported Backfill | 1,283 | CY | $ 44 | $ 56,468 |
| 57 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 58 | Seeding and Restoration | 889 | SY | $ 10 | $ 8,889 |
| 59 | | | | $ - | $ - |
| 60 | **Treatment Facility Low Flow Bypass System** | | | $ - | $ - |
| 61 | Pipe - 12" Diameter | 200 | LF | $ 140 | $ 28,000 |
| 62 | Bypass Structure | 1 | EA | $ 42,000 | $ 42,000 |
| 63 | Pipe - 8" Diameter | 500 | LF | $ 80 | $ 40,000 |
| 64 | 5' Wide Trench x 9'D to waste | 1,033 | CY | $ 79 | $ 81,633 |
| 65 | Trench Box Shoring (Shallow) | 7,000 | SF | $ 10 | $ 70,000 |
| 66 | Imported Backfill | 1,021 | CY | $ 44 | $ 44,926 |
| 67 | 48" Maintenance Hole | 1 | EA | $ 10,640 | $ 10,640 |
| 68 | Seeding and Restoration | 622 | SY | $ 10 | $ 6,222 |
| 69 | | | | | $ - |
| 70 | **Additional Costs** | | | | $ - |
| 71 | Removals @ 4% | 4.0% | LS | $ 2,273,458 | $ 90,938 |
| 72 | TESC @ 2% of Construction Costs | 2% | LS | $ 2,364,396 | $ 47,288 |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 2,411,684 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 241,168 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 2,652,853 |
| ***Direct: Subtotal Construction Costs*** | | | ***$ 2,652,900*** |

**Description: WQBE 22A - Regional Vegetated Media SW Facility on Public Property**

A large-scale vegetated media filtration facility designed to treat stormwater runoff from a large drainage area.

**Cost Assumptions**

Regional Media Filter Facility installation is per Filterra product specification. The concept design is based upon the Kitsap County Regional Media - Manchester SW Retrofit project.
The design includes requirements from the KC SWDM for Section 6.2, Water Quality Facilities.
A concrete sump box flow spreader is included that conforms to Section 6.2.6 of the KC SWDM.
The regional media facility is assumed to be a below grade cast-in-place closed facility for the cost model. The costs should be re-evaluated should smaller pre-cast modular systems be used.
The concrete walls are flush with ground surface.
The facility is a concrete open top structure with an interior bottom footprint of 5,940 square feet and a ponding depth of 0.70'.
Treatment vault has interior dimensions of 70'W x 84.9 x 5'H.
The exterior wall thickness is 1 foot wide and the base foundation slab is 2 feet thick.
The media and drain sections within the regional treatment facility consists of 0.3' of composting mulch, 1.8' of proprietary treatment media, and a 1.5' deep aggregate underdrain system.
The facility contains 12" slotted PVC underdrains that are spaced at 10 foot intervals within the facility. The underdrain piping system is approximately 594 feet in length.
There is a 0.5' layer of crushed base beneath the base/ballast slab.
The excavation for the structures are assumed to be open cut with 2:1 (run:rise) temporary construction slopes. A geotechnical report is required to confirm the required construction slope used.

It is assumed that the facility is located above the ground water table and that buoyancy considerations are not a factor and dewatering is not required.
A concrete flow dissipating structure is included with interior dimensions of 6' wide by 10' long and 6' high. The concrete structure is assumed to have the following:
The exterior wall thickness is 8" wide, a top slab that is 8" thick, and the base foundation slab is 1'-8" thick.
The media treatment facility is preceeded by a concrete flow spreading facility that meets the requirements of the King Co. Surface Water Design Manual Section 6.2.6B.

The flow spreader is a below grade, cast-in-place concrete structure with interior average dimensions of 69 feet wide by 2 feet long by 2 feet deep.
Gravel pads are used to dissipate energy at the locations where flow crests the flow spreading structure to enter the treatment structure.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.
The treatment facility is assumed to drain by gravity via a surface grate inlet.
Approximately 1000 LF of 12" diameter Inlet piping and 1000 LF and 8" diameter outlet pipe.
Trench Box shoring for pipe installation.
Concrete curb, gutter, and sidewalk removal and restoration is not required for the installation.
Restoration along the facility and pipe alignment is assumed to be seeded grass.
Landscape with trees, shrubs, and an irrigation system are assumed for restoration.
Removals are estimated at 4% of the item construction costs, in conformance with LTCP.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located outside of the roadway right-of-way and traffic control will not be required.
A street use permit is not required.
The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside right-of way. No property easements or acquisition are required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Moderate** indirect project cost complexity factor was assigned: 28% Design Engineering, 13%; Construction Management, Permitting & Support 2%, and 9% WTD Staff Labor

A **25%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Meaghan McGinn (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jeffrey Price (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_22B_Regional_Vegetated Media_SW_Facility With Propert Cost | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Regional Vegetated Media SW Facility (5940 SF Area) | 1 | EA | $ 2,652,900 | $ 2,652,900 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 2,652,900*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 663,225 |
| | | | | Street Use Permit (Y/N) N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 3,316,125*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 331,613 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 3,647,738*** |
| | | | | Construction Sales Tax | $ 373,893 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 4,021,600*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 1,021,367 |
| | | | | Construction Management | $ 474,206 |
| | | | | Permitting & Support | $ 72,955 |
| 6000 | s.f. Land Area | Medium | | Land Purchase/ROW Acquisition | $ 482,580 |
| 10000 | s.f. Land Area | Low | | Permanent Easements | $ 101,000 |
| | | | | WTD Staff Costs & Non-WTD Support | $ 328,296 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 2,480,404*** |
| | | | | Project Contingency | $ 1,950,601 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 4,431,000*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 8,452,600*** |

**Description: WQBE_22B_Regional_Vegetated Media_SW_Facility With Propert Cost (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1 | EA |
| **Initial Capital Cost** | **$ 8,452,600** | |
| Capital cost | $ 8,452,600 | $/Unit |
| Total Direct O&M/Year | $ 6,527 | |
| Direct O&M cost | $ 6,527 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 76,400 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 8,764,600** | **$/unit** |
| **Annual O&M Cost** | **$ 11,300** | **$/year** |
| Annualized Cost | $7,510 | $/year |

**Materials, Supplies, Other Costs**

| | | | | |
|---|---|---|---|---|
| Mulch | 2023 dollars | $ 2,215 | | |
| Annual plant replacement | 2023 dollars | $ 2,160 | $/year | |
| Vactor Truck Equipment + Labor Cost | 2023 dollars | $ 360 | $/year | |
| Subtotal | | $ 4,735 | | |
| Labor | | | | |
| Mulch Replacement | 16 | hr | | |
| Plant Health | 8 | hr | | |
| Removal of Debris with Vactor truck | 24 | hr | | |
| | 0 | hr | | |
| **Total hours per year** | 48 | | | |
| Raw Labor Rate/Hr | | $ 54 | | |
| Raw labor cost | (embedded) | $ 2,611 | | |
| Labor cost, burdened | O/H 150.0% | $ 6,527 | $ | 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | | |
| Life Cycle Period: | 30 | years | | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 225,270 | | $ 310,515 | **$9,141,185** | **$ 8,764,637** | | | |
| 0 | 1.000 | **$ 8,452,600** | | | $8,452,600 | $ 8,452,600 | $ 8,452,600 | $ 8,452,600 | $ 8,764,637 |
| 1 | 0.950 | $4,735 | $ - | $ 6,527 | $ 11,262 | $ 10,700 | $ 8,463,862 | $ 8,463,300 | $ 312,037 |
| 2 | 0.903 | $ 4,877 | $ - | $ 6,723 | $ 11,600 | $ 10,471 | $ 8,475,461 | $ 8,473,771 | $ 301,337 |
| 3 | 0.858 | $ 5,023 | $ - | $ 6,924 | $ 11,948 | $ 10,247 | $ 8,487,409 | $ 8,484,019 | $ 290,865 |
| 4 | 0.815 | $ 5,174 | $ - | $ 7,132 | $ 12,306 | $ 10,028 | $ 8,499,715 | $ 8,494,047 | $ 280,618 |
| 5 | 0.774 | $ 5,329 | $ - | $ 7,346 | $ 12,675 | $ 9,814 | $ 8,512,390 | $ 8,503,861 | $ 270,590 |
| 6 | 0.736 | $ 5,489 | $ - | $ 7,566 | $ 13,056 | $ 9,604 | $ 8,525,446 | $ 8,513,465 | $ 260,776 |
| 7 | 0.699 | $ 5,654 | $ - | $ 7,793 | $ 13,447 | $ 9,399 | $ 8,538,893 | $ 8,522,864 | $ 251,171 |
| 8 | 0.664 | $ 5,823 | $ - | $ 8,027 | $ 13,851 | $ 9,198 | $ 8,552,744 | $ 8,532,062 | $ 241,772 |
| 9 | 0.631 | $ 5,998 | $ - | $ 8,268 | $ 14,266 | $ 9,001 | $ 8,567,010 | $ 8,541,064 | $ 232,575 |
| 10 | 0.599 | $ 6,178 | $ 76,400 | $ 8,516 | $ 91,094 | $ 54,610 | $ 8,658,104 | $ 8,595,673 | $ 223,573 |
| 11 | 0.570 | $ 6,363 | $ - | $ 8,771 | $ 15,135 | $ 8,621 | $ 8,673,239 | $ 8,604,294 | $ 168,964 |
| 12 | 0.541 | $ 6,554 | $ - | $ 9,035 | $ 15,589 | $ 8,436 | $ 8,688,828 | $ 8,612,730 | $ 160,343 |
| 13 | 0.514 | $ 6,751 | $ - | $ 9,306 | $ 16,057 | $ 8,256 | $ 8,704,884 | $ 8,620,986 | $ 151,907 |
| 14 | 0.489 | $ 6,954 | $ - | $ 9,585 | $ 16,538 | $ 8,079 | $ 8,721,423 | $ 8,629,065 | $ 143,651 |
| 15 | 0.464 | $ 7,162 | $ - | $ 9,872 | $ 17,034 | $ 7,907 | $ 8,738,457 | $ 8,636,972 | $ 135,571 |
| 16 | 0.441 | $ 7,377 | $ - | $ 10,169 | $ 17,546 | $ 7,738 | $ 8,756,003 | $ 8,644,710 | $ 127,665 |
| 17 | 0.419 | $ 7,598 | $ - | $ 10,474 | $ 18,072 | $ 7,572 | $ 8,774,075 | $ 8,652,282 | $ 119,927 |
| 18 | 0.398 | $ 7,826 | $ - | $ 10,788 | $ 18,614 | $ 7,410 | $ 8,792,689 | $ 8,659,693 | $ 112,355 |
| 19 | 0.378 | $ 8,061 | $ - | $ 11,111 | $ 19,172 | $ 7,252 | $ 8,811,861 | $ 8,666,945 | $ 104,944 |
| 20 | 0.359 | $ 8,303 | $ 76,400 | $ 11,445 | $ 96,148 | $ 34,554 | $ 8,908,009 | $ 8,701,499 | $ 97,692 |
| 21 | 0.341 | $ 8,552 | $ - | $ 11,788 | $ 20,340 | $ 6,945 | $ 8,928,349 | $ 8,708,444 | $ 63,138 |
| 22 | 0.324 | $ 8,808 | $ - | $ 12,142 | $ 20,950 | $ 6,797 | $ 8,949,299 | $ 8,715,241 | $ 56,193 |
| 23 | 0.308 | $ 9,073 | $ - | $ 12,506 | $ 21,579 | $ 6,651 | $ 8,970,878 | $ 8,721,892 | $ 49,396 |
| 24 | 0.293 | $ 9,345 | $ - | $ 12,881 | $ 22,226 | $ 6,509 | $ 8,993,104 | $ 8,728,401 | $ 42,745 |
| 25 | 0.278 | $ 9,625 | $ - | $ 13,268 | $ 22,893 | $ 6,370 | $ 9,015,997 | $ 8,734,771 | $ 36,235 |
| 26 | 0.264 | $ 9,914 | $ - | $ 13,666 | $ 23,580 | $ 6,234 | $ 9,039,577 | $ 8,741,005 | $ 29,865 |
| 27 | 0.251 | $ 10,211 | $ - | $ 14,076 | $ 24,287 | $ 6,101 | $ 9,063,864 | $ 8,747,106 | $ 23,631 |
| 28 | 0.239 | $ 10,518 | $ - | $ 14,498 | $ 25,016 | $ 5,970 | $ 9,088,879 | $ 8,753,076 | $ 17,531 |
| 29 | 0.227 | $ 10,833 | $ - | $ 14,933 | $ 25,766 | $ 5,843 | $ 9,114,646 | $ 8,758,919 | $ 11,560 |
| 30 | 0.215 | $ 11,158 | $ - | $ 15,381 | $ 26,539 | $ 5,718 | $ 9,141,185 | $ 8,764,637 | $ 5,718 |

**Description: WQBE_22B_Regional_Vegetated Media_SW_Facility With Propert Cost**

A large-scale vegetated media filtration facility designed to treat stormwater runoff from a large drainage area.

**Life-Cycle Cost Model Input Assumptions:**

Capital replacement is input as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Removal of foreign debris, silt and trash from filter surface shall occur biannually or after a major storm event. This will include 2 crew members, 3 visits per year, 4 hours per visit, vactor truck included. Total of 24 man
24 hours.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) $360.

Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 2 hours per visit. Total of 8 man
8 hours.

Annual plant replacement allowance of $2,160. Will allow for the replacement of approximately 40 shrubs or other medium sized plant material.

Biannually 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 4 hours per visit, 16 man hours per year, includes dump truck and backhoe loader. Total of 16 man hours. Annual
16 cost of $2215 for mulch.

**Capital Replacement Assumptions:**

Replacement of mulch, plantings, and pipe discahrge riprap every 10 years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Meaghan McGinn (HDR)<br>Cindy Kinzer (HDR)<br>Troy Gibbs (HDR)<br>Jeffrey Price (HDR)<br>Jess Dexheimer (HDR) |
| **Description:** | WQBE_22B_Regional_Vegetated Media_SW_Facility With Propert Cost | | | **Version:** | 2 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | ***Flow Spreader Concete Sump Box*** | 4 | FT Depth | $ - | $ - |
| 2 | ***Spreader Interior Dimensions 70'W X 3'L*** | 210 | SF | $ - | $ - |
| 3 | Facility Excavation to Waste @ 3 ft 'D | 93 | CY | $ 79 | $ 7,315 |
| 4 | Concrete Walls @ 0.67' | 11 | CY | $ 1,250 | $ 13,586 |
| 5 | Concrete Base (4.3'L X 71.3'W X 1'T) | 11 | CY | $ 950 | $ 10,787 |
| 6 | Structure Rebar @ 225 lbs/cy | 5,000 | LBS | $ 1.38 | $ 6,901 |
| 7 | Crushed Aggregate Base | 6 | CY | $ 64 | $ 363 |
| 8 | Trench Shoring Facility | 560 | SF | $ 10 | $ 5,600 |
| 9 | | | | $ - | $ - |
| 10 | ***Energy Dissipating Concrete Structure*** | 6 | FT Depth | $ - | $ - |
| 11 | ***Structure Interior Dimensions 10'L X 6'W*** | 210 | SF | $ - | $ - |
| 12 | Facility Excavation to Waste - Open Cut 2:1 SS (@ 12'D) | 235 | CY | $ 79 | $ 18,570 |
| 13 | Imported Structural Fill | 208 | CY | $ 44 | $ 9,133 |
| 14 | Concrete Walls @ 0.67'T | 5 | CY | $ 1,250 | $ 6,812 |
| 15 | Concrete Base (7.3'W X 11.3'L X 1.67'T) | 5 | CY | $ 950 | $ 4,847 |
| 16 | Outfall Slab (5'L X 7'W X 1.67'T) | 2 | CY | $ 320 | $ 693 |
| 17 | Concrete Top Slab (0.67'T) | 2 | CY | $ 1,250 | $ 2,559 |
| 18 | Structure Rebar @ 225 lbs/cy | 3,322 | LBS | $ 1.38 | $ 4,584 |
| 19 | Crushed Aggregate Base (structure+slab) | 2 | CY | $ 64 | $ 139 |
| 20 | | | | $ - | $ - |
| 21 | ***Regional Media Filter - Property*** | 5,940 | SF | $ - | $ - |
| 22 | ***Treatment Facility Bottom Area : 84.9'L X 70'W*** | | | $ - | $ - |
| 23 | ***Curbed, vertical sides - Top Area*** | 5,940 | SF | $ - | $ - |
| 24 | Structural Excavation to Waste - Open Cut 2:1 SS (@ 6'D) | 2,344 | CY | $ 79 | $ 185,157 |
| 25 | Imported Structural Fill | 1,069 | CY | $ 44 | $ 47,046 |
| 26 | Vault Concrete Walls (85.9'L X 71.5'W X 5'H @ 1'T) | 58 | CY | $ 1,250 | $ 72,639 |
| 27 | Vault Concrete Base (86.9'L X 72'W X 2'T) | 463 | CY | $ 320 | $ 148,309 |
| 28 | Vault Rebar @ 225 lbs/cy | 117,355 | LBS | $ 1.38 | $ 161,950 |
| 29 | Crushed Aggregate Base | 116 | CY | $ 64 | $ 7,415 |
| 30 | Proprietary Treatment Media (@ 1.5'D) | 330 | CY | $ 707 | $ 233,310 |
| 31 | Mulch Compost (@ 0.3'D) | 66 | CY | $ 86 | $ 5,676 |
| 32 | Flow Discharge 6" Spalls | 13 | CY | $ 74 | $ 959 |
| 33 | | | | $ - | $ - |
| 34 | **Underdrain** | 594 | LF | $ - | $ - |
| 35 | Underdrain Aggregate (10'W X 84.9'L X 1.5'D) | 330 | CY | $ 133 | $ 43,890 |
| 36 | Pipe 12" Slotted Drain, PVC | 594 | LF | $ 111 | $ 65,756 |
| 37 | | | | $ - | $ - |
| 38 | **Restoration and Landscaping** | | | $ - | $ - |
| 39 | Landscaping, Planting, and Restoration (100' X 90') | 1,000 | SY | $ 59 | $ 59,000 |
| 40 | Trees Along the Perimeter | 10 | EA | $ 720 | $ 7,200 |
| 41 | Irrigation System | 9,000 | SF | $ 1.2 | $ 10,800 |
| 42 | | | | $ - | $ - |
| 43 | **Inlet Pipe** | | | $ - | $ - |
| 44 | Pipe - 12" Diameter | 1,000 | LF | $ 140 | $ 140,000 |
| 45 | 5' Wide Trench x 6' D to waste | 1,111 | CY | $ 79 | $ 87,778 |
| 46 | Trench Box Shoring (Shallow) | 12,000 | SF | $ 10 | $ 120,000 |
| 47 | Imported Backfill | 1,082 | CY | $ 44 | $ 47,609 |
| 48 | Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick) | 7 | CY | $ 346 | $ 2,460 |
| 49 | 48" Maintenance hole | 1 | EA | $ 10,640 | $ 10,640 |
| 50 | Seeding and Restoration | 889 | SY | $ 10 | $ 8,889 |
| 51 | | | | $ - | $ - |
| 52 | **Outlet Pipe** | | | $ - | $ - |
| 53 | Pipe - 8" Diameter | 1,000 | LF | $ 80 | $ 80,000 |
| 54 | 5' Wide Trench x 7'D to waste | 1,296 | CY | $ 79 | $ 102,407 |
| 55 | Trench Box Shoring (Shallow) | 14,000 | SF | $ 10 | $ 140,000 |
| 56 | Imported Backfill | 1,283 | CY | $ 44 | $ 56,468 |
| 57 | Catch Basin | 1 | EA | $ 3,900 | $ 3,900 |
| 58 | Seeding and Restoration | 889 | SY | $ 10 | $ 8,889 |
| 59 | | | | $ - | $ - |
| 60 | **Treatment Facility Low Flow Bypass System** | | | $ - | $ - |
| 61 | Pipe - 12" Diameter | 200 | LF | $ 140 | $ 28,000 |
| 62 | Bypass Structure | 1 | EA | $ 42,000 | $ 42,000 |
| 63 | Pipe - 8" Diameter | 500 | LF | $ 80 | $ 40,000 |
| 64 | 5' Wide Trench x 7'D to waste | 1,033 | CY | $ 79 | $ 81,633 |
| 65 | Trench Box Shoring (Shallow) | 7,000 | SF | $ 10 | $ 70,000 |
| 66 | Imported Backfill | 1,021 | CY | $ 44 | $ 44,926 |
| 67 | 48" Maintenance Hole | 1 | EA | $ 10,640 | $ 10,640 |
| 68 | Seeding and Restoration | 622 | SY | $ 10 | $ 6,222 |
| 69 | | | | | $ - |
| 70 | **Additional Costs** | | | | $ - |
| 71 | Removals @ 4% | 4.0% | LS | $ 2,273,458 | $ 90,938 |
| 72 | TESC @ 2% of Construction Costs | 2% | LS | $ 2,364,396 | $ 47,288 |
| | | | | | |
| | ***Item Subtotal Construction Costs (Year 2023)*** | | | | $ 2,411,684 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 241,168 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 2,652,853 |
| ***Direct: Subtotal Construction Costs (4 SF Area)*** | | | ***$ 2,652,900*** |

**Description: WQBE 22B - Regional Vegetated Media SW Facility With Property Cost**
A large-scale vegetated media filtration facility designed to treat stormwater runoff from a large drainage area.

**Cost Assumptions**
Regional Media Filter Facility installation is per Filterra product specification. The concept design is based upon the Kitsap County Regional Media - Manchester SW Retrofit project.
The design includes requirements from the KC SWDM for Section 6.2, Water Quality Facilities.
A concrete sump box flow spreader is included that conforms to Section 6.2.6 of the KC SWDM.
The regional media facility is assumed to be a below grade cast-in-place closed facility for the cost model. The costs should be re-evaluated should smaller pre-cast modular systems be used.
The concrete walls are flush with ground surface.
The facility is a concrete open top structure with an interior bottom footprint of 5,940 square feet and a ponding depth of 0.70'.
Treatment vault has interior dimensions of 70'W x 84.9 x 5'H.
The exterior wall thickness is 1 foot wide and the base foundation slab is 2 feet thick.
The media and drain sections within the regional treatment facility consists of 0.3' of composting mulch, 1.8' of proprietary treatment media, and a 1.5' deep aggregate underdrain system.
The facility contains 12" slotted PVC underdrains that are spaced at 10 foot intervals within the facility. The underdrain piping system is approximately 594 feet in length.
There is a 0.5' layer of crushed base beneath the base/ballast slab.
The excavation for the structures are assumed to be open cut with 2:1 (run:rise) temporary construction slopes. A geotechnical report is required to confirm the required construction slope used.

It is assumed that the facility is located above the ground water table and that buoyancy considerations are not a factor and dewatering is not required.
A concrete flow dissipating structure is included with interior dimensions of 6' wide by 10' long and 6' high. The concrete structure is assumed to have the following:
The exterior wall thickness is 8" wide, a top slab that is 8" thick, and the base foundation slab is 1'-8" thick.
The media treatment facility is preceeded by a concrete flow spreading facility that meets the requirements of the King Co. Surface Water Design Manual Section 6.2.6B.

The flow spreader is a below grade, cast-in-place concrete structure with interior average dimensions of 69 feet wide by 2 feet long by 2 feet deep.
Gravel pads are used to dissipate energy at the locations where flow crests the flow spreading structure to enter the treatment structure.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.
The treatment facility is assumed to drain by gravity via a surface grate inlet.
Approximately 1000 LF of 12" diameter Inlet piping and 1000 LF and 8" diameter outlet pipe.
Trench Box shoring for pipe installation.
Concrete curb, gutter, and sidewalk removal and restoration is not required for the installation.
Restoration along the facility and pipe alignment is assumed to be seeded grass.
Landscape with trees, shrubs, and an irrigation system are assumed for restoration.
Removals are estimated at 4% of the item construction costs, in conformance with LTCP.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and traffic control is not required.
A street use permit is not required.
The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to High.

**Planning Basis Assumptions:**
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**
All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Moderate** indirect project cost complexity factor was assigned: 22% Design Engineering, 13%; Construction Management, and 8% WTD Staff Cost
A **25%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**
This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Updated on 06/13/24

| | | | | | | | PHASE 3 COSTS (2023 Dollars) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item No. | Action | Class | Complexity | Description | Sub-Action Number | Subcategory | Action Unit | Design Drainage Area | Total Direct Construction Cost | Property acquisition | Total Indirect Non-Construction Costs | Total Project Cost | O&M Costs (Annual) | Life Cycle Cost (NPV) |
| 23 | Sports Field | Class 10 | Routine | WQBE_23_Sports Field and Park Detention | N/A | On property, no property acquisition. | 29,600 | 103,800 SF | $ 10,224,600 | $0 | $ 7,769,300 | $ 17,993,900 | $ 33,300 | $ 18,700,900 |

| MANDATORY INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |
| Retail Sales Tax Rate | 10.25% | Current Rate within City of Seattle is 10.25%, 10.1% outside of Seattle |
| Allowance for Indeterminates (AFI), Dependenent Upon Project Phase | 20% | Complexity Inputs for AFI (High = 30%; Moderate = 25%; Routine = 20%; Low = 15%) |
| Construction Change Order Allowance | 10% | |
| Project Contingency | 30% | |

| SECONDARY INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |
| Street Use Permit | $ 90,000 | In ROW only - Arterial @ $90,000/Unit; Non-Arterial @use $30000/unit |
| Outside Agency Construction | 2% | For Projects in ROW Utility coordination assumed to be at 2% construction cost. |

| PROJECT CATEGORY AND INDIRECT PROJECT INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |

**PROPERTY COST**

| Cost Category | $/sf |
|---|---|
| Low | $ 10.10 |
| Medium | $ 80.43 |
| High | $ 284.37 |
| None | $ - |

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/13/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer<br>Jess Dexheimer<br>Trooper Shaw |
| **Description:** | WQBE_23 - Sports Field and Park Detention | | | **Version:** | 2 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Sportsfield and Park Detention | 29,600 | SF | $ 237 | $ 7,025,750 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 7,025,750*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 1,405,150 |
| | | | | Street Use Permit (Y/N) N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 8,430,900*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 843,090 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 9,273,990*** |
| | | | | Construction Sales Tax | $ 950,584 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 10,224,600*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 2,040,278 |
| | | | | Construction Management | $ 927,399 |
| | | | | Permitting & Support | $ 92,740 |
| | s.f. Land Area | None | | Land Purchase/ROW Acquisition | $ - |
| | s.f. Land Area | None | | Permanent Easements | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 556,439 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 3,616,856*** |
| | | | | Project Contingency | $ 4,152,437 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 7,769,300*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 17,993,900*** |

**Description: WQBE 23 - Sports Field and Park Detention (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 29,600 | ft2 |
| **Initial Capital Cost** | **$ 17,993,900** | |
| Capital cost | $ 608 | $/Unit |
| Total Direct O&M/Year | $ 5,983 | |
| Direct O&M cost | $ 0.20 | $/Unit |
| Capital Replacement Costs (10 Years) | $ - | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 18,700,900** | **$/unit** |
| **Annual O&M Cost** | **$ 33,300** | **$/year** |
| Annualized Cost | $43,390 | $/year |

**Equipment, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Storm Facility Vactor Equipment Cost | 2023 dollars | $ 4,320 | $/year |
| Vactor Truck Equipment | 2023 dollars | $ 23,040 | $/year |
| Subtotal | | $27,360 | |

Labor

| | | | |
|---|---|---|---|
| Remove Trash, debris, clean storm structures | 12 | hr | |
| ADS Isolator Row Cleaning and Mtc. | 32 | hr | |
| | 0 | hr | |
| | 0 | hr | |
| **Total hours per year** | 44 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 2,393 | |
| Labor cost, burdened | O/H 150.0% | $ 5,983 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ 1,301,663 | | $ 284,639 | **$19,580,202** | **$ 18,700,855** | | | |
| 0 | 1.000 | **$ 17,993,900** | | | $17,993,900 | $ 17,993,900 | $ 17,993,900 | $ 17,993,900 | $ 18,700,855 |
| 1 | 0.950 | $27,360 | $ - | $ 5,983 | $ 33,343 | $ 31,680 | $ 18,027,243 | $ 18,025,580 | $ 706,955 |
| 2 | 0.903 | $ 28,181 | $ - | $ 6,162 | $ 34,343 | $ 31,002 | $ 18,061,586 | $ 18,056,582 | $ 675,276 |
| 3 | 0.858 | $ 29,026 | $ - | $ 6,347 | $ 35,373 | $ 30,340 | $ 18,096,960 | $ 18,086,922 | $ 644,273 |
| 4 | 0.815 | $ 29,897 | $ - | $ 6,538 | $ 36,435 | $ 29,691 | $ 18,133,394 | $ 18,116,613 | $ 613,933 |
| 5 | 0.774 | $ 30,794 | $ - | $ 6,734 | $ 37,528 | $ 29,056 | $ 18,170,922 | $ 18,145,669 | $ 584,242 |
| 6 | 0.736 | $ 31,718 | $ - | $ 6,936 | $ 38,654 | $ 28,435 | $ 18,209,576 | $ 18,174,105 | $ 555,186 |
| 7 | 0.699 | $ 32,669 | $ - | $ 7,144 | $ 39,813 | $ 27,827 | $ 18,249,389 | $ 18,201,932 | $ 526,751 |
| 8 | 0.664 | $ 33,649 | $ - | $ 7,358 | $ 41,008 | $ 27,232 | $ 18,290,396 | $ 18,229,164 | $ 498,923 |
| 9 | 0.631 | $ 34,659 | $ - | $ 7,579 | $ 42,238 | $ 26,650 | $ 18,332,634 | $ 18,255,815 | $ 471,691 |
| 10 | 0.599 | $ 35,699 | $ - | $ 7,806 | $ 43,505 | $ 26,081 | $ 18,376,139 | $ 18,281,895 | $ 445,040 |
| 11 | 0.570 | $ 36,770 | $ - | $ 8,041 | $ 44,810 | $ 25,523 | $ 18,420,949 | $ 18,307,418 | $ 418,960 |
| 12 | 0.541 | $ 37,873 | $ - | $ 8,282 | $ 46,154 | $ 24,977 | $ 18,467,103 | $ 18,332,396 | $ 393,437 |
| 13 | 0.514 | $ 39,009 | $ - | $ 8,530 | $ 47,539 | $ 24,443 | $ 18,514,642 | $ 18,356,839 | $ 368,459 |
| 14 | 0.489 | $ 40,179 | $ - | $ 8,786 | $ 48,965 | $ 23,921 | $ 18,563,608 | $ 18,380,760 | $ 344,016 |
| 15 | 0.464 | $ 41,384 | $ - | $ 9,050 | $ 50,434 | $ 23,410 | $ 18,614,042 | $ 18,404,170 | $ 320,095 |
| 16 | 0.441 | $ 42,626 | $ - | $ 9,321 | $ 51,947 | $ 22,909 | $ 18,665,989 | $ 18,427,079 | $ 296,686 |
| 17 | 0.419 | $ 43,905 | $ - | $ 9,601 | $ 53,506 | $ 22,419 | $ 18,719,494 | $ 18,449,498 | $ 273,776 |
| 18 | 0.398 | $ 45,222 | $ - | $ 9,889 | $ 55,111 | $ 21,940 | $ 18,774,605 | $ 18,471,438 | $ 251,357 |
| 19 | 0.378 | $ 46,579 | $ - | $ 10,185 | $ 56,764 | $ 21,471 | $ 18,831,369 | $ 18,492,909 | $ 229,417 |
| 20 | 0.359 | $ 47,976 | $ - | $ 10,491 | $ 58,467 | $ 21,012 | $ 18,889,836 | $ 18,513,921 | $ 207,946 |
| 21 | 0.341 | $ 49,415 | $ - | $ 10,806 | $ 60,221 | $ 20,563 | $ 18,950,057 | $ 18,534,484 | $ 186,934 |
| 22 | 0.324 | $ 50,898 | $ - | $ 11,130 | $ 62,028 | $ 20,123 | $ 19,012,085 | $ 18,554,608 | $ 166,371 |
| 23 | 0.308 | $ 52,425 | $ - | $ 11,464 | $ 63,888 | $ 19,693 | $ 19,075,973 | $ 18,574,301 | $ 146,248 |
| 24 | 0.293 | $ 53,997 | $ - | $ 11,808 | $ 65,805 | $ 19,272 | $ 19,141,778 | $ 18,593,573 | $ 126,555 |
| 25 | 0.278 | $ 55,617 | $ - | $ 12,162 | $ 67,779 | $ 18,860 | $ 19,209,558 | $ 18,612,433 | $ 107,283 |
| 26 | 0.264 | $ 57,286 | $ - | $ 12,527 | $ 69,813 | $ 18,457 | $ 19,279,370 | $ 18,630,890 | $ 88,422 |
| 27 | 0.251 | $ 59,004 | $ - | $ 12,903 | $ 71,907 | $ 18,062 | $ 19,351,277 | $ 18,648,952 | $ 69,965 |
| 28 | 0.239 | $ 60,774 | $ - | $ 13,290 | $ 74,064 | $ 17,676 | $ 19,425,341 | $ 18,666,628 | $ 51,903 |
| 29 | 0.227 | $ 62,598 | $ - | $ 13,688 | $ 76,286 | $ 17,298 | $ 19,501,628 | $ 18,683,927 | $ 34,227 |
| 30 | 0.215 | $ 64,476 | $ - | $ 14,099 | $ 78,575 | $ 16,929 | $ 19,580,202 | $ 18,700,855 | $ 16,929 |

**Description: WQBE 02A - Bioretention Planter on Property**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

Inspection and removal of trash, debris and obstruction limiting flow into slot drain storm piping, structures to remove trash, sediment and debris (2 visits/per year, 3 hour per visit) performed by a
12 crew of 2. Equipment costs at $360/hr not including labor costs.

Jet-Vactor clean isolator rows annually with a crew of 2 for a 16 hours. Equipment costs at $720/hr
32 not including labor costs.

**Replacement Assumptions:**

Per ADS Stormtech Life span is greater than 50 years if per mfg. and AASHTO design criteria.
Replacement Artificial Turf Assumed to be part of the sports field operational costs and not included with the ADS system.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/13/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer<br>Jess Dexheimer<br>Trooper Shaw |
| **Description:** | WQBE_23 - Sports Field and Park Detention | | | **Version:** | 2 |

**CONSTRUCTION COSTS**

| Item No. | Item Description | Quantity | Units | Unit Cost | Item Cost |
|---|---|---|---|---|---|
| 1 | ***Sportsfield Soccer Field Area*** | 29,600 | SF | | $ - |
| | *Field Length* | 150 | FT | | $ - |
| | *Field Width* | 185 | FT | | $ - |
| | | | | | $ - |
| | ***Drains and Infilration Layer Input*** | | | | $ - |
| | *Synthetic Turf System (infilled) @ 2" Depth* | 0.17 | FT | | $ - |
| | *Well Graded Sandy Gravel @ 2" Depth* | 0.17 | FT | | $ - |
| | *Crushed Surfacing (Choker Course) @ 2" Depth* | 0.17 | FT | | $ - |
| | *Depth from from Choker Course to Top of ADS* | 1.5 | FT | | $ - |
| | *ADS System Height* | 2.5 | FT | | $ - |
| | Sub-Exc for ADS layers | 1.5 | FT | | $ - |
| | | | | | $ - |
| | **Removals and Restoration** | | | | $ - |
| | Clearing and Grubbing | 3,289 | SY | $ 8 | $ 26,311 |
| | Artificial Turf System (installed) | 29,600 | SF | $ 35 | $ 1,036,000 |
| | | | | | $ - |
| | **Excavation and Backfill** | | | | $ - |
| | *Total Exc. Depth* | 6.0 | FT | | $ - |
| | Excavation and Disposal, Including Haul | 6,578 | CY | $ 79 | $ 519,644 |
| | WSDOT Permeable Ballast | 2,219 | CY | $ 95 | $ 210,759 |
| | | | | | $ - |
| | **Drains and Infilration Layers** | | | | $ - |
| | *ADS SC-740 Stormtech Chambers (length per unit)* | 75 | LF | | $ - |
| | *Number of Chambers* | 78 | EA | | $ - |
| | Observation Cleanout Ports @ 2/chamber | 156 | EA | $ 250 | $ 39,000 |
| | ADS SC-740 Stormtech Chambers (4' 3" Wide by 2' 6 3/4" High) | 5,850 | LF | $ 530 | $ 3,100,500 |
| | ADS Chamber Ends, Fittings, and Manifold Connections (for 78 chambers) | 1 | LS | $ 415,740 | $ 415,740 |
| | Crushed Surfacing (Choker) Course | 183 | CY | $ 105 | $ 19,185 |
| | Well Graded Sandy Gravel | 183 | CY | $ 85 | $ 15,531 |
| | Geofabric system (1 top layer + 1 bottom layer) | 3,289 | SY | $ 24 | $ 78,933 |
| | Stone with Liner System and end caps at 0.5 depth | 1,644 | CY | $ 110 | $ 180,889 |
| | | | | | $ - |
| | **Drainage Facilities and Inlet Piping** | | | | $ - |
| | 12"x12" Curb with 6" Pipe and Slot Drain (Field Edge) | 150 | LF | $ 228 | $ 34,200 |
| | Crushed Aggregate (6" thick) | 3 | CY | $ 133 | $ 369 |
| | Slot drain pipe connection 8" Dia. | 50 | LF | $ 48 | $ 2,400 |
| | 4' Wide Trench x 7'D to waste | 52 | CY | $ 79 | $ 4,096 |
| | 48" Diameter Manholes (pipe connections) | 2 | EA | $ 10,640 | $ 21,280 |
| | 36" Storm Pipe | 220 | LF | $ 480 | $ 105,600 |
| | 36" Storm Pipe (Influent) | 250 | LF | $ 480 | $ 120,000 |
| | 5' Wide Trench x 7'D to waste | 609 | CY | $ 79 | $ 48,131 |
| | Assume Open Cut & No Trench Box Shoring | | | | $ - |
| | 60" Type 2 Catch Basin | 2 | EA | $ 21,200 | $ 42,400 |
| | | | | | $ - |
| | **Additional Costs** | | | | $ - |
| | Removals @ 4% Construction Costs | 4.0% | LS | $ 6,020,970 | $ 240,839 |
| | TESC @2% Construction Costs | 2% | LS | $ 6,261,809 | $ 125,236 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 6,387,045 |

**DIRECT: CONSTRUCTION COST MARK-UPS**

| | | | |
|---|---|---|---|
| General Conditions | 0% | 1 | $ - |
| Mobilization/Demobilization | 10% | 1.1 | $ 638,705 |
| Overhead & Profit (OHP) | 0% | 1 | $ - |
| Insurance | 0.0% | 1 | $ - |
| Bonding | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | $ 7,025,750 |
| ***Direct: Subtotal Construction Costs (29600 SF Area)*** | | | ***$ 7,025,750*** |

**Description: WQBE 23A - Sportsfield**

Install subsurface storage at existing sportsfield or park to provide flow control while preserving recreational site use

**Cost Estimating Assumptions:**

The field area is assumed to be 150' long by 185' in width and a total of 29,600 sf area.

Field Restoration using an artificial turf system

The synthetic turf system (infilled) depth is 2-inches

the curshed surfacting (choker) course and well graded sandy gravel layer are each assumed to be 2-inches in depth.

the depth from the crushed surfacing to the ADS pipe system is 1.5 feet.

Array of ADS StormTech SC-740 that is 2 feet - 6 and 3/4 inches high by 4' - 3" wide.

The ADS stormtech chambers are 75 feet in length and a total of 78 chambers will be installed.

The chambers are capped on each end and connected with a manifold pipe.

Observation (cleanout) ports are provided at each end.

Insitu soils will not be suitable for re-use as backfill and trench material.

A 12 inch by 12 inch concrete curb with 6 inch slotted drain pipe will be installed along the upstream perimeter.

Two layers of geosynthetic liners will be installed at the bottom of the subsurface storage system.

Crushed gravel will be installed per ADS manufacturer requirements beneath the ADS storm tec system.

It is assumed that an 8" diameter pipe and two 48" manholes will be used to connect the slotted drain system to the main drain system.

the storm piping is 36 inches in diameter with two 60 inch diameter Type 2 Catch basins.

It is assumed that the ADS system and storm piping may be installed with open cut and trench shoring is not included.

Removals are assumed at 4% of the construction costs.

Erosion and sediment controls are assumed at 2% of the construction costs.

The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Updated on 6/7/24

| | | | | | | | PHASE 3 COSTS (2023 Dollars) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item No. | Action | Class | Complexity | Description | Sub-Action Number | Subcategory | Action Unit | Design Drainage Area | Total Direct Construction Cost | Property acquisition | Total Indirect Non-Construction Costs | Total Project Cost | O&M Costs (Annual) | Life Cycle Cost (NPV) |
| 24 | Blue Roof | Class 10 | Low | WQBE_24_Blue_Roof | N/A | On property, no property acquisition. | 1,000 SF | 1,000 SF | $ 82,300 | $0 | $ 34,200 | $ 116,500 | $ 2,600 | $ 170,900 |

| MANDATORY INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |
| Retail Sales Tax Rate | 10.25% | Current Rate within City of Seattle is 10.25%, 10.1% outside of Seattle |
| Allowance for Indeterminates (AFI), Dependenent Upon Project Phase | 15% | Complexity Inputs for AFI (High = 30%; Moderate = 25%; Routine = 20%; Low = 15%) |
| Construction Change Order Allowance | 10% | |
| Project Contingency | 15% | Override due to low complexity |

| SECONDARY INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |
| Street Use Permit | $ 90,000 | In ROW only - Arterial @ $90,000/Unit; Non-Arterial @use $30000/unit |
| Outside Agency Construction | 5% | Assumes Utility coordination and work will be required est. at 5% construction cost. |

| PROJECT CATEGORY AND INDIRECT PROJECT INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |

**PROPERTY COST**

| Cost Category | $/sf |
|---|---|
| Low | $ 10.10 |
| Medium | $ 80.43 |
| High | $ 284.37 |
| None | $ - |

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer<br>Jess Dexheimer<br>Trooper Shaw |
| **Description:** | WQBE_25 - Blue Roof | | | **Version:** | 1 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Blue Roof (1,000 sf) | 1,000 | SF | $ 59 | $ 59,000 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 59,000*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 8,850 |
| | | | | Street Use Permit (Y/N) N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 67,850*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 6,785 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 74,635*** |
| | | | | Construction Sales Tax | $ 7,650 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 82,300*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 8,956 |
| | | | | Construction Management | $ 5,971 |
| | | | | Permitting & Support | $ 373 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 3,732 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 19,032*** |
| | | | | Project Contingency | $ 15,200 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 34,200*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 116,500*** |

**Description: WQBE_25 Blue Roof (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 1,000 | ft2 |
| **Initial Capital Cost** | **$ 116,500** | |
| Capital cost | $ 117 | $/Unit |
| Total Direct O&M/Year | $ 2,448 | |
| Direct O&M cost | $ 2.45 | $/Unit |
| Capital Replacement Costs (20 Years) | $ - | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 170,900** | **$/unit** |
| **Annual O&M Cost** | **$ 2,600** | **$/year** |
| Annualized Cost | $4,070 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | $ - | $ - | $/year |
| Leak Sealant | 2023 dollars | $ 120 | $/year |
| | 2023 dollars | $ - | $/year |
| Subtotal | | $120 | |

Labor

| | | | |
|---|---|---|---|
| Inspection monthly to check for debris and clean drains | 12 | hr | |
| Remove sediment and debris and clean drains | 6 | hr | |
| | 0 | hr | |
| | | hr | |
| **Total hours per year** | 18 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 979 | |
| Labor cost, burdened | O/H 150.0% | $ 2,448 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 5,709 | | $ 116,443 | **$238,652** | **$ 170,939** | | | |
| 0 | 1.000 | **$ 116,500** | | | $116,500 | $ 116,500 | $ 116,500 | $ 116,500 | $ 170,939 |
| 1 | 0.950 | $120 | $ - | $ 2,448 | $ 2,568 | $ 2,439 | $ 119,068 | $ 118,939 | $ 54,439 |
| 2 | 0.903 | $ 124 | $ - | $ 2,521 | $ 2,645 | $ 2,387 | $ 121,712 | $ 121,327 | $ 51,999 |
| 3 | 0.858 | $ 127 | $ - | $ 2,597 | $ 2,724 | $ 2,336 | $ 124,436 | $ 123,663 | $ 49,612 |
| 4 | 0.815 | $ 131 | $ - | $ 2,675 | $ 2,806 | $ 2,286 | $ 127,242 | $ 125,949 | $ 47,276 |
| 5 | 0.774 | $ 135 | $ - | $ 2,755 | $ 2,890 | $ 2,237 | $ 130,131 | $ 128,187 | $ 44,989 |
| 6 | 0.736 | $ 139 | $ - | $ 2,837 | $ 2,976 | $ 2,190 | $ 133,108 | $ 130,377 | $ 42,752 |
| 7 | 0.699 | $ 143 | $ - | $ 2,923 | $ 3,066 | $ 2,143 | $ 136,174 | $ 132,519 | $ 40,562 |
| 8 | 0.664 | $ 148 | $ - | $ 3,010 | $ 3,158 | $ 2,097 | $ 139,332 | $ 134,616 | $ 38,419 |
| 9 | 0.631 | $ 152 | $ - | $ 3,100 | $ 3,252 | $ 2,052 | $ 142,584 | $ 136,669 | $ 36,322 |
| 10 | 0.599 | $ 157 | $ - | $ 3,193 | $ 3,350 | $ 2,008 | $ 145,934 | $ 138,677 | $ 34,270 |
| 11 | 0.570 | $ 161 | $ - | $ 3,289 | $ 3,451 | $ 1,965 | $ 149,385 | $ 140,642 | $ 32,262 |
| 12 | 0.541 | $ 166 | $ - | $ 3,388 | $ 3,554 | $ 1,923 | $ 152,939 | $ 142,566 | $ 30,296 |
| 13 | 0.514 | $ 171 | $ - | $ 3,490 | $ 3,661 | $ 1,882 | $ 156,599 | $ 144,448 | $ 28,373 |
| 14 | 0.489 | $ 176 | $ - | $ 3,594 | $ 3,771 | $ 1,842 | $ 160,370 | $ 146,290 | $ 26,491 |
| 15 | 0.464 | $ 182 | $ - | $ 3,702 | $ 3,884 | $ 1,803 | $ 164,254 | $ 148,093 | $ 24,649 |
| 16 | 0.441 | $ 187 | $ - | $ 3,813 | $ 4,000 | $ 1,764 | $ 168,254 | $ 149,857 | $ 22,846 |
| 17 | 0.419 | $ 193 | $ - | $ 3,928 | $ 4,120 | $ 1,726 | $ 172,374 | $ 151,583 | $ 21,082 |
| 18 | 0.398 | $ 198 | $ - | $ 4,045 | $ 4,244 | $ 1,689 | $ 176,618 | $ 153,273 | $ 19,356 |
| 19 | 0.378 | $ 204 | $ - | $ 4,167 | $ 4,371 | $ 1,653 | $ 180,989 | $ 154,926 | $ 17,666 |
| 20 | 0.359 | $ 210 | $ - | $ 4,292 | $ 4,502 | $ 1,618 | $ 185,491 | $ 156,544 | $ 16,013 |
| 21 | 0.341 | $ 217 | $ - | $ 4,421 | $ 4,637 | $ 1,583 | $ 190,128 | $ 158,127 | $ 14,395 |
| 22 | 0.324 | $ 223 | $ - | $ 4,553 | $ 4,776 | $ 1,550 | $ 194,905 | $ 159,677 | $ 12,811 |
| 23 | 0.308 | $ 230 | $ - | $ 4,690 | $ 4,920 | $ 1,516 | $ 199,824 | $ 161,193 | $ 11,262 |
| 24 | 0.293 | $ 237 | $ - | $ 4,830 | $ 5,067 | $ 1,484 | $ 204,892 | $ 162,677 | $ 9,745 |
| 25 | 0.278 | $ 244 | $ - | $ 4,975 | $ 5,219 | $ 1,452 | $ 210,111 | $ 164,130 | $ 8,261 |
| 26 | 0.264 | $ 251 | $ - | $ 5,125 | $ 5,376 | $ 1,421 | $ 215,487 | $ 165,551 | $ 6,809 |
| 27 | 0.251 | $ 259 | $ - | $ 5,278 | $ 5,537 | $ 1,391 | $ 221,024 | $ 166,942 | $ 5,388 |
| 28 | 0.239 | $ 267 | $ - | $ 5,437 | $ 5,703 | $ 1,361 | $ 226,727 | $ 168,303 | $ 3,997 |
| 29 | 0.227 | $ 275 | $ - | $ 5,600 | $ 5,874 | $ 1,332 | $ 232,602 | $ 169,635 | $ 2,636 |
| 30 | 0.215 | $ 283 | $ - | $ 5,768 | $ 6,051 | $ 1,304 | $ 238,652 | $ 170,939 | $ 1,304 |

**Description: WQBE_25 Blue Roof**

**Life-Cycle Cost Model Input Assumptions:**
Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**
12 Inspection once per month for 1 person at 1 hour. Inspect regularly following wind storm and rain events, look for agae and debris, and check drains.
6 Remove sediment and debris and clean drains by a one person using hand tools twice per year (2 visits per year, 3 hours per visit). Materials for sealing leaks estimated at $120/yr.

**Replacement Assumptions:**
Blue roof life expectancy is 40 years with no replacement costs.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer<br>Jess Dexheimer<br>Trooper Shaw |
| **Description:** | WQBE_25 - Blue Roof | | | **Version:** | 1 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | ***Blue Roof Area*** | 1,000 | SF | | $ - |
| 2 | *Blue Roof Storage Depth (4-inches)* | 0.33 | FT | | $ - |
| 3 | *Water Storage Volume* | 333 | CF | | $ - |
| 4 | | | | | $ - |
| 5 | **Demolition and Removals** | | | | $ - |
| 6 | Remove and dispose existing roofing | 1,000 | SF | $ 2 | $ 2,000 |
| | Remove and reset HVAC (incl. new base) | 1 | LS | $ 8,400 | $ 8,400 |
| | | | | | $ - |
| | **Blue Roof and Drain System** | | | | $ - |
| | Install PVC Roof Membrane Assembly (40 - 45 mil), Insulation, Coverboard, Taping) | 1,000 | SF | $ 27 | $ 27,000 |
| | | | | | $ - |
| | Roof Drain Riser Commercial Grade (Overflow) @ 1 drain per 250 SF | 4 | EA | $ 2,500 | $ 10,000 |
| | Roof Drain Piping (4" to 6" dia.) w/orifice, screen, and fittings | 200 | LF | $ 31 | $ 6,200 |
| | | | | | $ - |
| | | | | $ - | $ - |
| | | | | | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | | | $ 53,600 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| General Conditions | | | 0% | 1 | $ - |
| Mobilization/Demobilization | | | 10% | 1.1 | $ 5,360 |
| Overhead & Profit (OHP) | | | 0% | 1 | $ - |
| Insurance | | | 0.0% | 1 | $ - |
| Bonding | | | 0.0% | 1 | $ - |
| Escalation Multiplier from ENR-CCI | | | 0% | 1.0000 | $ - |
| ***Item Subtotal Construction Costs (Year 2023)*** | | | | | $ 58,960 |
| ***Direct: Subtotal Construction Costs (1000 SF Area)*** | | | | | ***$ 58,960*** |

| | |
|---|---|
| | |
| | **Description: WQBE 25 - Blue Roof** |
| | Rooftop detention designed to provide temporary storage and slow release of stormwater runoff<br>Retrofit of existing roof (flat with parapet) to provide up to 4 inches of storage draining to one control structure |
| | |
| | **Cost Estimating Assumptions:** |
| | Blue Roof for 1,000 sf area. |
| | Roof drainage system reconfigured to direct runoff from 500 sf (of the 1,000 sf total) to control structure. |
| | HVAC/utilities on roof raised 6 inches |
| | Control structure has 0.25 inch orifice and redundant overflow with protective screening (e.g. sand filter to protect orifice from clogging) |
| | Assumes structural upgrades not required |
| | No additional sewer connections will be required. |
| | Assume 1 overflow drain per 250 sf (4 total) |
| | Roof drainage system piping 6" PVC with 200 LF total piping |
| | No TESC measures are assumed for building retrofit system. |
| | The facility is located on property and traffic control will not be required. |
| | The facility is located outside of the ROW and a street use permit is not required. |
| | It is assumed that this facility is on public property and no acquisition or easements are required. |
| | |
| | **Planning Basis Assumptions:** |
| | No project construction plan is in place at this time. |
| | The assumed execution strategy is a standard work week with limited overtime. |
| | No alternative procurement methods have been considered as part of delivery of this concept. |
| | No unusual site conditions have been considered as part of this estimate. |
| | Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts. |
| | |
| | **Cost Basis Assumptions:** |
| | Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities. |
| | |
| | **Allowances:** |
| | The level and types of allowances used in the estimate are as follows: |
| | Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies. |
| | Allowance of 10% for potential change orders. |
| | This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor |
| | A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process. |
| | Costs were not included for Local Agency Mitigation and Indirect Burden. |
| | The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included. |
| | Costs were not included for utility relocation work. |
| | |
| | **Estimating Assumptions:** |
| | This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation. |
| | It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. |
| | It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials. |
| | It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces. |
| | It is assumed that there will be some degree of minimal cost rounding during the normal estimating process. |

Updated on 6/7/24

| | | | | | | | PHASE 3 COSTS (2023 Dollars) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item No. | Action | Class | Difficulty | Description | Sub-Action Number | Subcategory | Action Unit | Design Drainage Area | Total Direct Construction Cost | Property acquisition | Total Indirect Non-Construction Costs | Total Project Cost | O&M Costs (Annual) | Life Cycle Cost (NPV) |
| 25 | Compost Amendment | Class 10 | Low | WQBE_25_Compost_Amendment | N/A | On property, no acquisition | 500 sf | 500 SF | $ 4,200 | $0 | $ 1,700 | $ 5,900 | 300 | $ 13,400 |

| MANDATORY INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |
| Retail Sales Tax Rate | 10.25% | Current Rate within City of Seattle is 10.25%, 10.1% outside of Seattle |
| Allowance for Indeterminates (AFI), Dependenent Upon Project Phase | 15% | Complexity Inputs for AFI (High = 30%; Moderate = 25%; Routine = 20%; Low = 15%) |
| Construction Change Order Allowance | 10% | |
| Project Contingency | 15% | Override due to low complexity |

| SECONDARY INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |
| Street Use Permit | $ 700 | In ROW only - Arterial @ $700/Unit; Non-Arterial @use $300/unit |
| Outside Agency Construction | 2% | For Projects in ROW Utility coordination assumed to be at 2% construction cost. |

| PROJECT CATEGORY AND INDIRECT PROJECT INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |

**PROPERTY COST**

| Cost Category | $/sf |
|---|---|
| Low | $ 10.10 |
| Medium | $ 80.43 |
| High | $ 284.37 |
| None | $ - |

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Jess Dexheimer (HDR)<br>Tatiana Skadorwa (HDR)<br>Cindy Kinzer (HDR) |
| **Description:** | WQBE_25 - Compost Amendment | | | **Version:** | 1 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Compost Amendment | 500 | SF | $ 6 | $ 3,000 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 3,000*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 450 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 3,450*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 345 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 3,795*** |
| | | | | Construction Sales Tax | $ 389 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 4,200*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 455 |
| | | | | Construction Management | $ 304 |
| | | | | Permitting & Support | $ 19 |
| | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 190 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 968*** |
| | | | | Project Contingency | $ 775 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 1,700*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 5,900*** |

**Description: WQBE 25 - Compost Amendment (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 500 | ft2 |
| **Initial Capital Cost** | **$ 5,900** | |
| Capital cost | $ 12 | $/Unit |
| Total Direct O&M/Year | $ 136 | |
| Direct O&M cost | $ 0.27 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 1,046 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |

1/3 total replacement every 10 years.

| | | |
|---|---|---|
| **Total Cost (NPV)** | **$ 13,400** | **$/unit** |
| **Annual O&M Cost** | **$ 300** | **$/year** |
| Annualized Cost | $250 | $/year |

**Materials, Supplies, Other Costs**

| | | | |
|---|---|---|---|
| | | $ - | $/year |
| Aerator Equipment | 2023 dollars | $ 160 | $/year |
| | 2023 dollars | | $/year |
| Subtotal | | $160 | |

Labor

| | | | |
|---|---|---|---|
| Aerating soil | 1 | hr | |
| | | hr | |
| | | hr | |
| | 0 | hr | |
| **Total hours per year** | 1 | | |
| Raw Labor Rate/Hr | | $ 54 | |
| Raw labor cost | (embedded) | $ 54 | |
| Labor cost, burdened | O/H 150.0% | $ 136 | $ 135.98 |
| General and Labor Cost Escalation/Year | 3.0% | | |
| Life Cycle Period: | 30 | years | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ 7,612 | | $ 6,469 | **$23,118** | **$ 13,403** | | | |
| 0 | 1.000 | **$ 5,900** | | | $5,900 | $ 5,900 | $ 5,900 | $ 5,900 | $ 13,403 |
| 1 | 0.950 | $160 | $ - | $ 136 | $ 296 | $ 281 | $ 6,196 | $ 6,181 | $ 7,503 |
| 2 | 0.903 | $ 165 | $ - | $ 140 | $ 305 | $ 275 | $ 6,501 | $ 6,456 | $ 7,222 |
| 3 | 0.858 | $ 170 | $ - | $ 144 | $ 314 | $ 269 | $ 6,815 | $ 6,726 | $ 6,947 |
| 4 | 0.815 | $ 175 | $ - | $ 149 | $ 323 | $ 264 | $ 7,138 | $ 6,989 | $ 6,677 |
| 5 | 0.774 | $ 180 | $ - | $ 153 | $ 333 | $ 258 | $ 7,471 | $ 7,247 | $ 6,414 |
| 6 | 0.736 | $ 185 | $ - | $ 158 | $ 343 | $ 252 | $ 7,814 | $ 7,500 | $ 6,156 |
| 7 | 0.699 | $ 191 | $ - | $ 162 | $ 353 | $ 247 | $ 8,168 | $ 7,747 | $ 5,904 |
| 8 | 0.664 | $ 197 | $ - | $ 167 | $ 364 | $ 242 | $ 8,532 | $ 7,988 | $ 5,657 |
| 9 | 0.631 | $ 203 | $ - | $ 172 | $ 375 | $ 237 | $ 8,907 | $ 8,225 | $ 5,415 |
| 10 | 0.599 | $ 209 | $ 1,046 | $ 177 | $ 1,432 | $ 858 | $ 10,339 | $ 9,083 | $ 5,178 |
| 11 | 0.570 | $ 215 | $ - | $ 183 | $ 398 | $ 227 | $ 10,736 | $ 9,310 | $ 4,320 |
| 12 | 0.541 | $ 221 | $ - | $ 188 | $ 410 | $ 222 | $ 11,146 | $ 9,532 | $ 4,093 |
| 13 | 0.514 | $ 228 | $ - | $ 194 | $ 422 | $ 217 | $ 11,568 | $ 9,748 | $ 3,872 |
| 14 | 0.489 | $ 235 | $ - | $ 200 | $ 435 | $ 212 | $ 12,003 | $ 9,961 | $ 3,655 |
| 15 | 0.464 | $ 242 | $ - | $ 206 | $ 448 | $ 208 | $ 12,450 | $ 10,169 | $ 3,442 |
| 16 | 0.441 | $ 249 | $ - | $ 212 | $ 461 | $ 203 | $ 12,911 | $ 10,372 | $ 3,235 |
| 17 | 0.419 | $ 257 | $ - | $ 218 | $ 475 | $ 199 | $ 13,386 | $ 10,571 | $ 3,031 |
| 18 | 0.398 | $ 264 | $ - | $ 225 | $ 489 | $ 195 | $ 13,876 | $ 10,766 | $ 2,832 |
| 19 | 0.378 | $ 272 | $ - | $ 231 | $ 504 | $ 191 | $ 14,380 | $ 10,956 | $ 2,637 |
| 20 | 0.359 | $ 281 | $ 1,046 | $ 238 | $ 1,565 | $ 562 | $ 15,944 | $ 11,519 | $ 2,447 |
| 21 | 0.341 | $ 289 | $ - | $ 246 | $ 535 | $ 183 | $ 16,479 | $ 11,701 | $ 1,885 |
| 22 | 0.324 | $ 298 | $ - | $ 253 | $ 551 | $ 179 | $ 17,029 | $ 11,880 | $ 1,702 |
| 23 | 0.308 | $ 307 | $ - | $ 261 | $ 567 | $ 175 | $ 17,596 | $ 12,055 | $ 1,523 |
| 24 | 0.293 | $ 316 | $ - | $ 268 | $ 584 | $ 171 | $ 18,180 | $ 12,226 | $ 1,349 |
| 25 | 0.278 | $ 325 | $ - | $ 276 | $ 602 | $ 167 | $ 18,782 | $ 12,393 | $ 1,178 |
| 26 | 0.264 | $ 335 | $ - | $ 285 | $ 620 | $ 164 | $ 19,402 | $ 12,557 | $ 1,010 |
| 27 | 0.251 | $ 345 | $ - | $ 293 | $ 638 | $ 160 | $ 20,040 | $ 12,717 | $ 846 |
| 28 | 0.239 | $ 355 | $ - | $ 302 | $ 657 | $ 157 | $ 20,698 | $ 12,874 | $ 686 |
| 29 | 0.227 | $ 366 | $ - | $ 311 | $ 677 | $ 154 | $ 21,375 | $ 13,028 | $ 529 |
| 30 | 0.215 | $ 377 | $ 1,046 | $ 320 | $ 1,743 | $ 376 | $ 23,118 | $ 13,403 | $ 376 |

**Description: WQBE 25 - Compost Amendment**

**Life-Cycle Cost Model Input Assumptions:**
Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

1 Aerating by crew of one (one visit per year, 1 hour per visit). Equipment cost $160/hr.

**Replacement Assumptions:**
Replacement of 1/3 sod and mulch area every 10 years.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 6/7/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Jess Dexheimer (HDR)<br>Tatiana Skadorwa (HDR)<br>Cindy Kinzer (HDR) |
| **Description:** | WQBE_25 - Compost Amendment | | | **Version:** | 1 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Compost Amendment Area** | 500 | SF | | $ - |
| 2 | **Removal and Preparation** | | | | |
| 3 | Clearing and Grubbing | 56 | SY | $ 8 | $ 444 |
| 4 | Scarifying, disking, or tilling Soil with bed preparation | 56 | SY | $ 6 | $ 333 |
| | | | | | $ - |
| | **Restoration:** | | | | $ - |
| | Mulch Compost (@ 1.75" depth) | 3 | CY | $ 80 | $ 240 |
| | Rototill Mulch Compost 6.25" Depth | 56 | SY | $ 6 | $ 333 |
| | Subgrade Preparation (compact to 85% max dry density) | 56 | SY | $ 10 | $ 556 |
| | Grass Sod | 56 | SY | $ 16 | $ 889 |
| | | | | | $ - |
| | **Additional Costs** | | | | $ - |
| | TESC @2% Construction Costs | 2% | LS | $ 2,796 | $ 56 |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 2,851 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 285 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 3,137 |
| | | | | ***Direct: Subtotal Construction Costs (500 SF Area)*** | ***$ 3,137*** |

| | |
|---|---|
| | |
| | **Description: WQBE 25 Compost Amendment** |
| | Install subsurface storage at existing sportsfield or park to provide flow control while preserving recreational site use |
| | |
| | **Cost Estimating Assumptions:** |
| | Design is based on Washington State Department of Ecology's "Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13" Option 2 (amending existing site soil or subsoil) |
| | Remove lawn vegetation & Scarify (loosen) subgrade to 8 inches depth |
| | Place 1.75 inches of compost and rototill into 6.25 inches of soil (a total amended depth of about 9.5 inches, for a settled depth of 8 inches) |
| | Scarify (loosen) subsoil 4 inches below the amended layer to produce a 12-inch depth of uncompacted soil |
| | Roll to compact to 85% of maximum dry density |
| | Rake to level and remove surface woody debris and rocks larger than 1 inch diameter |
| | Restoration is with Sod Grass. |
| | Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs. |
| | The facility is located on property and traffic control will not be required. |
| | The facility is located outside of the ROW and a street use permit is not required. |
| | It is assumed that this facility is on public property and no acquisition or easements are required. |
| | |
| | **Planning Basis Assumptions:** |
| | No project construction plan is in place at this time. |
| | The assumed execution strategy is a standard work week with limited overtime. |
| | No alternative procurement methods have been considered as part of delivery of this concept. |
| | No unusual site conditions have been considered as part of this estimate. |
| | Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts. |
| | |
| | **Cost Basis Assumptions:** |
| | Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities. |
| | |
| | **Allowances:** |
| | The level and types of allowances used in the estimate are as follows: |
| | Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies. |
| | Allowance of 10% for potential change orders. |
| | This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor |
| | A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process. |
| | Costs were not included for Local Agency Mitigation and Indirect Burden. |
| | The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included. |
| | Costs were not included for utility relocation work. |
| | |
| | **Estimating Assumptions:** |
| | This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation. |
| | It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. |
| | It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials. |
| | It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces. |
| | It is assumed that there will be some degree of minimal cost rounding during the normal estimating process. |

| Updated on 7/21/24 | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | PHASE 3 COSTS (2023 Dollars) | | | | | | | |
| **Item No.** | **Action** | **Class** | **Difficulty** | **Description** | **Sub-Action Number** | **Subcategory** | **Action Unit** | **Design Drainage Area** | **Total Direct Construction Cost** | **Property acquisition** | **Total Indirect Non-Construction Costs** | **Total Project Cost** | **O&M Costs (Annual)** | **Life Cycle Cost (NPV)** |
| 26 | Reforestation | Class 10 | Routine | WQBE_26A_Reforest High Density Development | 26A | On property without Acquisition w/Building Demolition | 1 Acre | 43,560 SF | $ 11,075,000 | $ - | $ 8,415,500 | $ 19,490,500 | $ 3,300 | $ 19,577,100 |
| | | | | WQBE_26B_Reforest High Density Development w/Property Cost | 26B | On property with Acquisition w/Building Demolition | 1 Acre | 43,560 SF | $ 11,075,000 | $ 3,503,531 | $ 12,970,100 | $ 24,045,100 | $ 3,300 | $ 24,131,700 |
| | | | | WQBE_26C_Reforest Pervious Area | 26C | On property without Acquisition | 1 Acre | 43,560 SF | $ 992,900 | $ - | $ 754,500 | $ 1,747,400 | $ - | $ 1,747,400 |
| | | | | WQBE_26D_Reforest Pervious Area w/Property Cost | 26D | On property with Acquisition | 1 Acre | 43,560 SF | $ 992,900 | $ 3,503,531 | $ 5,309,100 | $ 6,302,000 | $ - | $ 6,302,000 |

| MANDATORY INPUTS | | |
|---|---|---|
| **Input Category** | **Inputs** | **Comments** |
| Retail Sales Tax Rate | 10.25% | Current Rate within City of Seattle is 10.25%, 10.1% outside of Seattle |
| Allowance for Indeterminates (AFI), Dependenent Upon Project Phase | 20% | Complexity Inputs for AFI (High = 30%; Moderate = 25%; Routine = 20%; Low = 15%) |
| Construction Change Order Allowance | 10% | |
| Project Contingency | 30% | |
| | | |
| **SECONDARY INPUTS** | | |
| **Input Category** | **Inputs** | **Comments** |
| Street Use Permit | $ 90,000 | In ROW only - Arterial @ $90,000/Unit; Non-Arterial @use $30000/unit |
| Outside Agency Construction | 2% | For Projects in ROW Utility coordination assumed to be at 2% construction cost. |
| | | |
| **PROJECT CATEGORY AND INDIRECT PROJECT INPUTS** | | |
| **Input Category** | **Inputs** | **Comments** |

| PROPERTY COST | Cost Category | $/sf |
|---|---|---|
| | Low | $ 10.10 |
| | Medium | $ 80.43 |
| | High | $ 284.37 |
| | None | $ - |

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 7/21/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer<br>Trooper Shaw<br>Jess Dexheimer |
| **Description:** | WQBE_26A - Reforestation High Density Development - On Property | | | **Version:** | 1 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Reforestation High Density Development - On Property (43,560 SF Area) | 43,560 | SF | $ 175 | $ 7,610,085 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 7,610,085*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 1,522,017 |
| | | | | Street Use Permit (Y/N) N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 9,132,102*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 913,210 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 10,045,312*** |
| | | | | Construction Sales Tax | $ 1,029,645 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 11,075,000*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 2,209,969 |
| | | | | Construction Management | $ 1,004,531 |
| | | | | Permitting & Support | $ 100,453 |
| | s.f. Land Area | None | | Land Purchase/ROW Acquisition | $ - |
| | s.f. Land Area | None | | Permanent Easements | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 602,719 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 3,917,672*** |
| | | | | Project Contingency | $ 4,497,802 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 8,415,500*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 19,490,500*** |

**Description: WQBE_26A - Reforestation High Density Development - On Property (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 43,560 | ft2 |
| **Initial Capital Cost** | **$ 19,490,500** | |
| Capital cost | $ 447 | $/Unit |
| Total Direct O&M/Year | $ 3,263 | |
| Reforestation On Property with Property Cost (43,560 SF Area) | $ 0.07 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 19,096 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |
| **Total Cost (NPV)** | **$ 19,577,100** | **$/unit** |
| **Annual O&M Cost** | **$ 3,300** | **$/year** |
| Annualized Cost | $5,180 | $/year |

**Materials, Supplies, Other Costs**

| | | | | |
|---|---|---|---|---|
| | $ - | $ - | $/year | |
| | 2023 dollars | $ - | $/year | |
| | 2023 dollars | $ - | $/year | |
| Subtotal | | $0 | | |
| Labor | | | | |
| Remove Trash and trail maintenance | 16 | hr | | |
| Plant inspections | 8 | hr | | |
| | 0 | hr | | |
| | | hr | | |
| **Total hours per year** | 24 | | | |
| Raw Labor Rate/Hr | | $ 54 | | |
| Raw labor cost | (embedded) | $ 1,305 | | |
| Labor cost, burdened | O/H 150.0% | $ 3,263 | $ 135.98 | |
| General and Labor Cost Escalation/Year | 3.0% | | | |
| Life Cycle Period: | 30 | years | | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ - | | $ 155,258 | **$19,683,950** | **$ 19,577,090** | | | |
| 0 | 1.000 | **$ 19,490,500** | | | $19,490,500 | $ 19,490,500 | $ 19,490,500 | $ 19,490,500 | $ 19,577,090 |
| 1 | 0.950 | $0 | $ - | $ 3,263 | $ 3,263 | $ 3,101 | $ 19,493,763 | $ 19,493,601 | $ 86,590 |
| 2 | 0.903 | $ - | $ - | $ 3,361 | $ 3,361 | $ 3,034 | $ 19,497,125 | $ 19,496,635 | $ 83,489 |
| 3 | 0.858 | $ - | $ - | $ 3,462 | $ 3,462 | $ 2,969 | $ 19,500,587 | $ 19,499,604 | $ 80,455 |
| 4 | 0.815 | $ - | $ - | $ 3,566 | $ 3,566 | $ 2,906 | $ 19,504,153 | $ 19,502,510 | $ 77,485 |
| 5 | 0.774 | $ - | $ - | $ 3,673 | $ 3,673 | $ 2,844 | $ 19,507,826 | $ 19,505,354 | $ 74,579 |
| 6 | 0.736 | $ - | $ - | $ 3,783 | $ 3,783 | $ 2,783 | $ 19,511,609 | $ 19,508,137 | $ 71,735 |
| 7 | 0.699 | $ - | $ - | $ 3,897 | $ 3,897 | $ 2,724 | $ 19,515,506 | $ 19,510,861 | $ 68,952 |
| 8 | 0.664 | $ - | $ - | $ 4,014 | $ 4,014 | $ 2,665 | $ 19,519,519 | $ 19,513,526 | $ 66,229 |
| 9 | 0.631 | $ - | $ - | $ 4,134 | $ 4,134 | $ 2,608 | $ 19,523,653 | $ 19,516,135 | $ 63,563 |
| 10 | 0.599 | $ - | $ - | $ 4,258 | $ 4,258 | $ 2,553 | $ 19,527,911 | $ 19,518,687 | $ 60,955 |
| 11 | 0.570 | $ - | $ 19,096 | $ 4,386 | $ 23,482 | $ 13,375 | $ 19,551,393 | $ 19,532,062 | $ 58,402 |
| 12 | 0.541 | $ - | $ - | $ 4,517 | $ 4,517 | $ 2,445 | $ 19,555,910 | $ 19,534,507 | $ 45,028 |
| 13 | 0.514 | $ - | $ - | $ 4,653 | $ 4,653 | $ 2,392 | $ 19,560,563 | $ 19,536,899 | $ 42,583 |
| 14 | 0.489 | $ - | $ - | $ 4,792 | $ 4,792 | $ 2,341 | $ 19,565,356 | $ 19,539,240 | $ 40,191 |
| 15 | 0.464 | $ - | $ - | $ 4,936 | $ 4,936 | $ 2,291 | $ 19,570,292 | $ 19,541,531 | $ 37,849 |
| 16 | 0.441 | $ - | $ - | $ 5,084 | $ 5,084 | $ 2,242 | $ 19,575,376 | $ 19,543,774 | $ 35,558 |
| 17 | 0.419 | $ - | $ - | $ 5,237 | $ 5,237 | $ 2,194 | $ 19,580,613 | $ 19,545,968 | $ 33,316 |
| 18 | 0.398 | $ - | $ - | $ 5,394 | $ 5,394 | $ 2,147 | $ 19,586,007 | $ 19,548,115 | $ 31,122 |
| 19 | 0.378 | $ - | $ - | $ 5,556 | $ 5,556 | $ 2,101 | $ 19,591,562 | $ 19,550,217 | $ 28,974 |
| 20 | 0.359 | $ - | $ - | $ 5,722 | $ 5,722 | $ 2,057 | $ 19,597,285 | $ 19,552,273 | $ 26,873 |
| 21 | 0.341 | $ - | $ 19,096 | $ 5,894 | $ 24,990 | $ 8,533 | $ 19,622,275 | $ 19,560,806 | $ 24,816 |
| 22 | 0.324 | $ - | $ - | $ 6,071 | $ 6,071 | $ 1,970 | $ 19,628,346 | $ 19,562,776 | $ 16,283 |
| 23 | 0.308 | $ - | $ - | $ 6,253 | $ 6,253 | $ 1,927 | $ 19,634,599 | $ 19,564,703 | $ 14,314 |
| 24 | 0.293 | $ - | $ - | $ 6,441 | $ 6,441 | $ 1,886 | $ 19,641,039 | $ 19,566,590 | $ 12,386 |
| 25 | 0.278 | $ - | $ - | $ 6,634 | $ 6,634 | $ 1,846 | $ 19,647,673 | $ 19,568,435 | $ 10,500 |
| 26 | 0.264 | $ - | $ - | $ 6,833 | $ 6,833 | $ 1,806 | $ 19,654,506 | $ 19,570,242 | $ 8,654 |
| 27 | 0.251 | $ - | $ - | $ 7,038 | $ 7,038 | $ 1,768 | $ 19,661,544 | $ 19,572,010 | $ 6,848 |
| 28 | 0.239 | $ - | $ - | $ 7,249 | $ 7,249 | $ 1,730 | $ 19,668,793 | $ 19,573,740 | $ 5,080 |
| 29 | 0.227 | $ - | $ - | $ 7,466 | $ 7,466 | $ 1,693 | $ 19,676,259 | $ 19,575,433 | $ 3,350 |
| 30 | 0.215 | $ - | $ - | $ 7,690 | $ 7,690 | $ 1,657 | $ 19,683,950 | $ 19,577,090 | $ 1,657 |

**Description: WQBE_26A - Reforestation High Density Development on Property**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.

Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

16 Removal of trash and debris along the pedestrian trail to occur annually. Work to be performed by a crew of two using hand tools (1 visits per year, 8 hours per visit).

8 Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed annually by a crew of two using hand tools (1 visits per year, 4 hours per visit).

**Replacement Assumptions:**

Replace signage every 10 years. Repairs at 10% of trail every 10 years.

The irrigation system is to be abandoned in place and will not be replaced.

It is assumed that the reforested area will remain natural and plant replacement beyond the establishment period will not be required.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 7/21/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer<br>Trooper Shaw<br>Jess Dexheimer |
| **Description:** | WQBE_26A - Reforestation High Density Development - On Property | | | **Version:** | 1 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | **Reforestation On Property (43,560 SF Area)** | 43,560 | SF | | $ - |
| 2 | Existing Building % of total area | 40% | | | $ - |
| 3 | Existing Parking Lot % of total area | 60% | | | $ - |
| 4 | Building foundation depth | 4 | FT | | $ - |
| 5 | | | | | $ - |
| 6 | **Demolition and Removals** | | | | $ - |
| 7 | Remove Existing Pavement | 2,904 | SY | $ 14 | $ 40,656 |
| 8 | Demolition, Haul, and Disposal Existing Building & Utilities (Standard Construction) | 40,656 | SF | $ 30 | $ 1,219,680 |
| 9 | Remove, Haul, Disposal Concrete Buidling Foundation | 12,046 | TN | $ 334 | $ 4,023,438 |
| 10 | Allowance for removal, haul, and Disposal of Existing Site Utilities | 1 | LS | $ 50,000 | $ 50,000 |
| 11 | | | | | $ - |
| 12 | **Earthwork and Site Preparation** | | | | |
| 13 | Site Grading, Shaping, and Building Foundation Backfill (No Import) | 2,420 | CY | $ 28 | $ 67,760 |
| 14 | Scarifying subsoil (to 6" Depth) | 2,904 | SY | $ 4 | $ 11,616 |
| 15 | Topsoil @ 18" depth | 2,420 | CY | $ 105 | $ 254,100 |
| 16 | Mulch Compost @4" depth | 538 | CY | $ 80 | $ 43,022 |
| 17 | | | | | $ - |
| 18 | **Site Restoration & Reforestation** | | | | $ - |
| 19 | *Paved Trail Length* | 1,200 | LF | | $ - |
| 20 | *Paved Trail Width* | 12 | FT | | $ - |
| 21 | Trail 4" HMA/4"CSBC | 1,600 | SY | $ 71 | $ 113,600 |
| 22 | Trees @ 2 trees/1000 sf | 88 | EA | $ 720 | $ 63,360 |
| 23 | Bareroot schrubs @62/1000 sf for 90% area | 2,701 | EA | $ 50 | $ 135,050 |
| 24 | Bareroot groundcover @13/1000 sf | 567 | EA | $ 42 | $ 23,814 |
| 25 | Temporary Irrigation System | 1 | LS | $ 39,410 | $ 39,410 |
| 25 | Landscape Establishment - 2 years | 1 | LS | $ 74,500 | $ 74,500 |
| 25 | Trail Signage Allowance | 1 | LS | $ 6,000 | $ 6,000 |
| 25 | | | | | $ - |
| 25 | **Additional Costs** | | | | $ - |
| 25 | Removals @ 10% Construction Costs | 10% | LS | $ 6,166,006 | $ 616,601 |
| 25 | TESC @ 2% of Construction Costs | 2% | LS | $ 6,782,607 | $ 135,652 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 6,918,259 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 691,826 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 7,610,085 |
| | | | | ***Direct: Subtotal Construction Costs (43560 SF Area)*** | ***$ 7,610,085*** |

| | |
|---|---|
| | |
| | **Description: WQBE 26A - Reforestation High Density Development On Property** |
| | Convert existing impervious surfaces to forest by uncompacting/amending soil and planting trees and understory vegetation.<br>Typical "strip mall" no acquisition; structure and parking lot razed/removed; parcel restored as forest cover with simple trail. |
| | |
| | **Cost Estimating Assumptions:** |
| | Pavement removal per the King Co. SW Design Manual Appendix C, Section C.2.9. |
| | Reforestation On Property no property aquisition (43,560 SF Area) |
| | The total removal footprint = 1 acre (43,560 sf) with a 1:1 length to width ratio. |
| | Assume strip mall; parcel area coverage = 60% parking (26,136 sf) and 40% single story structure (17,424 sf) |
| | The cost model assumes a commercial parking lot type application. |
| | Site soils and CSBC may be used for backfill of building foundation removals and import will not be required. |
| | Existing impervious surface 4" HMA and 4" CSBC (e.g., crushed rock, gravel, etc.) removal. |
| | Scarify subsoil to 6" depth and place 18 inches of topsoil type A |
| | A minimum of 4 inches of compost amendment is added and mixed into the scarified soils. |
| | Plant multi-layer native plant communities:<br>--Plant with 5-gallon container trees at a spacing of 25 ft on center (2 trees/1,000 sqft).<br>--Plant with bareroot shrubs at a spacing of 5 ft on center for 90% of remaining area (62 schrubs/1,000 sqft).<br>--Plant with bareroot groundcover at a spacing of 3 ft on center for 10% of remaining area (13 groundcovers/1,000 sqft |
| | Assume simple trail 4" HMA/4" CSBC @ 8' width through forest |
| | Maintain plants during 2 year plant establishment period |
| | Temporary irrigation system will be required during the establishment period. |
| | The existing water and power service will be available for the temporary irrigation system and utilities will not be required. |
| | The project is located in a developed and potentially urbanized area. Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs. |
| | A removal allowance estimated at 10% of the construction cost is assumed for removals of existing utilities, storm structures, and unidentified existing structures and obstructions. |
| | The facility is located on property and traffic control will not be required. |
| | The facility is located outside of the ROW and a street use permit is not required. |
| | No property easements or acquisition are required. |
| | |
| | **Planning Basis Assumptions:** |
| | No project construction plan is in place at this time. |
| | The assumed execution strategy is a standard work week with limited overtime. |
| | No alternative procurement methods have been considered as part of delivery of this concept. |
| | No unusual site conditions have been considered as part of this estimate. |
| | Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts. |
| | |
| | **Cost Basis Assumptions:** |
| | Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities. |
| | |
| | **Allowances:** |
| | The level and types of allowances used in the estimate are as follows: |
| | Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies. |
| | Allowance of 10% for potential change orders. |
| | This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor |
| | A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process. |
| | Costs were not included for Local Agency Mitigation and Indirect Burden. |
| | The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included. |
| | Costs were not included for utility relocation work. |
| | |
| | **Estimating Assumptions:** |
| | This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation. |
| | It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. |
| | It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials. |
| | It is assumed that there will be some degree of minimal cost rounding during the normal estimating process. |
| | A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process. |

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 7/21/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer<br>Trooper Shaw<br>Jess Dexheimer |
| **Description:** | WQBE_26B - Reforestation High Density Development - On Property with Property Cost | | | **Version:** | 1 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Reforestation High Density Development - On Property w/Property Cost (43,560 SF Area) | 43,560 | SF | $ 175 | $ 7,610,085 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 7,610,085*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 1,522,017 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 9,132,102*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 913,210 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 10,045,312*** |
| | | | | Construction Sales Tax | $ 1,029,645 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 11,075,000*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 2,209,969 |
| | | | | Construction Management | $ 1,004,531 |
| | | | | Permitting & Support | $ 100,453 |
| 43560 | s.f. Land Area | Medium | Land Purchase/ROW Acquisition | | $ 3,503,531 |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 602,719 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 7,421,203*** |
| | | | | Project Contingency | $ 5,548,861 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 12,970,100*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 24,045,100*** |

**Description: WQBE_26B - Reforestation High Density Development - On Property w/Property Cost (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 43,560 | ft2 |
| **WQBE_26 - Reforestation On Property with Property Cost** | **$ 24,045,100** | |
| Capital cost | $ 552 | $/Unit |
| Total Direct O&M/Year | $ 3,263 | |
| Reforestation On Property with Property Cost (43,560 SF Area) | $ 0.07 | $/Unit |
| Capital Replacement Costs (10 Years) | $ 19,096 | $/unit |
| Discount rate (%) | 5.25 | $/Unit |
| **Total Cost (NPV)** | **$ 24,131,700** | **$/unit** |
| **Annual O&M Cost** | **$ 3,300** | **$/year** |
| Annualized Cost | $5,180 | $/year |

**Materials, Supplies, Other Costs**

| | | | | |
|---|---|---|---|---|
| | $ - | $ - | $/year | |
| | 2023 dollars | $ - | $/year | |
| | 2023 dollars | $ - | $/year | |
| Subtotal | | $0 | | |
| Labor | | | | |
| Remove Trash and trail maintenance | 16 | hr | | |
| Plant inspections | 8 | hr | | |
| | 0 | hr | | |
| | | hr | | |
| **Total hours per year** | 24 | | | |
| Raw Labor Rate/Hr | | $ 54 | | |
| Raw labor cost | (embedded) | $ 1,305 | | |
| Labor cost, burdened | O/H 150.0% | $ 3,263 | $ 135.98 | |
| General and Labor Cost Escalation/Year | 3.0% | | | |
| Life Cycle Period: | 30 | years | | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ - | | $ 155,258 | **$24,238,550** | **$ 24,131,690** | | | |
| 0 | 1.000 | **$ 24,045,100** | | | $24,045,100 | $ 24,045,100 | $ 24,045,100 | $ 24,045,100 | $ 24,131,690 |
| 1 | 0.950 | $0 | $ - | $ 3,263 | $ 3,263 | $ 3,101 | $ 24,048,363 | $ 24,048,201 | $ 86,590 |
| 2 | 0.903 | $ - | $ - | $ 3,361 | $ 3,361 | $ 3,034 | $ 24,051,725 | $ 24,051,235 | $ 83,489 |
| 3 | 0.858 | $ - | $ - | $ 3,462 | $ 3,462 | $ 2,969 | $ 24,055,187 | $ 24,054,204 | $ 80,455 |
| 4 | 0.815 | $ - | $ - | $ 3,566 | $ 3,566 | $ 2,906 | $ 24,058,753 | $ 24,057,110 | $ 77,485 |
| 5 | 0.774 | $ - | $ - | $ 3,673 | $ 3,673 | $ 2,844 | $ 24,062,426 | $ 24,059,954 | $ 74,579 |
| 6 | 0.736 | $ - | $ - | $ 3,783 | $ 3,783 | $ 2,783 | $ 24,066,209 | $ 24,062,737 | $ 71,735 |
| 7 | 0.699 | $ - | $ - | $ 3,897 | $ 3,897 | $ 2,724 | $ 24,070,106 | $ 24,065,461 | $ 68,952 |
| 8 | 0.664 | $ - | $ - | $ 4,014 | $ 4,014 | $ 2,665 | $ 24,074,119 | $ 24,068,126 | $ 66,229 |
| 9 | 0.631 | $ - | $ - | $ 4,134 | $ 4,134 | $ 2,608 | $ 24,078,253 | $ 24,070,735 | $ 63,563 |
| 10 | 0.599 | $ - | $ - | $ 4,258 | $ 4,258 | $ 2,553 | $ 24,082,511 | $ 24,073,287 | $ 60,955 |
| 11 | 0.570 | $ - | $ 19,096 | $ 4,386 | $ 23,482 | $ 13,375 | $ 24,105,993 | $ 24,086,662 | $ 58,402 |
| 12 | 0.541 | $ - | $ - | $ 4,517 | $ 4,517 | $ 2,445 | $ 24,110,510 | $ 24,089,107 | $ 45,028 |
| 13 | 0.514 | $ - | $ - | $ 4,653 | $ 4,653 | $ 2,392 | $ 24,115,163 | $ 24,091,499 | $ 42,583 |
| 14 | 0.489 | $ - | $ - | $ 4,792 | $ 4,792 | $ 2,341 | $ 24,119,956 | $ 24,093,840 | $ 40,191 |
| 15 | 0.464 | $ - | $ - | $ 4,936 | $ 4,936 | $ 2,291 | $ 24,124,892 | $ 24,096,131 | $ 37,849 |
| 16 | 0.441 | $ - | $ - | $ 5,084 | $ 5,084 | $ 2,242 | $ 24,129,976 | $ 24,098,374 | $ 35,558 |
| 17 | 0.419 | $ - | $ - | $ 5,237 | $ 5,237 | $ 2,194 | $ 24,135,213 | $ 24,100,568 | $ 33,316 |
| 18 | 0.398 | $ - | $ - | $ 5,394 | $ 5,394 | $ 2,147 | $ 24,140,607 | $ 24,102,715 | $ 31,122 |
| 19 | 0.378 | $ - | $ - | $ 5,556 | $ 5,556 | $ 2,101 | $ 24,146,162 | $ 24,104,817 | $ 28,974 |
| 20 | 0.359 | $ - | $ - | $ 5,722 | $ 5,722 | $ 2,057 | $ 24,151,885 | $ 24,106,873 | $ 26,873 |
| 21 | 0.341 | $ - | $ 19,096 | $ 5,894 | $ 24,990 | $ 8,533 | $ 24,176,875 | $ 24,115,406 | $ 24,816 |
| 22 | 0.324 | $ - | $ - | $ 6,071 | $ 6,071 | $ 1,970 | $ 24,182,946 | $ 24,117,376 | $ 16,283 |
| 23 | 0.308 | $ - | $ - | $ 6,253 | $ 6,253 | $ 1,927 | $ 24,189,199 | $ 24,119,303 | $ 14,314 |
| 24 | 0.293 | $ - | $ - | $ 6,441 | $ 6,441 | $ 1,886 | $ 24,195,639 | $ 24,121,190 | $ 12,386 |
| 25 | 0.278 | $ - | $ - | $ 6,634 | $ 6,634 | $ 1,846 | $ 24,202,273 | $ 24,123,035 | $ 10,500 |
| 26 | 0.264 | $ - | $ - | $ 6,833 | $ 6,833 | $ 1,806 | $ 24,209,106 | $ 24,124,842 | $ 8,654 |
| 27 | 0.251 | $ - | $ - | $ 7,038 | $ 7,038 | $ 1,768 | $ 24,216,144 | $ 24,126,610 | $ 6,848 |
| 28 | 0.239 | $ - | $ - | $ 7,249 | $ 7,249 | $ 1,730 | $ 24,223,393 | $ 24,128,340 | $ 5,080 |
| 29 | 0.227 | $ - | $ - | $ 7,466 | $ 7,466 | $ 1,693 | $ 24,230,859 | $ 24,130,033 | $ 3,350 |
| 30 | 0.215 | $ - | $ - | $ 7,690 | $ 7,690 | $ 1,657 | $ 24,238,550 | $ 24,131,690 | $ 1,657 |

**Description: WQBE_26B - Reforestation High Density Development On Property with Property Cost**

**Life-Cycle Cost Model Input Assumptions:**

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**

16 Removal of trash and debris along the pedestrian trail to occur annually. Work to be performed by a crew of two using hand tools (1 visits per year, 8 hours per visit).

8 Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed annually by a crew of two using hand tools (1 visits per year, 4 hours per visit).

**Replacement Assumptions:**

Replace signage every 10 years. Repairs at 10% of trail every 10 years.
The irrigation system is to be abandoned in place and will not be replaced.
It is assumed that the reforested area will remain natural and plant replacement beyond the establishment period will not be required.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 7/21/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer<br>Trooper Shaw<br>Jess Dexheimer |
| **Description:** | WQBE_26B - Reforestation High Density Development - On Property with Property Cost | | | **Version:** | 1 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| | **Reforestation On Property with Property Cost (43,560 SF Area)** | 43,560 | SF | | $ - |
| | Existing Building % of total area | 40% | | | $ - |
| | Existing Parking Lot % of total area | 60% | | | $ - |
| | Building foundation depth | 4 | FT | | $ - |
| | | | | | $ - |
| | **Demolition and Removals** | | | | $ - |
| | Remove Existing Pavement | 2,904 | SY | $ 14 | $ 40,656 |
| | Demolition, Haul, and Disposal Existing Building & Utilities (Standard Construction) | 40,656 | SF | $ 30 | $ 1,219,680 |
| | Remove, Haul, Disposal Concrete Buidling Foundation | 12,046 | TN | $ 334 | $ 4,023,438 |
| | Allowance for removal, haul, and Disposal of Existing Site Utilities | 1 | LS | $ 50,000 | $ 50,000 |
| | | | | | $ - |
| | **Earthwork and Site Preparation** | | | | |
| | Site Grading, Shaping, and Building Foundation Backfill (No Import) | 2,420 | CY | $ 28 | $ 67,760 |
| | Scarifying subsoil (to 6" Depth) | 2,904 | SY | $ 4 | $ 11,616 |
| | Topsoil @ 18" depth | 2,420 | CY | $ 105 | $ 254,100 |
| | Mulch Compost @4" depth | 538 | CY | $ 80 | $ 43,022 |
| | | | | | $ - |
| | **Site Restoration & Reforestation** | | | | $ - |
| | *Paved Trail Length* | 1,200 | LF | | $ - |
| | *Paved Trail Width* | 12 | FT | | $ - |
| | Trail 4" HMA/4"CSBC | 1,600 | SY | $ 71 | $ 113,600 |
| | Trees @ 2 trees/1000 sf | 88 | EA | $ 720 | $ 63,360 |
| | Bareroot schrubs @62/1000 sf for 90% area | 2,701 | EA | $ 50 | $ 135,050 |
| | Bareroot groundcover @13/1000 sf | 567 | EA | $ 42 | $ 23,814 |
| | Temporary Irrigation System | 1 | LS | $ 39,410 | $ 39,410 |
| | Landscape Establishment - 2 years | 1 | LS | $ 74,500 | $ 74,500 |
| | Trail Signage Allowance | 1 | LS | $ 6,000 | $ 6,000 |
| | | | | | $ - |
| | **Additional Costs** | | | | $ - |
| | Removals @ 10% Construction Costs | 10% | LS | $ 6,166,006 | $ 616,601 |
| | TESC @ 2% of Construction Costs | 2% | LS | $ 6,782,607 | $ 135,652 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 6,918,259 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 691,826 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 7,610,085 |
| | | | | ***Direct: Subtotal Construction Costs (43560 SF Area)*** | ***$ 7,610,085*** |

**Description: WQBE 26B - Reforestation On Property w/Property Cost**

Convert existing impervious surfaces to forest by uncompacting/amending soil and planting trees and understory vegetation.
Typical "strip mall" parcel acquired; structure and parking lot razed/removed; parcel restored as forest cover with simple trail.

**Cost Estimating Assumptions:**

Pavement removal per the King Co. SW Design Manual Appendix C, Section C.2.9.
Reforestation On Property with Property Cost (43,560 SF Area)
The total removal footprint = 1 acre (43,560 sf) with a 1:1 length to width ratio.
Assume strip mall; parcel area coverage = 60% parking (26,136 sf) and 40% single story structure (17,424 sf)
The cost model assumes a commercial parking lot type application.
Site soils and CSBC may be used for backfill of building foundation removals and import will not be required.
Existing impervious surface 4" HMA and 4" CSBC (e.g., crushed rock, gravel, etc.) removal.
Scarify subsoil to 6" depth and place 18 inches of topsoil type A
A minimum of 4 inches of compost amendment is added and mixed into the scarified soils.

Plant multi-layer native plant communities:
--Plant with 5-gallon container trees at a spacing of 25 ft on center (2 trees/1,000 sqft).
--Plant with bareroot shrubs at a spacing of 5 ft on center for 90% of remaining area (62 schrubs/1,000 sqft).
--Plant with bareroot groundcover at a spacing of 3 ft on center for 10% of remaining area (13 groundcovers/1,000 sqft

Assume simple trail 4" HMA/4" CSBC @ 8' width through forest
Maintain plants during 2 year plant establishment period
Temporary irrigation system will be required during the establishment period.
The existing water and power service will be available for the temporary irrigation system and utilities will not be required.
The project is located in a developed and potentially urbanized area. Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
A removal allowance estimated at 10% of the construction cost is assumed for removals of existing utilities, storm structures, and unidentified existing structures and obstructions.
The facility is located on property and traffic control will not be required.
The facility is located outside of the ROW and a street use permit is not required.
The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to Medium.

**Planning Basis Assumptions:**

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

**Cost Basis Assumptions:**

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

**Allowances:**

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

**Estimating Assumptions:**

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 7/21/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer<br>Trooper Shaw<br>Jess Dexheimer |
| **Description:** | WQBE_26C - Reforestation Pervious Area on Property (43560 SF Area) | | | **Version:** | 1 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Reforestation Pervious Area on Property (43,560 SF Area) | 43,560 | SF | $ 16 | $ 682,257 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 682,257*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 136,451 |
| | | | | Street Use Permit (Y/N) N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 818,708*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 81,871 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 900,579*** |
| | | | | Construction Sales Tax | $ 92,309 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 992,900*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 198,127 |
| | | | | Construction Management | $ 90,058 |
| | | | | Permitting & Support | $ 9,006 |
| 43560 | s.f. Land Area | None | Land Purchase/ROW Acquisition | | $ - |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 54,035 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 351,226*** |
| | | | | Project Contingency | $ 403,238 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 754,500*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 1,747,400*** |

| | | |
|---|---|---|
| **Description: WQBE_26C - Reforestation Pervious Area On Property (2023 Dollars)** | | |
| Unit | 43,560 | ft2 |
| **E 26 - Reforestation On Cleared Property with Property Cost** | **$ 1,747,400** | |
| Capital cost | $ 40 | $/Unit |
| Total Direct O&M/Year | $ - | |
| Reforestation On Property with Property Cost (43,560 SF Area) | $ - | $/Unit |
| Capital Replacement Costs (10 Years) | $ - | $/unit |
| Discount rate (%) | 5.25 | $/Unit |
| **Total Cost (NPV)** | **$ 1,747,400** | **$/unit** |
| **Annual O&M Cost** | **$ -** | **$/year** |
| Annualized Cost | $0 | $/year |

**Materials, Supplies, Other Costs**

| | | | | |
|---|---|---|---|---|
| | $ - | $ - | $/year | |
| | 2023 dollars | $ - | $/year | |
| | 2023 dollars | $ - | $/year | |
| Subtotal | | $0 | | |
| Labor | | | | |
| | 0 | hr | | |
| | 0 | hr | | |
| | 0 | hr | | |
| | | hr | | |
| **Total hours per year** | 0 | | | |
| Raw Labor Rate/Hr | | $ 54 | | |
| Raw labor cost | (embedded) | $ - | | |
| Labor cost, burdened | O/H 150.0% | $ - | $ 135.98 | |
| General and Labor Cost Escalation/Year | 3.0% | | | |
| Life Cycle Period: | 30 | years | | |

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs: Cash | Cumulative Costs: Present Value | Cumulative Costs: Discounted Cost per Year |
|---|---|---|---|---|---|---|---|---|---|
| **Cash Sum ($)** | | $ - | | $ - | **$1,747,400** | **$ 1,747,400** | | | |
| 0 | 1.000 | **$ 1,747,400** | | | $1,747,400 | $ 1,747,400 | $ 1,747,400 | $ 1,747,400 | $ 1,747,400 |
| 1 | 0.950 | $0 | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 2 | 0.903 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 3 | 0.858 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 4 | 0.815 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 5 | 0.774 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 6 | 0.736 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 7 | 0.699 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 8 | 0.664 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 9 | 0.631 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 10 | 0.599 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 11 | 0.570 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 12 | 0.541 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 13 | 0.514 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 14 | 0.489 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 15 | 0.464 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 16 | 0.441 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 17 | 0.419 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 18 | 0.398 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 19 | 0.378 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 20 | 0.359 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 21 | 0.341 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 22 | 0.324 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 23 | 0.308 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 24 | 0.293 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 25 | 0.278 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 26 | 0.264 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 27 | 0.251 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 28 | 0.239 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 29 | 0.227 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |
| 30 | 0.215 | $ - | $ - | $ - | $ - | $ - | $ 1,747,400 | $ 1,747,400 | $ - |

**Description: WQBE_26C - Reforestation Pervious Area On Property**

**Life-Cycle Cost Model Input Assumptions:**
Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**
The property is assumed to be rural and not accessible for public use.

**Replacement Assumptions:**
The irrigation system is to be abandoned in place and will not be replaced.
It is assumed that the reforested area will remain natural and plant replacement beyond the establishment period will not be required.

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 7/21/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer<br>Trooper Shaw<br>Jess Dexheimer |
| **Description:** | WQBE_26C - Reforestation Pervious Area on Property (43560 SF Area) | | | **Version:** | 1 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| | **Reforestation On Property with Property Cost (43,560 SF Area)** | 43,560 | SF | | $ - |
| | | | | | $ - |
| | **Demolition and Removals** | | | | $ - |
| | Clearing and Grubbing | 4,840 | SY | $ 12 | $ 58,080 |
| | | | | | $ - |
| | **Earthwork and Site Preparation** | | | | |
| | Scarifying subsoil (to 6" Depth) | 2,420 | SY | $ 4 | $ 9,680 |
| | Topsoil @ 12" depth | 1,613 | CY | $ 105 | $ 169,400 |
| | Mulch Compost @4" depth | 538 | CY | $ 80 | $ 43,022 |
| | | | | | $ - |
| | **Site Restoration & Reforestation** | | | | $ - |
| | Trees @ 2 trees/1000 sf | 88 | EA | $ 720 | $ 63,360 |
| | Bareroot schrubs @62/1000 sf for 90% area | 2,701 | EA | $ 50 | $ 135,050 |
| | Bareroot groundcover @13/1000 sf | 567 | EA | $ 42 | $ 23,814 |
| | Temporary Irrigation System | 1 | LS | $ 39,410 | $ 39,410 |
| | Landscape Establishment - 1 year | 1 | LS | $ 37,300 | $ 37,300 |
| | | | | | $ - |
| | **Additional Costs** | | | | $ - |
| | Removals @ 5% Construction Costs | 5% | LS | $ 579,116 | $ 28,956 |
| | TESC @ 2% of Construction Costs | 2% | LS | $ 608,072 | $ 12,161 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 620,233 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | | General Conditions | 0% | 1 | $ - |
| | | Mobilization/Demobilization | 10% | 1.1 | $ 62,023 |
| | | Overhead & Profit (OHP) | 0% | 1 | $ - |
| | | Insurance | 0.0% | 1 | $ - |
| | | Bonding | 0.0% | 1 | $ - |
| | | Escalation Multiplier from ENR-CCI | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 682,257 |
| | | | | ***Direct: Subtotal Construction Costs (43560 SF Area)*** | ***$ 682,257*** |

| | |
|---|---|
| | |
| | **Description: WQBE 26C - Reforestation Pervious Area On Property** |
| | Convert existing developed areas to forest by uncompacting/amending soil and planting trees and understory vegetation.<br>Cleared parcel; parking lot razed/removed; parcel restored as forest cover with simple trail. |
| | |
| | **Cost Estimating Assumptions:** |
| | Pavement removal is not included. |
| | Reforestation On Cleared Property No Property Cost (43,560 SF Area) |
| | The cost model assumes a rural, open area. |
| | 1/2 of the area will require scarification and topsoil application. Scarify subsoil to 6" depth and place 12 inches of topsoil type A |
| | A minimum of 4 inches of compost amendment is added and mixed into the scarified soils. |
| | Plant multi-layer native plant communities:<br>--Plant with 5-gallon container trees at a spacing of 25 ft on center (2 trees/1,000 sqft).<br>--Plant with bareroot shrubs at a spacing of 5 ft on center for 90% of remaining area (62 schrubs/1,000 sqft).<br>--Plant with bareroot groundcover at a spacing of 3 ft on center for 10% of remaining area (13 groundcovers/1,000 sqft |
| | Maintain plants during 1 year plant establishment period |
| | Temporary irrigation system will be required during the establishment period. The irrigation system will operate with gravity feed and will not have an electrical controller. |
| | The existing water and power service will not be available for the temporary irrigation system. |
| | The project is located in a developed in rural areas. Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs. |
| | A removal allowance estimated at 5% of the construction cost is assumed for removals of existing obstructions. |
| | The facility is located on property and traffic control will not be required. |
| | The facility is located outside of the ROW and a street use permit is not required. |
| | No property easements or acquisition are required. |
| | |
| | **Planning Basis Assumptions:** |
| | No project construction plan is in place at this time. |
| | The assumed execution strategy is a standard work week with limited overtime. |
| | No alternative procurement methods have been considered as part of delivery of this concept. |
| | No unusual site conditions have been considered as part of this estimate. |
| | |
| | **Cost Basis Assumptions:** |
| | Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities. |
| | |
| | **Allowances:** |
| | The level and types of allowances used in the estimate are as follows: |
| | Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies. |
| | Allowance of 10% for potential change orders. |
| | This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor |
| | A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process. |
| | Costs were not included for Local Agency Mitigation and Indirect Burden. |
| | The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included. |
| | Costs were not included for utility relocation work. |
| | |
| | **Estimating Assumptions:** |
| | This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation. |
| | It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. |
| | It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials. |
| | It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces. |
| | It is assumed that there will be some degree of minimal cost rounding during the normal estimating process. |

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 7/21/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer<br>Trooper Shaw<br>Jess Dexheimer |
| **Description:** | WQBE_26D - Reforestation Pervious Area On Property w/Property Cost | | | **Version:** | 1 |
| **DIRECT: SUBTOTAL CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| 1 | Reforestation Pervious Area On Property w/Property Cost (43,560 SF Area) | 43,560 | SF | $ 16 | $ 682,257 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | $ - |
| | | | | | $ - |
| | | | | | $ - |
| | | | | ***Subtotal Construction Costs*** | ***$ 682,257*** |
| | | | | Allowance for Indeterminates (Design Allowance) | $ 136,451 |
| | | | Street Use Permit (Y/N) | N | $ - |
| | | | | ***ESTIMATED PROBABLE COST OF CONSTRUCTION BID*** | ***$ 818,708*** |
| **DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS** | | | | | |
| | | | | Construction Change Order Allowance | $ 81,871 |
| | | | | ***Subtotal Primary Construction Amount*** | ***$ 900,579*** |
| | | | | Construction Sales Tax | $ 92,309 |
| | | | | Outside Agency Construction | $ - |
| | | | | ***TOTAL DIRECT CONSTRUCTION COSTS*** | ***$ 992,900*** |
| **INDIRECT: NON-CONSTRUCTION COSTS** | | | | | |
| | | | | Design Engineering | $ 198,127 |
| | | | | Construction Management | $ 90,058 |
| | | | | Permitting & Support | $ 9,006 |
| 43560 | s.f. Land Area | Medium | Land Purchase/ROW Acquisition | | $ 3,503,531 |
| | s.f. Land Area | None | Permanent Easements | | $ - |
| | | | | WTD Staff Costs & Non-WTD Support | $ 54,035 |
| | | | | ***Subtotal Non-Construction Costs*** | ***$ 3,854,757*** |
| | | | | Project Contingency | $ 1,454,297 |
| | | | | ***TOTAL INDIRECT NON-CONSTRUCTION COSTS*** | ***$ 5,309,100*** |
| | | | | ***TOTAL PROJECT COST*** | ***$ 6,302,000*** |

**Description: WQBE_26D - Reforestation Pervious Area w/Property Cost (2023 Dollars)**

| | | |
|---|---|---|
| Unit | 43,560 | ft2 |
| **E_26 - Reforestation On Cleared Property with Property Cost** | **$ 6,302,000** | |
| Capital cost | $ 145 | $/Unit |
| Total Direct O&M/Year | $ - | |
| Reforestation On Property with Property Cost (43,560 SF Area) | $ - | $/Unit |
| Capital Replacement Costs (10 Years) | $ - | $/unit |
| Discount rate (%) | 5.25 | $/Unit |
| | | |
| **Total Cost (NPV)** | **$ 6,302,000** | **$/unit** |
| **Annual O&M Cost** | **$ -** | **$/year** |
| Annualized Cost | $0 | $/year |

**Materials, Supplies, Other Costs**

| | | | | |
|---|---|---|---|---|
| | $ - | $ - | $/year | |
| | 2023 dollars | $ - | $/year | |
| | 2023 dollars | $ - | $/year | |
| Subtotal | | $0 | | |
| Labor | | | | |
| | 0 | hr | | |
| | 0 | hr | | |
| | 0 | hr | | |
| | | hr | | |
| **Total hours per year** | 0 | | | |
| Raw Labor Rate/Hr | | $ 54 | | |
| Raw labor cost | (embedded) | $ - | | |
| Labor cost, burdened | O/H 150.0% | $ - | $ 135.98 | |
| General and Labor Cost Escalation/Year | 3.0% | | | |
| Life Cycle Period: | 30 | years | | |

**Description: WQBE_26D - Reforestation Pervious Area w/Property Cost**

**Life-Cycle Cost Model Input Assumptions:**
Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

**O&M Estimating Assumptions:**
The property is assumed to be rural and not accessible for public use.

**Replacement Assumptions:**
The irrigation system is to be abandoned in place and will not be replaced.
It is assumed that the reforested area will remain natural and plant replacement beyond the establishment period will not be required.

| Year | Discount Factor | Capital & Assoc. Costs | Capital Replacement Costs | Regular Maint. Costs | Total Costs | Present Value of Costs | Cumulative Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cash | Present Value | Discounted Cost per Year |
| **Cash Sum ($)** | | $ - | | $ - | **$6,302,000** | **$ 6,302,000** | | | |
| 0 | 1.000 | **$ 6,302,000** | | | $6,302,000 | $ 6,302,000 | $ 6,302,000 | $ 6,302,000 | $ 6,302,000 |
| 1 | 0.950 | $0 | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 2 | 0.903 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 3 | 0.858 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 4 | 0.815 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 5 | 0.774 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 6 | 0.736 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 7 | 0.699 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 8 | 0.664 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 9 | 0.631 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 10 | 0.599 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 11 | 0.570 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 12 | 0.541 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 13 | 0.514 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 14 | 0.489 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 15 | 0.464 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 16 | 0.441 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 17 | 0.419 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 18 | 0.398 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 19 | 0.378 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 20 | 0.359 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 21 | 0.341 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 22 | 0.324 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 23 | 0.308 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 24 | 0.293 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 25 | 0.278 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 26 | 0.264 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 27 | 0.251 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 28 | 0.239 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 29 | 0.227 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |
| 30 | 0.215 | $ - | $ - | $ - | $ - | $ - | $ 6,302,000 | $ 6,302,000 | $ - |

| Estimate - AACEI Class 10 | | | | | |
|---|---|---|---|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation | | | **Date:** | 7/21/2024 |
| **Location:** | King County, WA | | | **Estimator:** | Cindy Kinzer<br>Trooper Shaw<br>Jess Dexheimer |
| **Description:** | WQBE_26D - Reforestation Pervious Area On Property w/Property Cost | | | **Version:** | 1 |
| **CONSTRUCTION COSTS** | | | | | |
| **Item No.** | **Item Description** | **Quantity** | **Units** | **Unit Cost** | **Item Cost** |
| | **Reforestation On Property with Property Cost (43,560 SF Area)** | 43,560 | SF | | $ - |
| | | | | | $ - |
| | **Demolition and Removals** | | | | $ - |
| | Clearing and Grubbing | 4,840 | SY | $ 12 | $ 58,080 |
| | | | | | $ - |
| | **Earthwork and Site Preparation** | | | | |
| | Scarifying subsoil (to 6" Depth) | 2,420 | SY | $ 4 | $ 9,680 |
| | Topsoil @ 18" depth | 1,613 | CY | $ 105 | $ 169,400 |
| | Mulch Compost @4" depth | 538 | CY | $ 80 | $ 43,022 |
| | | | | | $ - |
| | **Site Restoration & Reforestation** | | | | $ - |
| | Trees @ 2 trees/1000 sf | 88 | EA | $ 720 | $ 63,360 |
| | Bareroot shrubs @62/1000 sf for 90% area | 2,701 | EA | $ 50 | $ 135,050 |
| | Bareroot groundcover @13/1000 sf | 567 | EA | $ 42 | $ 23,814 |
| | Temporary Irrigation System | 1 | LS | $ 39,410 | $ 39,410 |
| | Landscape Establishment - 1 year | 1 | LS | $ 37,300 | $ 37,300 |
| | | | | | $ - |
| | **Additional Costs** | | | | $ - |
| | Removals @ 5% Construction Costs | 5% | LS | $ 579,116 | $ 28,956 |
| | TESC @ 2% of Construction Costs | 2% | LS | $ 608,072 | $ 12,161 |
| | | | | | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 620,233 |
| **DIRECT: CONSTRUCTION COST MARK-UPS** | | | | | |
| | General Conditions | | 0% | 1 | $ - |
| | Mobilization/Demobilization | | 10% | 1.1 | $ 62,023 |
| | Overhead & Profit (OHP) | | 0% | 1 | $ - |
| | Insurance | | 0.0% | 1 | $ - |
| | Bonding | | 0.0% | 1 | $ - |
| | Escalation Multiplier from ENR-CCI | | 0% | 1.0000 | $ - |
| | | | | ***Item Subtotal Construction Costs (Year 2023)*** | $ 682,257 |
| | | | | ***Direct: Subtotal Construction Costs (43560 SF Area)*** | ***$ 682,257*** |

| | |
|---|---|
| | |
| | **Description: WQBE 26D - Reforestation Pervious Area On Property w/Property Cost** |
| | Convert existing developed areas to forest by uncompacting/amending soil and planting trees and understory vegetation.<br>Cleared parcel; parking lot razed/removed; parcel restored as forest cover with simple trail. |
| | |
| | **Cost Estimating Assumptions:** |
| | Pavement removal is not included. |
| | Reforestation On Cleared Property with Property Cost (43,560 SF Area) |
| | The cost model assumes a rural, open area. |
| | 1/2 of the area will require scarification and topsoil application. Scarify subsoil to 6" depth and place 12 inches of topsoil type A |
| | A minimum of 4 inches of compost amendment is added and mixed into the scarified soils. |
| | Plant multi-layer native plant communities:<br>--Plant with 5-gallon container trees at a spacing of 25 ft on center (2 trees/1,000 sqft).<br>--Plant with bareroot shrubs at a spacing of 5 ft on center for 90% of remaining area (62 shrubs/1,000 sqft).<br>--Plant with bareroot groundcover at a spacing of 3 ft on center for 10% of remaining area (13 groundcovers/1,000 sqft |
| | Maintain plants during 1 year plant establishment period |
| | Temporary irrigation system will be required during the establishment period. The irrigation system will operate with gravity feed and will not have an electrical controller. |
| | The existing water and power service will not be available for the temporary irrigation system. |
| | The project is located in a developed in rural areas. Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs. |
| | A removal allowance estimated at 5% of the construction cost is assumed for removals of existing obstructions. |
| | The facility is located on property and traffic control will not be required. |
| | The facility is located outside of the ROW and a street use permit is not required. |
| | The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to Medium. |
| | |
| | **Planning Basis Assumptions:** |
| | No project construction plan is in place at this time. |
| | The assumed execution strategy is a standard work week with limited overtime. |
| | No alternative procurement methods have been considered as part of delivery of this concept. |
| | No unusual site conditions have been considered as part of this estimate. |
| | |
| | **Cost Basis Assumptions:** |
| | Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities. |
| | |
| | **Allowances:** |
| | The level and types of allowances used in the estimate are as follows: |
| | Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies. |
| | Allowance of 10% for potential change orders. |
| | This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor |
| | A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process. |
| | Costs were not included for Local Agency Mitigation and Indirect Burden. |
| | The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included. |
| | Costs were not included for utility relocation work. |
| | |
| | **Estimating Assumptions:** |
| | This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation. |
| | It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. |
| | It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials. |
| | It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces. |
| | It is assumed that there will be some degree of minimal cost rounding during the normal estimating process. |

# Attachment B

## Cost Estimates with Life-Cycle Cost Analysis Workbooks

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The contents of this attachment are provided in a separate electronic file.

# Attachment C

## Benchmarking Review Form

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# FORM WQBE QC-1: TECHNICAL REVIEW COMMENTS

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| **Project #:** | 1136613 |
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| **Contact:** | Carly Greyell (carly.greyell@kingcounty.gov) |

| Comment Type Category: |
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| **G - General** |
| **T - Technical** |
| **E - Editorial** |
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| DOCUMENT INFORMATION | |
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| **Created by:** | HDR |
| **Contact:** | Cindy Kinzer (cindy.kinzer@hdrinc.com) |
| **Type:** | Spreadsheets |
| **Date:** | 1/16/2024 |
| **Purpose:** | Estimate unit cost of project implementation for full suite of WQBE Actions including design, construction, CM, and agency support + overall contingency. |

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| **Response Date:** | 6/7/2024 |
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| **Company:** | Lotus Water | |
| **Title:** | Senior QA/QC Reviewer | |
| **Review Date:** | 1/29/2024 | |
| **Email:** | rdusenbury@lotuswater.com | |

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|---|---|---|---|---|---|---|---|---|
| 1 | RD | T | **01 Rain Garden**: Recommend lowering unit cost for for Rain Garden Landscape to $25/sf and $500 lump sum to restore existing landscape around the new Rain Garden (in place of 125 sf @ $10/sf). This facility is similar to a swale in that it involves grading, soil amendments, and plants + compost, yet it is ~3X the unit cost to account for homeowners wanting things' "just so" in their backyard. I would expect total project cost for a 25 sf rain garden in a residential backyard to be <$10K. | CK | 2 | Raingarden restoration estimating basis assumptions were coordinated with Lotus and Herrera on 02/26/24 and revised to match review recommendations. | OW | 1 |
| 2 | RD | G | **02 Bioretention Planter**: Looks go be in reasonable range. | CK | 2 | Noted with no action required. | OW | 1 |

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|---|---|---|---|---|---|---|---|---|
| 3 | RD | T | **03 Bioretention**: Would expect lack for form work to drive down cost more compared to 02 BP, plus economies of scale are better. A closer look revealed that method of scaling costs for line items under Outlet Pipe were biased against this Action and should be revisited to lower those costs. Recommend lowering those line-item costs. Recommend lowering Landscaping and Restoration to $25/sf. | CK | 2 | The first comment was coordinated with the HEC team based on simialr projects within a high density residential setting (vs. urban). Comment 3a was implemented. Comment 3b was rejected since costs were set at $59/SY. | OW | 1 |
| 4 | RD | G | **04 Bioswale**: Looks to be in reasonable range. | CK | 2 | Noted with no action required. | OW | 1 |
| 5 | RD | G | **05 Media Filter**: I have no particular insight into costs for this Action. They are not used much in the SF Bay Area. | CK | 2 | Noted with no action required. | OW | 1 |

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|---|---|---|---|---|---|---|---|---|
| 6 | RD | T | **06 Drywell**: Contractors advertise installation of residential dry wells in suburban settings on the Peninsula south of SF for half of this WQBE estimate. Recommend revisiting and potentially lowering to be consistent with costs for installed systems in suburban Seattle. | CK | 4 | Costs were based on SPU standard details for a drywell and catch basin w/piping system. The costs were considered consistent with complete installations of the system described. | OW | 1 |
| 7 | RD | G | **07 Deep UIC Well**: I have no particular insight into costs for this Action. | CK | 2 | Noted with no action required. | OW | 1 |
| 8 | RD | G | **08 Permeable Pavement**: These costs look reasonable for all types considered. | CK | 2 | Noted with no action required. | OW | 1 |
| 9 | RD | G | **09 Depaving**: These costs look reasonable. | CK | 2 | Noted with no action required. | OW | 1 |

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|---|---|---|---|---|---|---|---|---|
| 10 | RD | T | **11 Detention Vault**: The unit cost for this Action remains stubbornly high as compared to system installed by SWS at Evans Creek in 2017. Even with 5% annual escalation, WQBE costs are 4X on a unit basis. This has been attributed to updates in the design basis, but it is a very large difference from actual built costs not that long ago. | CK | 4 | Per the Benchmarking TM, wetvaults at Evans Ck. were retrofit and there may be dissimilarities in design/estimating basis assumptions. It is recommended that the ratio to dead storage vs. live storage be evaluated for the vault actions (#11 14, & 19), which can be a cost driver. It is recommended that the storage depth/small storage volume assumptions be evaluated using a depth to storage cost sensitivity analysis or in comparison with existing regional facility installations within King Co. or western Washington. | OW | 1 |
| 11 | RD | T | **12 Detention Pond**: No cost basis for comparison, but costs seem reasonable given headboard and overflow structure design basis. | CK | 2 | Noted with no action required. | OW | 1 |

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|---|---|---|---|---|---|---|---|---|
| 12 | RD | T | **13 Infiltration Pond**: No cost basis for comparison, but costs seem reasonable given headboard, overflow structure, and treatment layer design basis. | CK | 2 | Noted with no action required. | OW | 1 |
| 13 | RD | T | **14 Infiltration Vault**: No cost basis for comparison, but comments apply from Action 19 Wet Vault. | CK | 4 | Refer to Infiltration vault response under #13. | OW | 1 |

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| 14 | RD | T | **18 Wet Pond**: Unit cost is $929/sf, which is 6X those of Action 12 Detention Pond and seems unreasonably high. SWS installed 2 Wet Pond projects (Seola Creek in 2012 and White Center in 2012-13). With 5% annual escalation, the WQBE unit cost estimate is still 7X those systems. As with the Vaults, this has been attributed to updates in the design basis, but it is a very large difference from actual built costs. It should be noted the built installations were orders of magnitude larger so enjoyed positive economies of scale. Recommend Ponds for use as regional collection facilities at large scale. | CK | 4 | Costs on the pond and SW treatment wetland actions (#12, 13, 18, and 20) were based on minimum to low storage depth for the facility area which can be a cost driver. It is recommended that the storage depth/small storage volume assumptions be evaluated using a depth to storage cost sensitivity analysis or in comparison with existing regional facility installations within King Co. or western Washington. | OW | 1 |

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|---|---|---|---|---|---|---|---|---|
| 15 | RD | T | **19 Wet Vault**: The unit cost for this Action remains stubbornly high as compared to system installed by SWS at Evans Creek in 2017. Even with 5% annual escalation, WQBE costs are 4X on a unit basis. This has been attributed to updates in the design basis, but it is a very large difference from actual built costs not that long ago. | CK | 4 | Per the Benchmarking TM prepared by Lotus Water (Feb. 2021), wetvaults at Evans Ck. were retrofit and there may be dissimilarities in design/estimating basis assumptions. It is recommended that the ratio to dead storage vs. live storage be evaluated for the vault actions (#11 14, & 19), which can be a cost driver. It is recommended that the storage depth/small storage volume assumptions be evaluated using a depth to storage cost sensitivity analysis or in comparison with existing regional facility installations within King Co. or western Washington. | OW | 1 |

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| **Type:** | Spreadsheets |
| **Date:** | 1/16/2024 |
| **Purpose:** | Estimate unit cost of project implementation for full suite of WQBE Actions including design, construction, CM, and agency support + overall contingency. |

| RESPONDER | |
|---|---|
| **Name:** | Cindy Kinzer |
| **Company/Agency:** | HDR |
| **Title:** | Stormwater Lead |
| **Response Date:** | 6/7/2024 |
| **Email:** | Cindy.Kinzer@hdrinc.com |

| Response Code: |
|---|
| 1 - Accepted - Will comply |
| 2 - Accepted - Action completed |
| 3 - Discussion or clarification required |
| 4 - Unacceptable for reasons given |

| REVIEWERS | Reviewer #1 | Reviewer #2 |
|---|---|---|
| **Name:** | Robert Dusenbury (RD) | |
| **Company:** | Lotus Water | |
| **Title:** | Senior QA/QC Reviewer | |
| **Review Date:** | 1/29/2024 | |
| **Email:** | rdusenbury@lotuswater.com | |

| Comment Status Code: |
|---|
| 1 - Resolved |
| 2 - Resolution pending |
| 3 - Unresolved |
| 4 - Rolled over to next submittal |

| Comment No. | Reviewer | Comment Type | Review Comment | Responder | Response Code | Response Comment | Verifier | Comment Status Code |
|---|---|---|---|---|---|---|---|---|
| 16 | RD | G | **20 SW Treatment Wetland**: I don't have specific cost info, but $958/sf is an order of magnitude higher than reported costs I have heard for these systems. | CK | 2 | Costs on the pond and SW treatment wetland actions (#12, 13, 18, and 20) are based on minimum to low storage depth for the facility area which can be a cost driver. It is recommended that the storage depth/small storage volume assumptions be evaluated using a depth to storage cost sensitivity analysis or in comparison with existing regional facility installations within King Co. or western Washington. | OW | 1 |
| 17 | RD | G | **21 High Rate Underground Filter**: I have no particular insights into costs for this Action. | CK | 2 | Noted with no action required. | OW | 1 |
| 18 | RD | G | **22 Regional Vegetated Media Systems**: I have no particular insights into costs for this Action. Overall project cost seems appropriate, though. | CK | 2 | Noted with no action required. | OW | 1 |

# FORM WQBE QC-1: TECHNICAL REVIEW COMMENTS

| PROJECT INFORMATION | |
|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation (WQBE) |
| **Project #:** | 1136613 |
| **Subtask:** | Subtask 439 - Flow Control Action and Program Development |
| **Contact:** | Carly Greyell (carly.greyell@kingcounty.gov) |

| Comment Type Category: |
|---|
| G - General |
| T - Technical |
| E - Editorial |
| C - Coordination |

| DOCUMENT INFORMATION | |
|---|---|
| **Title:** | WQBE WO12 Action Estimates (LCC_DRAFT_2024.01.31) |
| **Created by:** | HDR |
| **Contact:** | Cindy Kinzer (cindy.kinzer@hdrinc.com) |
| **Type:** | Spreadsheets |
| **Date:** | 1/16/2024 |
| **Purpose:** | Estimate unit cost of project implementation for full suite of WQBE Actions including design, construction, CM, and agency support + overall contingency. |

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| **Title:** | Stormwater Lead |
| **Response Date:** | 6/7/2024 |
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| Comment No. | Reviewer | Comment Type | Review Comment | Responder | Response Code | Response Comment | Verifier | Comment Status Code |
|---|---|---|---|---|---|---|---|---|
| 19 | RD | T | **23 Sports Field and Park Detention**: The sizing ratio of 30% seems very low. It was explained that is due to assumed till soil conditions at project site. Recommend assuming outwash and lowering both sizing ratio and feasibility %. For costs, a regional capture project in South SF completed in May 2022 had an instream diversion, more complex capture/infiltration/reuse components, 1.8 MG of deep subsurface storage, and an advanced reuse system, and it came in for less than this. The WQBE Action has ~0.5M gal of storage and is a pretty basic system. There is a $4.6M line item for geomembrane+fabric liner for a 30,000 sf facility; recommend assuming wrapped in geotextile only with no geomembrane. I expect that taking the sizing and costing together, the projected cost-effectiveness is off by orders of magnitude from a built project in outwash soils. Costs for artificial turf at the South SF project came | CK | 2 | The design and estimating basis assumptions were coordinated with Lotus and Herrera on 02/26/24. The design basis was revised to allow infiltration and geomembrane liner was deleted from the cost model. Sports field assumed that excavated soils would be unsuitable for re-use. It is recommended that the estimate be evaluated (as a sub-category) with the facility placed in outwash soils during a future phase. | OW | 1 |

# FORM WQBE QC-1: TECHNICAL REVIEW COMMENTS

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|---|---|
| **Title:** | WQBE WO12 Action Estimates (LCC_DRAFT_2024.01.31) |
| **Created by:** | HDR |
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| Comment No. | Reviewer | Comment Type | Review Comment | Responder | Response Code | Response Comment | Verifier | Comment Status Code |
|---|---|---|---|---|---|---|---|---|
| 20 | | T | **24 Blue Roof**: I think of this Action as a relatively inexpensive alternative to green roofs without the multiple benefits, but the $154/sf estimate is at the high end of what I have seen for green roofs. The only agency in the U.S. that I know of that has installed a decent # of green roofs is NYC Dept of the Environment. That was about a decade ago, but they were advertising blue roof costs at $5/sf. Recommend eliminating Permavoid and the leak detection system entirely. Consider costing these as the differential between a blue roof and regular roof replacement and reduce feasibility % to be based on building already needing a new roof. Full response from former NYC Director of GI program forwarded separately. | CK | 2 | The design and estimating basis assumptions were coordinated with Lotus and Herrera on 02/26/24. The leak detection system was eliminated (replaced with frequent inspections) and permavoid was eliminated from the cost model. Blue roof costs for the retrofit described were based on contractor provided information for Seattle/Portland area. | OW | 1 |

# FORM WQBE QC-1: TECHNICAL REVIEW COMMENTS

| PROJECT INFORMATION | |
|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation (WQBE) |
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| Comment No. | Reviewer | Comment Type | Review Comment | Responder | Response Code | Response Comment | Verifier | Comment Status Code |
|---|---|---|---|---|---|---|---|---|
| 21 | | G | **25 Compost Amendment**: I have no particular insight into costs for this Action. | CK | 2 | Noted with no action required. | OW | 1 |
| 22 | | G | **26 Reforestation**: I have no particular insight into costs for this Action. | CK | 2 | Noted with no action required. | OW | 1 |

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# Appendix F

## Phase 3 Program Development

HERRERA
Science + Planning + Design

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HERRERA
Science + Planning + Design

# TECHNICAL MEMORANDUM


**Date:** October 4, 2024

**To:** Carly Greyell, King County Water and Land Resources Division
Jim Simmonds, King County Wastewater Treatment Division

**From:** Alice Lancaster, Herrera Environmental Consultants, Inc.
Olivia Wright, Herrera Environmental Consultants, Inc.
John Lenth, Herrera Environmental Consultants, Inc.


**Subject:** WQBE Phase 3 Program Development (Appendix F to 439-TM1)

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# Contents

# Tables



# Figures

# Introduction

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes for selecting cost-effective water quality investments, reducing pollutant load and improving ecological and human health outcomes. The WQBE Toolkit will include a set of computational models:

- Integrated pollutant loading models, which estimate pollutant loads for major King County waterbodies taking into account major pollutant pathways and sources.
- System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) models, which identify cost-effective combinations of potential water quality improvement investments for reduction of pollutant loads or stormwater volumes.
- Qualitative causal models, which define relationships between potential water quality projects and programs and five ecological/human health endpoints (southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches).

The WQBE Toolkit provides information that will be used in planning and prioritization of water quality investments. However, it is not the only information that informs these decisions. These efforts will also consider information not provided by the WQBE Toolkit, including how well different actions would advance equity and social justice, meet regulatory requirements, impact the cost of wastewater rates, and reflect other regional priorities (e.g., sustainability, community well-being, and more).

Part of this effort has involved the development of model inputs for "Actions" composed of structural or nonstructural stormwater controls that improve water quality and/or provide flow control. These Actions provide the unit building blocks (or "unit Actions") that are aggregated and combined to develop "Programs," or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. SUSTAIN models are then developed for each Program to evaluate cost effectiveness combinations of Actions, or "Packages", for improving water quality or providing flow control.

The WQBE Toolkit is being developed in three phases over a period extending from 2020 through 2024.

- **Phase 1 (2020)**: Assumptions for a preliminary set of nineteen Actions and three Programs focused on improving water quality were developed to be modeled with the WQBE Toolkit.
- **Phase 2 (2021-2022):** Preliminary Actions and Programs from Phase 1 were refined to improve their representation in SUSTAIN (Herrera 2022a). The three water quality Programs from Phase 1 were subsequently modeled with SUSTAIN (Paradigm and Herrera 2022).
- **Phase 3 (2023-2024):** An additional five Actions and four Programs focused on providing flow control were developed and the Phase 2 Action costs were refined using a simplified approach that allows for more direct comparison to similar planning level cost estimates in the region.

This memorandum documents the four new Flow Control Programs developed in Phase 3 for the WQBE Toolkit. The following information is provided: an overview of the Programs, an introduction to the Program Fact Sheets, the assumptions and technical basis for the Program Fact Sheet content, and key limitations/future considerations.

# Program Development Process

The Core Team (Consultant and County staff directly overseeing WQBE toolkit development) held a workshop with King County staff on April 18, 2023, to select and define the WQBE flow control Programs to be developed under Phase 3. The results of this workshop are summarized in a companion memorandum (Herrera 2023). The following Programs were recommended for development:

- GSI Incentive Flow Control Program
- Roadway Retrofit Flow Control Program
- Regional Facility Flow Control Program
- Reforestation Flow Control Program

# Program Overview

This section provides a high-level description of the WQBE Programs from Phase 3 and the component Actions and introduces the Program Fact Sheets.

## Flow Control Programs

Four flow control Programs were developed in Phase 3. A high-level description of each Program is provided below. Detailed Program descriptions are provided in the Program Fact Sheets (see Appendix H of Herrera 2024).

The **Green Stormwater Infrastructure (GSI) Incentive Flow Control Program** would provide incentives for property owners to install small scale GSI practices to help manage the rain that falls on their roofs and other impervious surfaces, such as parking lots and driveways. The Program would provide grants, rebates, or other financial incentives to eligible property owners for installing and maintaining GSI on their properties. This Program's objective is to provide flow control for stormwater runoff from developed parcels with little or no stormwater controls.

The **Roadway Retrofit Flow Control Program** would fund, plan, and implement capital improvement projects to construct flow control practices to manage runoff from roads and highways in King County. The Program would be administered by King County in partnership with the Washington State Department of Transportation (WSDOT), other jurisdictions and nongovernmental agencies. The objective of this Program is to provide flow control for stormwater runoff from road surfaces along County and partner rights-of-way.

The **Regional Facility Flow Control Program** would fund, plan, and implement capital improvement projects to construct regional stormwater flow control facilities to manage runoff from large drainage areas that may include multiple types of land uses. The Program would be administered by King County in partnership with other jurisdictions and nongovernmental agencies. The objective of this Program is to provide flow control for stormwater runoff from a variety of land uses with centralized regional facilities located on both private and public parcels. For private parcels, cost for land acquisition is included.

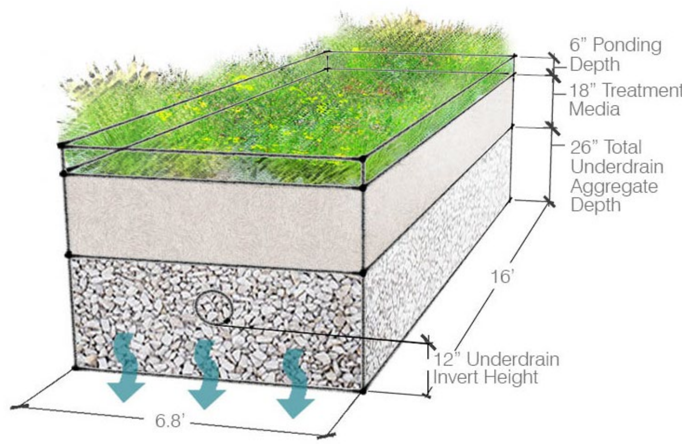
The **Reforestation Flow Control Program** would fund, plan, and implement reforestation projects on public lands and acquired private parcels in King County. The Program would be administered by King County, potentially in partnership with other jurisdictions and nongovernmental agencies. The objective of this Program is to provide flow control for stormwater runoff from previously developed areas.

The four Programs were developed with the intention of modeling them together in SUSTAIN to identify the most cost-effective combination of Actions in the project area.

## Component Actions

Programs are composed of a suite of unit Actions (structural or nonstructural stormwater controls) that could be implemented to provide flow control and/or improve water quality across a geographic area.

Figure 1. Schematic for a Unit of Bioretention.




In Phase 2, nineteen Actions were developed, including GSI, traditional (retention, detention, infiltration), and regional stormwater management practices. These Actions are documented under in Appendix B of Herrera (2024). The costs for these Actions were updated under Phase 3 (HDR and Herrera 2024).

In Phase 3, five new flow control-focused Actions were developed, including:

- Sports Fields and Parks Detention,
- Blue Roofs,
- Compost Amendment,
- Reforest High Density Development, and
- Reforest Pervious Area.

The details of these Actions are documented under a separate Phase 3 memorandum (see Appendix C of Herrera 2024).

Phase 3 flow control Programs include a mix of Actions developed under Phase 2 and Phase 3.

# Program Fact Sheets

Program Fact Sheets were developed to compile detailed Program descriptions and information to support Program optimization using the SUSTAIN model. They include the following:

- Detailed description of the Program
- Actions that could be included in the Program
- Program implementation area, including a map showing eligible basins
- Program applicability by jurisdiction, drainage basin type, property type, land use and surface type
- A runoff routing schematic showing how flow is routed through Actions in the SUSTAIN model
- Program implementation constraints that are used to quantify the maximum area that could be managed by each Action
- Program cost information
- Approach for optimizing the Program using the SUSTAIN model
- Program linkages to causal models

Phase 3 Program Fact Sheets for the Flow Control Programs are included in Appendix H of Herrera 2024.

# Program Assumptions and Technical Basis

The key assumptions and technical basis for information included in the Program Fact Sheets are provided below.

## Actions Included in Programs

Each Fact Sheet includes a suite of Actions that could be included in the Program (see example in Figure 2). The most cost-effective combination of Actions for each Program will be identified using the SUSTAIN model.

Figure 2. “Actions Included” Example from GSI Incentive Flow Control Program Fact Sheet.

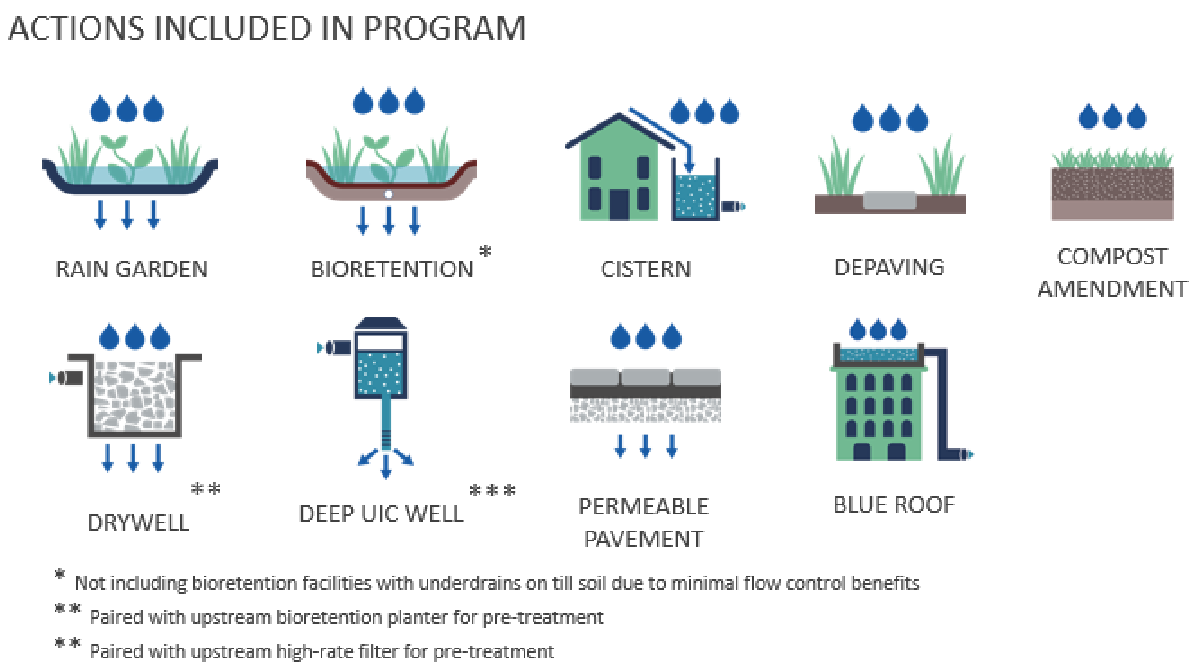



Table 1 summarizes the Actions included in each Program. The GSI Incentive Flow Control Program includes a suite of small-scale GSI Actions that are appropriate for parcel retrofits. The Roadway Retrofit Flow Control Program includes a suite of stormwater flow control Actions that are applicable in a range of roadway and highway settings, including linear and centralized treatment facilities. The Regional Facility Flow Control Program includes a suite of regional stormwater flow control Actions to manage runoff from large drainage areas. The Reforestation Program includes reforestation of high-density development and pervious areas.

Some Actions require pretreatment as indicated in Table 1. These are paired with upstream treatment Actions.

**Table 1. Water Quality Actions included in Flow Control Programs.**

| Action | GSI Incentive Flow Control Program | Roadway Retrofit Flow Control Program | Regional Facility Flow Control Program | Reforestation Flow Control Program |
|---|---|---|---|---|
| Rain Garden | ● | | | |
| Bioretention | ● | ● | | |
| Bioretention Planter[a] | | | | |
| Deep UIC Well[b] | ● | ● | | |
| Cistern | ● | | | |
| Drywell[b] | ● | | | |
| Permeable Pavement | ● | | | |
| Depaving | ● | | | |
| Bioswale [a] | | | | |
| Media Filter Drain [a] | | | | |
| Stormwater Treatment Wetland [a] | | | | |
| High-Rate Underground Filter System [a] | | | | |
| Wetpond [a] | | | | |
| Wetvault [a] | | | | |
| Infiltration Pond[b] | | ● | ● | |
| Infiltration Vault[b] | | ● | ● | |
| Regional Vegetated Media Filtration Facility [a] | | | | |
| Detention Pond | | ● | ● | |
| Detention Vault | | ● | ● | |
| Stormwater Field and Park Detention | | | ● | |
| Blue Roof | ● | | | |
| Compost Amendment | ● | | | |
| Reforest High Density Development | | | | ● |
| Reforest Easement | | | | ● |

[a] Actions not included in flow control Programs are intended for water quality treatment and provide limited flow control benefits.

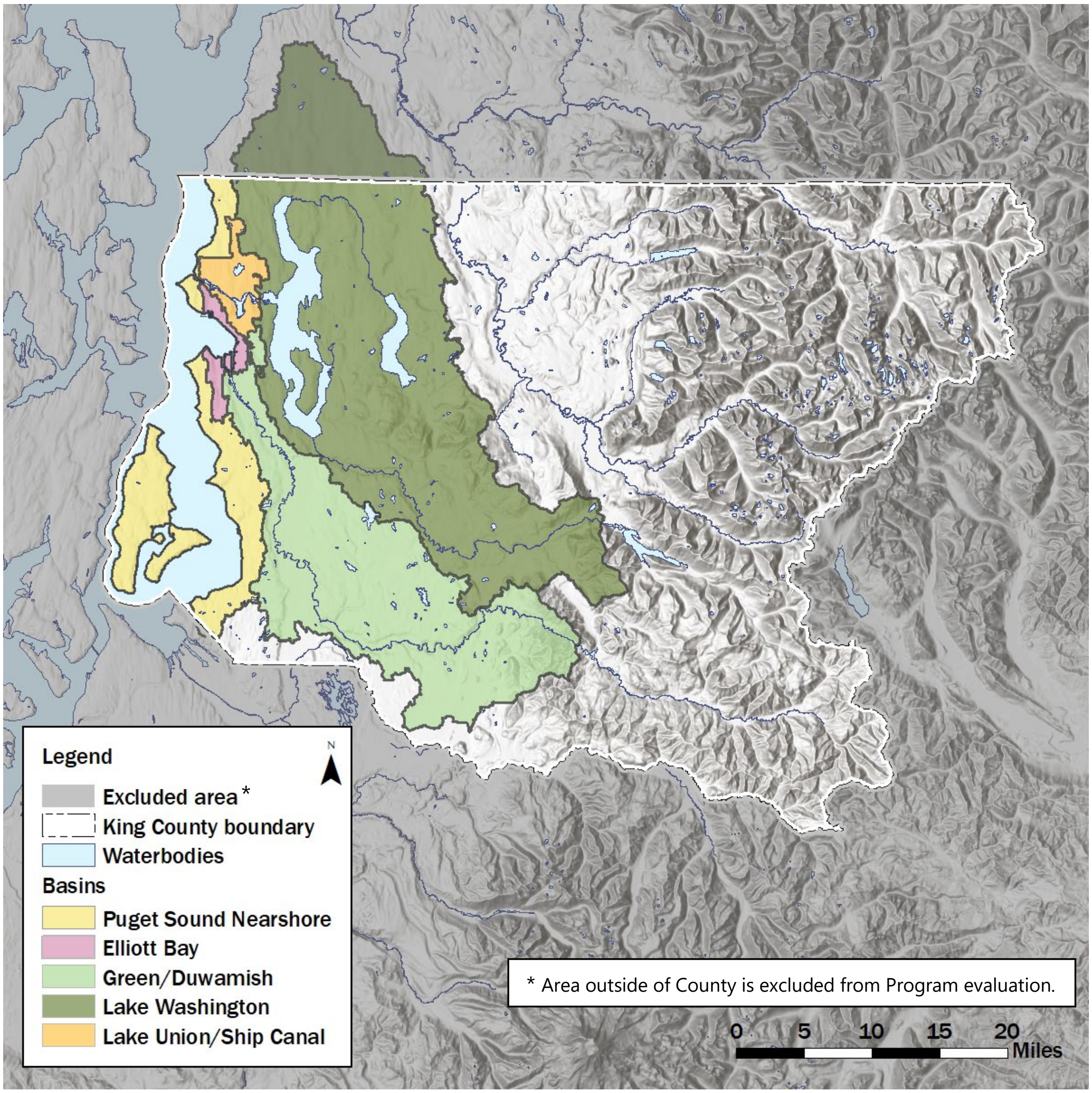
[b] Requires pretreatment; paired with upstream treatment Action in runoff routing schematic.

UIC = Underground Injection Control

## Program Implementation Area and Applicability

Each Fact Sheet includes an "Implementation Area" map showing the eligible basin areas. The WQBE target basins are shown in Figure 3.

Figure 3. Target Basins for Programs within King County.




Fact Sheets also list the Program applicability by jurisdiction, drainage basin type, property type, land use, and surface type to summarize where the Programs are intended to be implemented. Program implementation area and applicability are summarized in Table 2.

**Table 2. Comparison of Program Implementation Area and Applicability.**

| Implementation Area/Applicability | | | GSI Incentive Flow Control Program | Roadway Retrofit Flow Control Program | Regional Facility Flow Control Program | Reforestation Flow Control Program |
|---|---|---|---|---|---|---|
| Eligible Basins | Puget Sound Nearshore | | ● | ● | ● | ● |
| | Elliott Bay | | ● | ● | ● | ● |
| | Green/Duwamish | | ● | ● | ● | ● |
| | Lake Washington | | ● | ● | ● | ● |
| | Lake Union/Ship Canal | | ● | ● | ● | ● |
| Jurisdictions | Unincorporated County | | ● | ● | ● | ● |
| | Incorporated Cities | | ● | ● | ● | ● |
| Drainage Basin Type Managed | Separated | | ● | ● | ● | ● |
| | Partially Separated [a,b] | | ● | ● | ● | ● |
| | Combined [b] | | | | | |
| Land Uses/ Surface Types Managed | Low Density Residential | Road | | ● | ● | |
| | | Roof | ● | | ● | |
| | | Other Impervious | ● | | ● | |
| | | Pervious | ● | | ● | |
| | High Density Residential | Road | | ● | ● | |
| | | Roof | ● | | ● | |
| | | Other Impervious | ● | | ● | |
| | | Pervious | ● | | ● | |
| | Commercial | Road | | ● | ● | |
| | | Roof | ● | | ● | ● |
| | | Other Impervious | ● | | ● | ● |
| | | Pervious | ● | | ● | ● |
| | Industrial | Road | | ● | ● | |
| | | Roof | ● | | ● | ● |
| | | Other Impervious | ● | | ● | ● |
| | | Pervious | ● | | ● | ● |
| | Highway | Road | | ● | ● | |
| | | Pervious | | | ● | |
| | Agriculture | Road | | ● | ● | |
| | | Roof | ● | | ● | |
| | | Other Impervious | ● | | ● | |
| | | Pervious | | | ● | |
| | Forest | Impervious | | | ● | |
| | | Pervious | | | ● | |
| Land Uses/Surface Types Managed (continued) | | Private Parcels | ● | | ● | ● |
| | | Public Parcels | ● | | ● | ● |
| | | Right of Way | | ● | ● | |

[a] Only includes disconnected impervious areas in partially separated basins (i.e. areas not connected to the combined sewer.

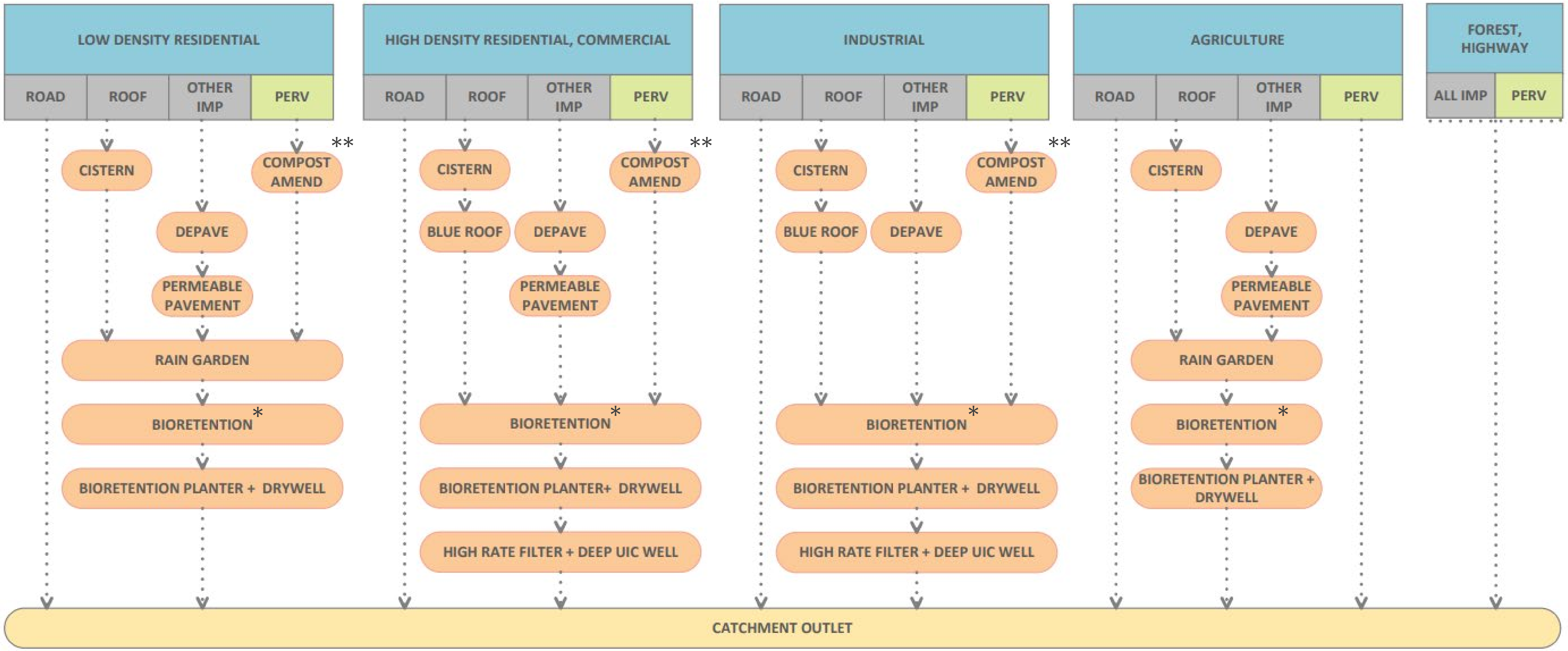
[b] The Programs could be adapted for application in combined drainage areas with the objective to reduce combined sewer overflows.

## Runoff Routing

Fact Sheets include diagrams showing how stormwater runoff is routed through Actions in the SUSTAIN model (see example for the GSI Incentive Flow Control Program in Figure 4). The arrows characterize the routing of runoff from each drainage area (land use and surface combination, such as high-density residential roof) to the Actions. Overflow from the Actions and unmanaged runoff is routed to the catchment outlet. Actions are sometimes listed in a sequence ("treatment train") where runoff from one drainage area is routed to a number of sequential Actions. In these cases, SUSTAIN provides an assessment of the most cost-effective combination of Actions within a sequence to achieve different levels of flow control.

Most Actions are represented in SUSTAIN as a lumped facility at the bottom of each catchment, even though in reality these would likely be implemented as several distributed installations.

Figure 4. Runoff Routing Schematic Example from GSI Incentive Flow Control Program Fact Sheet.




* Not including bioretention facilities with underdrains on till soil due to minimal flow control benefits
** Compost amendment is only applied for lawn surfaces

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# Program Implementation Constraints

Only a portion of the drainage areas routed to Actions in the runoff routing schematics (e.g., Figure 4) could realistically be managed due to real-world implementation constraints. To address this, feasibility criteria, and technical and participation constraints, were characterized for the Actions in each flow control Program to represent realistic implementation by land use, surface type, and parcel ownership. These implementation constraints are summarized in the Fact Sheets and detailed in Tables 3 through 7. The methodology used varies by Program, as described below.

## GSI Incentive, Roadway Retrofit, and Reforestation Flow Control Programs

For the GSI Incentive, Roadway Retrofit, and Reforestation Flow Control Programs, the total implementation area (as defined in Table 2) will be further refined as follows to define the maximum drainage area:

- "Infeasible Areas" will be eliminated: Infeasible areas that can be readily delineated in GIS (e.g., unsuitable soil conditions, slopes, groundwater protection areas) will be excluded.
- A “Technical Factor” will be applied: This factor represents the estimated fraction of the remaining drainage area that could feasibly be managed based on technical considerations like infiltration restrictions (e.g., high groundwater), space constraints, utility conflicts, existing runoff patterns, and site uses. The Technical Factors range from 5 to 80 percent, depending upon the Action and setting (land use and surface type).
- A “Participation Factor” will be applied: This factor represents the anticipated participation rate in the Program based on an assessment of the benefits, risks, and burdens (e.g., long term maintenance) that could influence participants. The Participation Factors range from 2 to 30 percent, depending upon the Action and setting (land use and surface type).
- The combination of the “Technical Factor” and the “Participation Factor” is called the “Composite Factor”. This describes the total influence these factors have on the total implementation area after it’s reduced by infeasible areas.

The maximum drainage area managed by each Action in the SUSTAIN model is calculated as follows:

= Total Implementation Area (reduced by infeasible areas) x “Technical Factor” x "Participation Factor“
= Total Implementation Area (reduced by infeasible areas) x “Composite Factor“

The Composite Factors (i.e., Technical Factor x Participation Factor) range from 0.2 to 24 percent.

An overview of the process for calculating the maximum area managed by each Action is shown in Figure 5. Calculations are based on Program implementation area and applicability listed in Table 2, the drainage areas from the routing schematic (example provided as Figure 4), Action infeasibility criteria (see Tables 3, 4 and 5), and Action Technical and Participation Factors (see Tables 3, 4 and 5).

The Technical and Participation Factors were estimated based on best professional judgment of the County and Consultant teams, who have extensive experience with design and implementation of similar Actions (rationale is provided in Tables 3, 4 and 5). A number of simplifications were made to develop high-level representative factors. For example, factors are assumed to be the same across all Program basins, while, in actuality, these factors would likely vary spatially (e.g., in urban and rural areas). Additionally, Participation Factors are assumed to be the same for all land uses, while they would likely vary (e.g., in residential versus commercial areas). It is expected that the factors will underestimate implementation rates for some scenarios, overestimate implementation rates for others, and be generally representative at the basin and county scale.

Programs can be modeled with Participation Factors applied to represent a realistic scenario or without Participation Factors applied to provide an upper bound (i.e., a scenario restricted solely based on technical factors). This provides a range of results to represent more optimistic (i.e., 100%) participation rates.

Figure 5. Steps for Calculating Maximum Area Managed by Actions in SUSTAIN Model.

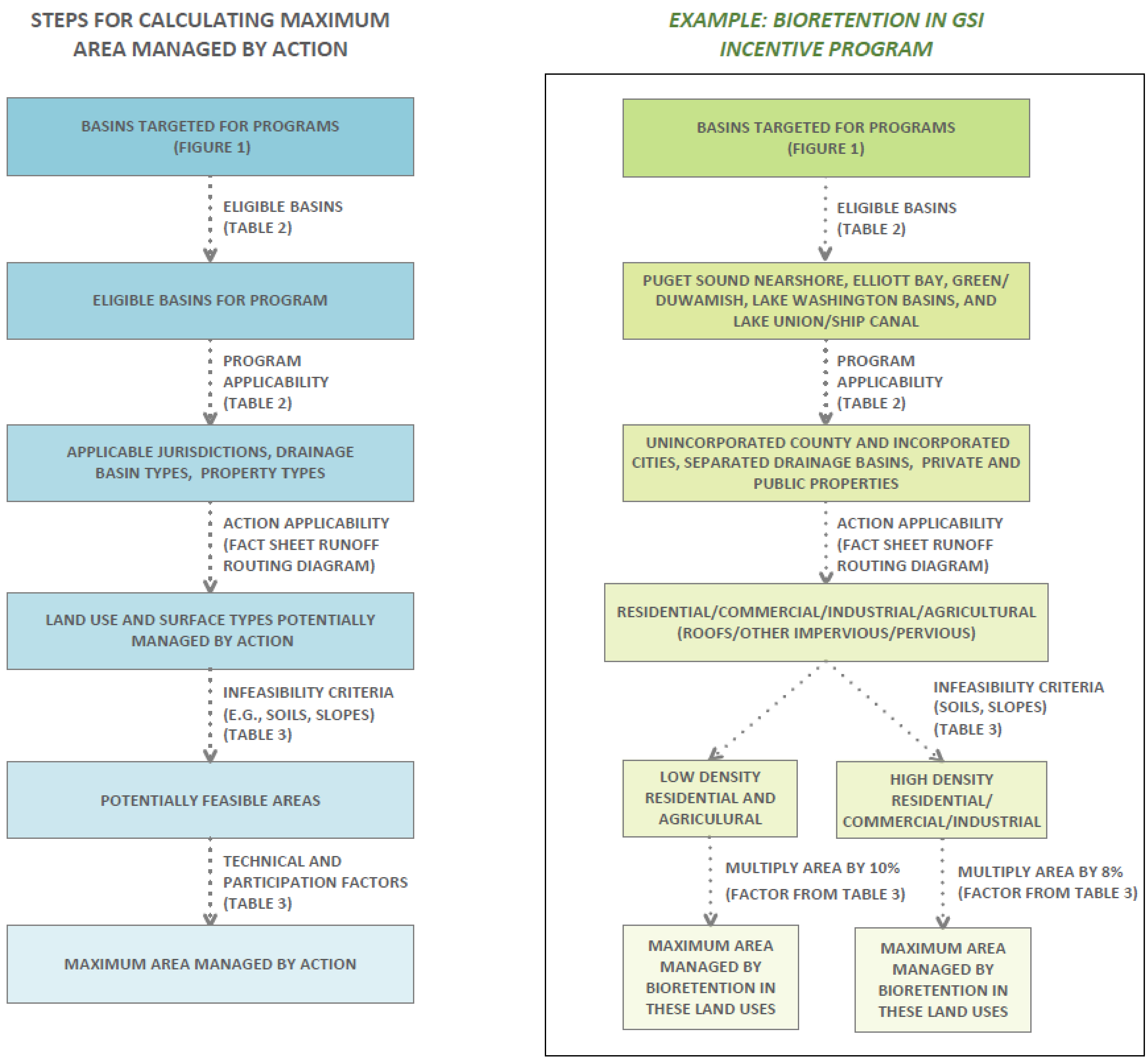

**Table 3. GSI Incentive Flow Control Program Implementation Constraints.**

| GSI Action | Infeasible Areas[a] | Technical Factor[b] | | | | | | | | Participation Factor[c] | Composite Factor (Technical x Participation)[d] | Rationale[f] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Low Density Residential | | | High Density Residential, Commercial, and Industrial | | | Agricultural | | | | Technical Factor[g] | Participation Factor[h] |
| | | Roof | Other Imp | Perv | Roof | Other Imp | Perv | Roof | Other Imp | | | | |
| Rain garden on till | Outwash soil, slopes > 10% | 30% | 30% | 30% | | | | 30% | 30% | 20% | 6.0% | Larger footprint than on outwash soil; needs positive drainage to rain garden and overflow to right of way. Less space available in denser areas. | Vegetated amenity; larger footprint on till soil; popular in RainWise program. |
| Rain garden on outwash | Till soil, slopes > 10% | 50% | 50% | 50% | | | | 50% | 50% | 20% | 10.0% | Smaller footprint than on till soil; needs positive drainage to facility and overflow to right of way. Less space available in denser areas. | Vegetated amenity; smaller footprint on outwash soil; popular in RainWise program. |
| Bioretention on outwash | Till soil, slopes > 10% | 50% | 50% | 50% | 40% | 40% | 40% | 50% | 50% | 20% | 8.0% - 10.0 % | Smaller footprint than on till soil; needs positive drainage to facility and overflow to right of way. Less space available in denser areas. | Vegetated amenity; smaller footprint on outwash soil. |
| Cisterns | – | 50% | | | 50% | | | 50% | | 25% | 12.5% | Small footprint; above ground; needs positive drainage for overflow to right of way. | Small footprint; popular in RainWise program; requires seasonal operation and maintenance. |
| Bioretention planter to drywell | Till soil | 30% | 30% | 30% | 30% | 30% | 30% | 30% | 30% | 15% | 4.5% | Drywell has small footprint; depth may limit feasibility based on separation from groundwater. | Vegetated amenity; additional maintenance for underdrain/drywell. |
| High rate filter to deep UIC well | Outwash soil, gw protection areas | | | | 20% | 20% | 20% | | | 5% | 1.0% | Limited opportunities for UIC siting (requires thick, unsaturated deep aquifer). | UIC well would likely reduce participation due to risk and maintenance. |
| Depaving | – | | 20% | | | 10% | | | 20% | 5% | 0.5% - 1.0% | Site uses often preclude depaving; more opportunities in residential/agricultural setting. | Most paved space is required for site use reducing participation. |
| Permeable pavement | Slopes > 3% | | 30% | | | 30%[e] | | | 10% | 2% | 0.2% - 0.6% | Site use may preclude permeable pavement; not appropriate where clogging may result from sedimentation/sanding or with pollutant spills risk. | Desire for retrofit likely limited to settings where existing pavement is in poor condition. |
| Blue roof | | | | | 20% | | | | | 2% | 0.4% | Requires flat roof with parapet; structure must be able to support loading of a blue roof without structural upgrades. | Desire for retrofit likely limited to settings where existing roof needs upgrades |
| Compost amendment | | | | 80% | | | 80% | | | 30% | 24% | Few technical constraints for this Action (e.g., soil contamination, steep slopes). | Minor impact (except for establishment period) and does not change or reduce usable lawn area. |

gw- groundwater UIC - Underground injection control

a "Infeasible Areas" are areas where the Action will not be applied.

b "Technical Factor" represents the estimated fraction of the drainage area that could feasibly be managed based on technical considerations like space constraints, utility conflicts, existing runoff patterns, and site uses.

c "Participation Factor" represents for the anticipated participation in the Program.

d "Composite Factor" is the combined factor applied to estimate the maximum implementation area.

e Permeable pavement not applied for industrial land use.

f Technical and participation factors are based on professional judgement. While these factors would vary spatially (e.g., in urban and rural areas), for the purposes of this analysis, factors are assumed to be the same across all Program basins.

g Additional technical consideration for roofs: 1) downspout reconfiguration often required to route roof runoff to Action, and 2) challenge to collect water from internal downspouts on flat roof buildings

h While participation rates would vary by land use, for the purposes of this analysis, a constant participation factor is assumed.

Max Implementation Area = Total Drainage Area (reduced by infeasible areas) x "Technical Factor" x "Participation Factor"

=Total Drainage Area (reduced by infeasible areas) x "Composite Factor"

**LEGEND**

| | |
|---|---|
| Action not applied | |
| High Implementation | ≥30% |
| Medium Implementation | 15 to <30% |
| Low Implementation | ≤15% |

**Table 4. Roadway Retrofit Flow Control Program Implementation Constraints.**

| Flow Control Action | Infeasible Areas[a] | Technical Factor[b]: Residential, Commercial, Industrial – Local Road in City | Technical Factor[b]: Residential, Commercial, Industrial – Local Road Outside City | Technical Factor[b]: Residential, Commercial, Industrial – Arterial | Technical Factor[b]: Agriculture – All Roads | Technical Factor[b]: Highway – Highway | Participation Factor[c] | Composite Factor (Technical x Participation)[d] | Rationale[f]: Technical Factor | Rationale[f]: Participation Factor[g] |
|---|---|---|---|---|---|---|---|---|---|---|
| Bioretention on outwash | Till soil, slopes > 10% | 30% | 40% | 30% | 40% | 40% | 30% | 9% - 12% | Requires positive drainage for inflow to adjacent vegetated strip; linear systems have more siting opportunities along right of way; fewer siting opportunities in denser areas. | Reflects willingness of jurisdictions/WSDOT/King County Roads to participate. Assuming an average of 30 percent. |
| Detention pond | | | | | 20% | 5% | 30% | 2% - 6% | Larger area required for pond; assume highway siting opportunities limited to offramp areas. | Reflects willingness of jurisdictions/WSDOT/King County Roads to participate. Assuming an average of 30 percent. |
| Detention vault[5] | | 40% | 40% | 40% | | | 30% | 12% | Smaller footprint; can install under road or shoulder, increasing opportunities. | Reflects willingness of jurisdictions/WSDOT/King County Roads to participate. Assuming an average of 30 percent. |
| High-rate filter to infiltration vault[5] | Till soil | 30% | 30% | 30% | | | 30% | 9.0% | Can install under road or shoulder, increasing opportunities. | Reflects willingness of jurisdictions/WSDOT/King County Roads to participate. Assuming an average of 30 percent. |
| High-rate filter to infiltration pond | Till soil | | | | 20% | 5% | 30% | 2% - 6% | Larger area required for pond; assume highway siting opportunities limited to offramp areas. | Reflects willingness of jurisdictions/WSDOT/King County Roads to participate. Assuming an average of 30 percent. |
| High-rate filter to deep UIC well | Outwash soil, gw protection areas | 10% | 10% | 10% | | | 20% | 2% | Limited opportunities for UIC siting (requires thick, unsaturated deep aquifer). | UIC well would likely reduce participation due to risk and maintenance. |

gw- groundwater UIC - Underground injection control

[a] "Infeasible Areas" are areas where the Action will not be applied.

[b] "Technical Factor" represents the estimated fraction of the drainage area that could feasibly be managed based on technical considerations like space constraints, utility conflicts, existing runoff patterns, and site uses.

[c] "Participation Factor" represents for the anticipated participation in the Program.

[d] "Composite Factor" is the combined factor applied to estimate the maximum implementation area.

[e] Action not applied for residential land use.

[f] Technical and participation factors are based on professional judgement. While these factors would vary spatially (e.g., in urban and rural areas), for the purposes of this analysis, factors are assumed to be the same across all Program basins.

[g] While participation rates would vary by land use and partner agency, for the purposes of this analysis, a constant participation factor is assumed.

Max Implementation Area = Total Drainage Area (reduced by infeasible areas) x "Technical Factor" x "Participation Factor"

=Total Drainage Area (reduced by infeasible areas) x "Composite Factor"

**LEGEND**

| | |
|---|---|
| Action not applied | |
| High Implementation | ≥30% |
| Medium Implementation | 15 to <30% |
| Low Implementation | ≤15% |

**Table 5. Reforestation Flow Control Program Implementation Constraints.**

| Action | Infeasible Areas [1] | Technical Factor [2] | | | | | | | | Participation Factor [3] | Composite Factor (Technical x Participation) [4] | Rationale[5] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential | | Commercial | | | Industial | | | | | | |
| | | Perv Inside City | Perv Outside City | Roof | Other Imp | Perv | Roof | Other Imp | Perv | | | Technical Factor | Participation Factor[6] |
| Reforest High Density Development on private parcel | Publicly-owned parcel | | | 80% | 80% | 80% | 40% | 40% | 40% | 5% | 2% - 4% | Primary technical constraint is soil contamination in industrial areas. | Few private parcel owners would be willing to sell. |
| Reforest High Density Development on public parcel | Privately-owned parcel | | | 80% | 80% | 80% | 40% | 40% | 40% | 2% | 1% - 2% | Primary technical constraint is soil contamination in industrial areas. | Most publicly-owned space has an established use. |
| Reforest Pervious Area on private parcel | Publicly-owned parcel | 2% | 10% | | | | | | | 2% | 0.04% - 0.2% | Requires large pervious area without an established use. | Few private parcel owners would allow easement. |

[a] "Infeasible Areas" are areas where the action will not be applied.

[b] "Technical Factor" represents the estimated fraction of the drainage area that could feasibly be managed based on technical considerations like space constraints, utility conflicts, existing runoff patterns, and site uses.

[c] "Participation Factor" represents the anticipated participation in the Program.

[d] "Composite Factor" is the combined factor applied to estimate the maximum implementation area. ("Composite Factor" = "Technical Factor" x "Participation Factor").

[e] Technical and Participation Factors are based on professional judgment. While these factors would vary spatially (e.g., in urban and rural areas, by partnering jurisdiction), for the purposes of this analysis, factors are assumed to be the same across all program basins.

[f] While participation rates would vary by land use, for the purposes of this analysis, a constant participation factor is assumed.

Max Implementation Area = Total Area (reduced by infeasible areas) x "Technical Factor" x "Participation Factor"

=Total Area (reduced by infeasible areas) x "Composite Factor"

LEGEND

| | |
|---|---|
| Action not applied | |
| High Implementation | ≥30% |
| Medium Implementation | 15 to <30% |
| Low Implementation | ≤15% |

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## Regional Facility Flow Control Program

The nature of the Regional Facility Flow Control Program is different than the flow control Programs described above in that the implementation rate will be primarily limited by the available space for regional facilities. Given that, implementation factors were developed to estimate the maximum facility footprint area (rather than the maximum drainage area managed, as described for the other Programs).

To estimate the maximum potential facility footprint area for a regional facility, public and private parcel area in each catchment will be screened in aggregate to estimate the total candidate footprint area where facilities may be feasible. Screening will be conducted in GIS based on the criteria in Table 6. Because not all candidate areas identified in GIS would prove feasible during planning, Technical and Participation Factors will be applied to the candidate footprint area for these facilities in each catchment to estimate a more realistic level of implementation. The rationale for those factors is provided in Table 7.

The maximum footprint area for regional flow control facilities on public or private parcels is calculated as follows:

> = Candidate footprint area (reduced by screening criteria) x “Technical Factor” x "Participation Factor“
> = Candidate footprint area (reduced by screening criteria) x “Composite Factor“

The Composite Factors (i.e., Technical Factor x Participation Factor) for regional flow control facilities is 0.2 percent on private parcels and 6 percent on public parcels.

After applying the Composite Factor, if the total maximum facility footprint area in a catchment is the unit size of a regional facility (defined in the Action Fact Sheets), or larger, regional facilities on public or private parcels will be considered for that specific catchment.

**Table 6. Regional Stormwater Treatment Program—Screening Criteria for Candidate Sites for Facilities on Public and Private Parcels.**

| Criteria Category | Screening Criteria |
|---|---|
| Parcel Type/Ownership | • For publicly owned parcels: publicly-owned parcels, excluding airports, cemeteries, and trail corridors<br>• For privately-owned parcels: privately owned parcels |
| Outside Critical Areas/ Floodplain/ Sloped Areas | Located outside of:<br>• 100-year FEMA floodplain<br>• Areas with slope exceeding 10%<br>• Critical areas (steep slopes and buffers, wetlands, etc.) |

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**Table 7. Regional Facility Flow Control Program Implementation Constraints (for Maximum Footprint Area).**

| Flow Control Action | Infeasible Areas[a] | Private Parcels | | | Public Parcels | | | Rationale[e] | |
|---|---|---|---|---|---|---|---|---|---|
| | | Technical Factor[b] | Participation Factor[c] | Composite Factor (Technical x Participation)[d] | Technical Factor[b] | Participation Factor[c] | Composite Factor (Technical x Participation)[d] | Technical Factor | Participation Factor[6] |
| Detention pond | See screening criteria | **10%** | **2%** | **0.2%** | **20%** | **30%** | **6%** | Requires site with sufficient upstream drainage area that can be captured on site. Requires sufficient feasible space (e.g., open/unused space outside of critical areas with mild slope) with feasible tie in to downstream drainage system. | Not all publicly owned parcels would be willing to partner. Few privately owned parcels would be willing to sell. |
| Detention vault | See screening criteria | **10%** | **2%** | **0.2%** | **20%** | **30%** | **6%** | Requires site with sufficient upstream drainage area that can be captured on site. Requires sufficient feasible space (e.g., open/unused space outside of critical areas with mild slope) with feasible tie in to downstream drainage system. | Not all publicly owned parcels would be willing to partner. Few privately owned parcels would be willing to sell. |
| High-rate filter to infiltration vault | See screening criteria, till soil | **10%** | **2%** | **0.2%** | **20%** | **30%** | **6%** | Requires site with sufficient upstream drainage area that can be captured on site. Requires sufficient feasible space (e.g., open/unused space outside of critical areas with mild slope) with feasible tie in to downstream drainage system. | Not all publicly owned parcels would be willing to partner. Few privately owned parcels would be willing to sell. |
| High-rate filter to infiltration pond | See screening criteria, till soil | **10%** | **2%** | **0.2%** | **20%** | **30%** | **6%** | Requires site with sufficient upstream drainage area that can be captured on site. Requires sufficient feasible space (e.g., open/unused space outside of critical areas with mild slope) with feasible tie in to downstream drainage system. | Not all publicly owned parcels would be willing to partner. Few privately owned parcels would be willing to sell. |
| Sports Field / Park Detention | See screening criteria, areas other than public sports fields or parks | | | | **20%** | **30%** | **6%** | Requires park or sports field with sufficient upstream drainage area that can be captured on site. Requires sufficient feasible space (e.g., open/unused space outside of critical areas with mild slope) with feasible tie in to downstream drainage system. | Not all publicly owned parcels would be willing to partner. Few privately owned parcels would be willing to sell. |

[a] "Infeasible Areas" are areas where the Action will not be applied.

[b] "Technical Factor" represents the estimated fraction of the drainage area that could feasibly be treated based on technical considerations like space constraints, utility conflicts, existing runoff patterns, and site uses.

[c] "Participation Factor" represents for the anticipated participation in the Program.

[d] "Composite Factor" is the combined factor applied to estimate the maximum implementation area.

[e] Technical and participation factors are based on professional judgement. While these factors would vary spatially (e.g., in urban and rural areas, by partnering jurisdiction), for the purposes of this analysis, factors are assumed to be the same across all Program basins.

Maximum Footprint Area = Candidate Footprint Area (reduced by infeasible areas) x "Technical Factor" x "Participation Factor"

= Candidate Footprint Area (reduced by infeasible areas) x "Composite Factor"

LEGEND

| | |
|---|---|
| Action not applied | |
| High Implementation | ≥30% |
| Medium Implementation | 15 to <30% |
| Low Implementation | ≤15% |

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# Program Costs

Program Fact Sheets provide lifecycle costs for unit Actions, including initial capital, operations and maintenance, and capital replacement costs over a 30-year lifecycle. In Phase 3, the Action lifecycle costs were refined to reflect a simplified costing approach to better meet the County's needs. Basis of estimate documentation for Action lifecycles costs developed in Phase 3 is provided in HDR and Herrera (2024).

Program administration elements, such as Program development, outreach, application processing, inspections, are listed in the Program Description/Assumptions text box in the Program Fact Sheet. These costs will be developed and applied after Program optimization. Appendix I of Herrera (2024) provides example applications of different Program delivery models for different levels of Program implementation.

# SUSTAIN Program Optimization

Program Fact Sheets provide a description of how SUSTAIN will be used to evaluate and optimize the Programs. The Programs will be optimized based on the most cost-effective Actions.

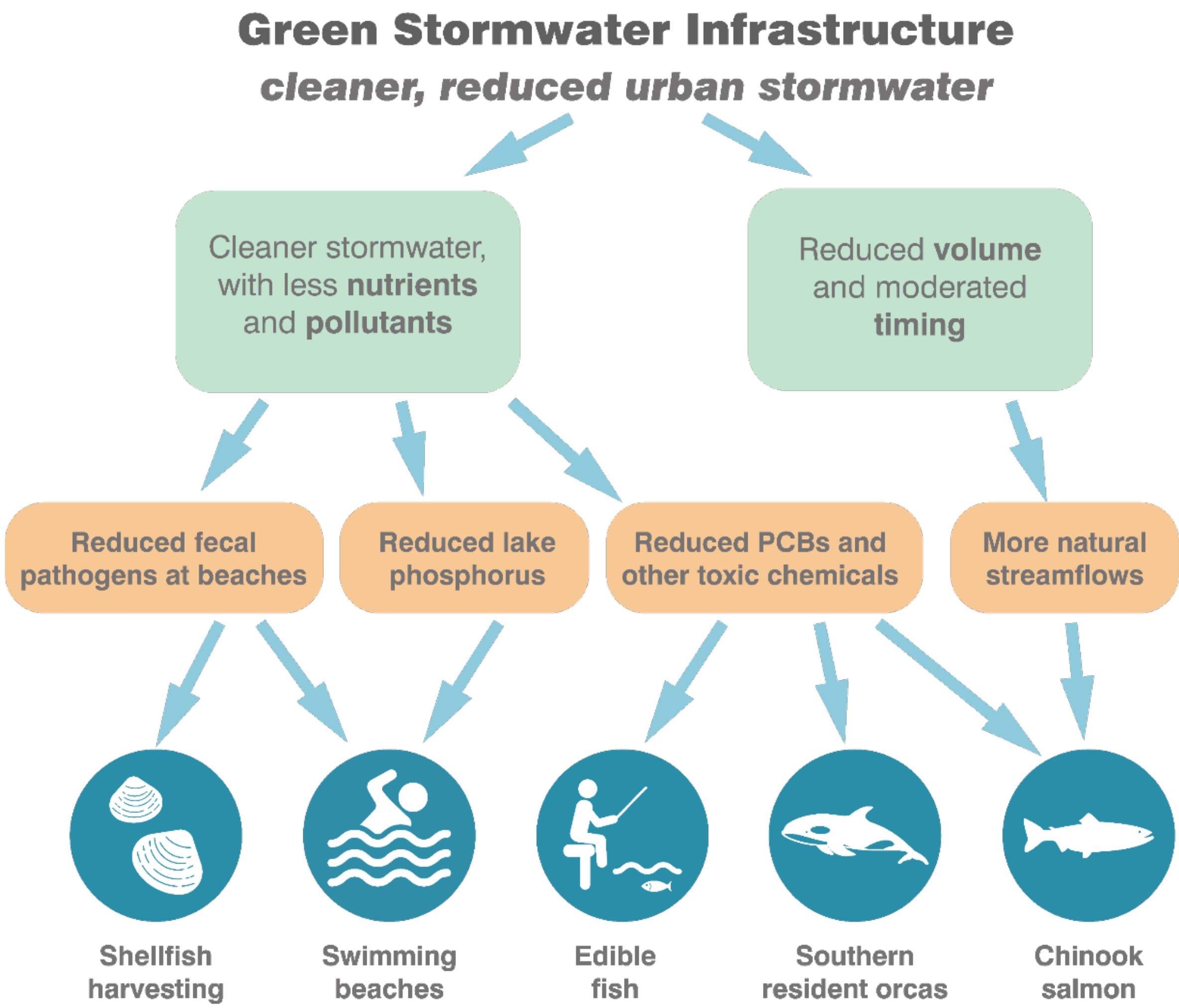
For performance, Actions will be optimized for runoff volume reduction on days in the timeseries where runoff exceeds a threshold that represents an unnatural hydrograph. The associated pollutant load reduction provided by the optimized Actions will be estimated.

For costs, SUSTAIN optimization will be based on Action 30-year lifecycle costs. Program development and administration costs will be scaled and applied to modeling results.

# Causal Model Linkages

Programs can also be evaluated using causal models to assess benefits to a suite of human and ecological health endpoints. The Fact Sheets provide a narrative and graphic to illustrate the types of factors (e.g., pollutant load reductions) that might be influenced by a Program and how changes in those factors might improve outcomes for shellfish harvest, swimming beaches, edible fish, Chinook salmon, and Southern Resident orcas. An example graphic is provided as Figure 6.

Figure 6. "Causal Model Linkage" Graphic Example from GSI Incentive Program Fact Sheet.




# Key Limitations and Future Considerations

This document provides an overview of the assumptions and technical basis for the Program Fact Sheet content. The following text provides a summary of key limitations in the development of the WQBE Programs and considerations for future Programs.

- Participation and Technical Factors for each Program were developed based on best professional judgment. While these factors would vary spatially, they were applied county-wide for this planning-level analysis to simplify model assumptions. To improve model accuracy, the Participation and Technical Factors could be refined and varied in future modeling efforts to reflect anticipated differences in specific areas of the county (e.g., rural versus urban).

- The maximum facility footprint area for the Regional Facility Flow Control Program will be evaluated using GIS based on high-level screening criteria. These areas will not be evaluated further (e.g., ground-truthed) so additional Technical and Participation Factors were developed to account for the unknowns on public and private property. Further investigation of site conditions would be necessary to confirm feasibility of any particular site or area.

- While the Programs developed for this phase of modeling focus specifically on flow control, the information compiled for the WQBE toolkit thus far provides a high degree of flexibility for refining or enhancing the existing Programs or developing completely new Programs. Information for new Actions could also be developed in the future to provide even more modeling flexibility within the WQBE toolkit.

# References

HDR and Herrera. 2024. Phase 3 Unit Cost Basis for Water Quality Benefits Evaluation (Appendix G to 439-TM1). Technical Memorandum prepared for King County Wastewater Treatment Division by HDR Engineering, Inc. March.

Herrera. 2022. Water Quality Benefits Evaluation – Phase 2 Action and Program Factsheet Development (431-TM1). Prepared for King County Water and Land Resources Division by Herrera Environmental Consultants. May.

Herrera. 2023. Proposed Flow Control Actions and Programs Assessment (TM #438-TM1). Prepared for King County Wastewater Treatment Division by Herrera Environmental Consultants, Inc., Seattle, Washington.

Herrera. 2024. WQBE Phase 3 Action and Program Fact Sheet Development (439-TM1). Prepared for King County Wastewater Treatment Division by Herrera Environmental Consultants, Inc., Seattle, Washington.

Paradigm and Herrera. 2022. Water Quality Benefits Evaluation – Phase 2 SUSTAIN Model Development (821-TM1). Prepared for King County Water and Land Resources Division by Paradigm Environmental and Herrera Environmental Consultants. December.

# Appendix G

## Phase 3 Action Fact Sheets

HERRERA
Science + Planning + Design

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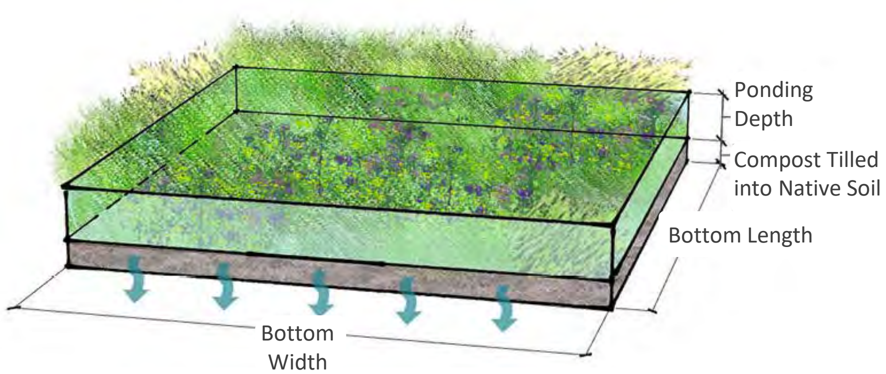
# RAIN GARDEN
Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

City of Bellevue 145th Place SE Project
Photo courtesy of RKI

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

A shallow, landscaped depression with adapted plants, visually similar to bioretention but with compost-amended native soils and no underdrain. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas and to allow stormwater to pass through the amended soil profile. Provides volume and peak flow reduction and water quality treatment.

## DESIGN PARAMETERS

| Parameter | Soil Type: Till | Soil Type: Outwash |
|---|---|---|
| Unit Footprint Area | 25 SF | 25 SF |
| Unit Drainage Area | 806 SF | 2,844 SF |
| Ponding Depth | 6 in | 6 in |
| Bottom Length | 7.08 ft | 7.08 ft |
| Bottom Width | 3.54 ft | 3.54 ft |
| Side Slope | 3H : 1V | 3H : 1V |
| Treatment Media Depth [a] | 8 in | 8 in |
| Treatment Media Porosity [a] | 25% | 25% |
| Native Soil Design Infiltration Rate | 0.3 in/hr | 2.5 in/hr |

N/A: Not Applicable

a. The Treatment Media is non-engineered and does not provide Basic Water Quality treatment. Infiltration through the Treatment Media is assumed to occur at the Native Soil Design Infiltration Rate

Note: For Actions with side slopes, see SUSTAIN representation in 439-TM1 Appendix B.

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## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial

**Property Types:**
- Private Parcel
- Public Parcel

**Surface Types:**
- Roofs
- Lawns
- Driveways
- Sidewalks
- Parking Lots

## DESIGN ASSUMPTIONS

- Design is based on the *Seattle Stormwater Manual, "Rain Garden"* (Volume 3 Section 5.4.5).
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Although not listed in the Basic or Enhanced Water Quality Treatment Menu in the *2016 King County Surface Water Design Manual*, this project assumes the Unit Action provides Basic Water Quality Treatment.
- Non-engineered treatment media consists of 3" compost tilled in to an 8-inch finished depth.
- No underdrain included.



Visit kingcounty.gov/WQBE for more information.

A project for Clean Water Healthy Habitat

# RAIN GARDEN
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Model explicitly represents ponding, infiltration, and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

**Treatment:**
- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | N/A | N/A |
| Dissolved Copper | N/A | N/A |
| Total Zinc | N/A | N/A |
| Dissolved Zinc | N/A | N/A |
| Total Phosphorus | N/A | N/A |
| Total Nitrogen | N/A | N/A |
| Total Suspended Solids | N/A | N/A |
| Total PCBs | N/A | N/A |
| Total PBDEs | N/A | N/A |
| Total PAHs | N/A | N/A |
| Bis(2-ethylhexyl)phthalate | N/A | N/A |
| Fecal Coliform | N/A | N/A |

N/A: Not applicable. See model representation treatment section.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property without Acquisition |
|---|---|
| Total Project | $8,200 |
| Total Direct Construction | $5,800 |
| Total Indirect Non-Construction | $2,400 |
| Operation and Maintenance | $2,100/year |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Maximum drainage areas of 10,000 square feet of impervious surface to an individual facility.
- Meet local jurisdiction utility separation requirements.
- Locate away from traveled areas on individual lots to prevent soil compaction and damage to vegetation.
- No discharge towards existing basements, erosion hazard areas, or landslide hazard areas.
- Meet infiltration siting restrictions, including setbacks:
  - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
  - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
  - 100 feet away from proposed or existing septic system drainfields
- See comprehensive list of infeasibility criteria in Section C.2.6 of the *2016 King County Surface Water Design Manual.*



Visit kingcounty.gov/WQBE for more information.

A project for Clean Water Healthy Habitat

# BIORETENTION HPBSM PLANTER

## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

Photo courtesy of Paradigm

## ACTION DESCRIPTION

Similar to bioretention, this Action includes a designed high-performance bioretention soil media (HPBSM) and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants. This Action varies from bioretention in that the sides are vertically contained by walls constructed from formed concrete. These designs are often used in highly-urbanized settings. Provides water quality treatment and peak flow reduction. For this analysis, the Action is assumed to have an underdrain and closed bottom.

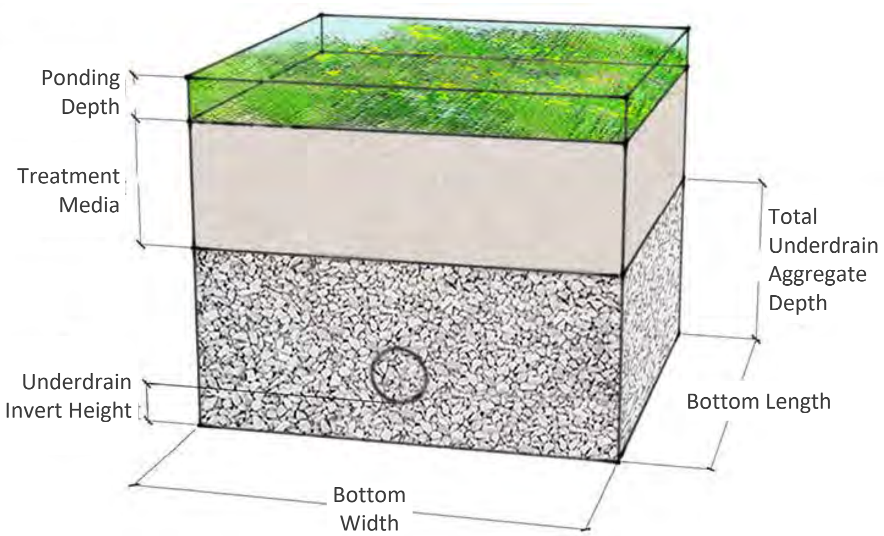
## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial
- Industrial

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Driveways
- Parking Lots
- Sidewalks
- Plazas
- Local Roads
- Arterial Roads

## UNIT ACTION SCHEMATIC




## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 25 SF |
| Unit Drainage Area | 2,357 SF |
| Ponding Depth | 6 in |
| Bottom Length | 8.7 ft |
| Bottom Width | 2.9 ft |
| Side Slope | Vertical |
| Treatment Media Depth | 18 in |
| Treatment Media Porosity | 30% |
| Treatment Media Design Infiltration Rate | 6 in/hr |
| Total Underdrain Aggregate Depth | 26 in |
| Underdrain Invert Height | 6 in |
| Underdrain Diameter | 8 in |
| Underdrain Aggregate Porosity | 40% |
| Native Soil Design Infiltration Rate [a] | N/A |

N/A: Not Applicable

a. Incidental infiltration to native soils neglected.

## DESIGN ASSUMPTIONS

- Design is based on the *Seattle Stormwater Manual*, "Non-infiltrating Bioretention" (Volume 3 Section 5.8.2).
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Although not listed in the Basic or Enhanced Water Quality Treatment Menu in the KCSWDM, this project assumes the Action, including the HPBSM, provides Enhanced Water Quality Treatment.
- The HPBSM is a low phosphorus media composed of 70% sand, 20% coir and 10% high carbon wood ash (biochar). No polishing layer is included.
- Underdrain layer includes 12" cover, 8" underdrain pipe, and 6" bedding.
- Vertical sides.



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# BIORETENTION HPBSM PLANTER
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Model explicitly represents ponding, infiltration, underdrain flow, and overflow.

**Treatment:**
- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal [a] | 25th Percentile Effluent Concentration [a] |
|---|---|---|
| Total Copper | 62.3% | 7.1 µg/L |
| Dissolved Copper | 57.6% | 4.6 µg/L |
| Total Zinc | 91.0% | 5.0 µg/L |
| Dissolved Zinc | 86.2% | <4.0 µg/L [b] |
| Total Phosphorus | 54.9% | 0.024 mg/L |
| Total Nitrogen | 51.3% | 1.2 mg/L |
| Total Suspended Solids | 78.0% | 13.5 mg/L |
| Total PCBs | 78.0%[c] | 358 pg/L[c] |
| Total PBDEs | 67.1%[c] | 0.034 ng/L[c] |
| Total PAHs | 95.1% | <0.01 µg/L [b] |
| Bis(2-ethylhexyl)phthalate | 63.2%[c] | 0.044 µg/L[c] |
| Fecal Coliform | 61.5 % | 31.5 CFU/100 mL |

a. Performance based on the low phosphorus alternative bioretention soil media with 70% sand/20% coconut coir/10% high carbon wood ash
b. Method detection limit.
c. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property without Acquisition | In Right of Way |
|---|---|---|
| Total Project | $26,500 | $36,500 |
| Total Direct Construction | $18,700 | $25,800 |
| Total Indirect Non-Construction | $7,800 | $10,700 |
| Operation and Maintenance | $2,800 | $2,800 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Because non-infiltrating bioretention facilities do not infiltrate water to surrounding soils (water discharges via an underdrain and surface overflow), these Actions are not subject to infiltration facility requirements.
- Non-infiltrating bioretention is not permitted if the under-drained water would be routed to a nutrient-critical receiving water.
- Public Right-of-Way installation for urban areas only.



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# BIORETENTION HPBSM
## Water Quality Benefits Evaluation Action Fact Sheet

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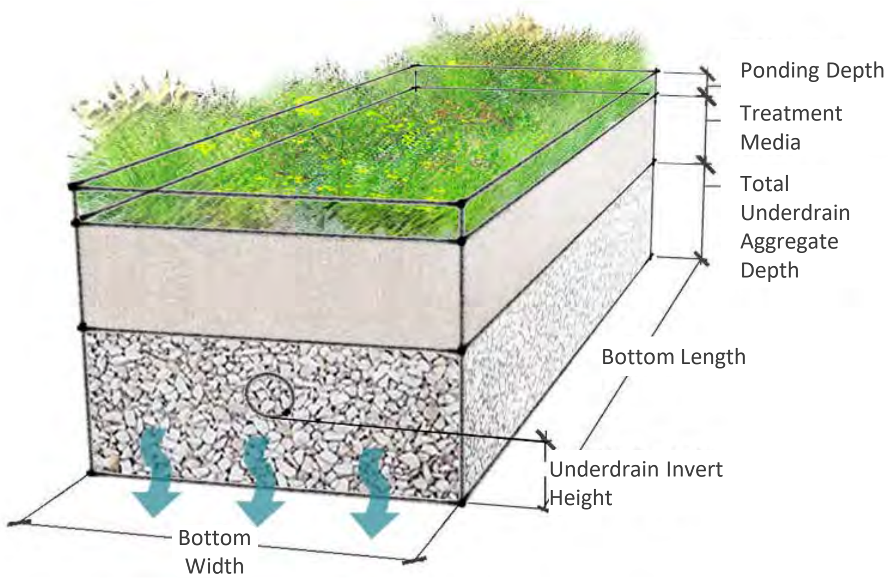
City of Redmond Overlake Village LID Retrofit Project
Photo courtesy of RKI

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

Shallow earthen depressions with a designed high-performance bioretention soil media (HPBSM) and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system. Provides volume and peak flow reduction and water quality treatment.

## DESIGN PARAMETERS

| | Soil Type | |
|---|---|---|
| **Parameter** | **Till** | **Outwash** |
| Unit Footprint Area | 85 SF | 85 SF |
| Unit Drainage Area | 12,148 SF | 9,570 SF |
| Ponding Depth | 6 in | 6 in |
| Bottom Length | 16 ft | 16 ft |
| Bottom Width | 5.33 ft | 5.33 ft |
| Side Slope | 3H : 1V | 3H : 1V |
| Treatment Media Depth | 18 in | 18 in |
| Treatment Media Porosity | 30% | 30% |
| Treatment Media Infiltration Rate | 6 in/hr | 6 in/hr |
| Total Underdrain Aggregate Depth | 26 in | N/A |
| Underdrain Invert Height | 12 in | N/A |
| Underdrain Diameter | 8 in | N/A |
| Underdrain Aggregate Porosity | 40% | N/A |
| Native Soil Design Infiltration Rate | 0.3 in/hr | 2.5 in/hr |

N/A: Not Applicable

Note: For Actions with side slopes, see SUSTAIN representation in 439-TM1 Appendix B.

## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Driveways
- Parking Lots
- Sidewalk
- Plazas
- Local Roads
- Arterial Roads
- Highways

## DESIGN ASSUMPTIONS

- Design is based on *2016 King County Surface Water Design Manual (KCSWDM)* Section C.2.6.1.
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Although not listed in the Basic or Enhanced Water Quality Treatment Menu in the KCSWDM, this project assumes the Action, including the HPBSM, provides Enhanced Water Quality Treatment.
- The HPBSM is a low phosphorus media composed of 70% sand, 20% coir and 10% high carbon wood ash (biochar). No polishing layer is included.
- For bioretention installed in till soils, an elevated underdrain promotes infiltration. Design includes 6” cover, 8” underdrain pipe, and 12” bedding.
- For bioretention installed on outwash soils, no underdrain is included.



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## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**

- Model explicitly represents ponding, infiltration, underdrain flow, and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

**Treatment:**

- Water that infiltrates is lost to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal [a] | 25th Percentile Effluent Concentration [a] |
|---|---|---|
| Total Copper | 62.3% | 7.1 μg/L |
| Dissolved Copper | 57.6% | 4.6 μg/L |
| Total Zinc | 91.0% | 5.0 μg/L |
| Dissolved Zinc | 86.2% | <4.0 μg/L [b] |
| Total Phosphorus | 54.9% | 0.024 mg/L |
| Total Nitrogen | 51.3% | 1.2 mg/L |
| Total Suspended Solids | 78.0% | 13.5 mg/L |
| Total PCBs | 78.0%[c] | 358 pg/L[c] |
| Total PBDEs | 67.1%[c] | 0.034 ng/L[c] |
| Total PAHs | 95.1% | <0.01 μg/L [b] |
| Bis(2-ethylhexyl)phthalate | 63.2%[c] | 0.044 μg/L[c] |
| Fecal Coliform | 61.5 % | 31.5 CFU/100 mL |

a. Performance based on the low phosphorus alternative bioretention soil media with 70% sand/20% coconut coir/10% high carbon wood ash
b. Method detection limit
c. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | With Underdrain | | No Underdrain | |
|---|---|---|---|---|
| | On Property without Acquisition | In Right of Way/ Highway | On Property without Acquisition | In Right of Way/ Highway |
| Total Project | $50,100 | $90,300 | $46,500 | $90,000 |
| Total Direct Construction | $35,400 | $63,900 | $32,800 | $63,700 |
| Total Indirect Non-Construction | $14,700 | $26,400 | $13,700 | $26,300 |
| Operation and Maintenance | $3,100/year | $3,100/year | $3,100/year | $3,100/year |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Site must have sufficient space (e.g., right-of-way applications typically require minimum planter width of 12 feet)
- Locate away from traveled areas on individual lots to prevent soil compaction and damage to vegetation
- No discharge towards existing basements, erosion hazard areas, or landslide hazard areas
- Meet infiltration siting restrictions, including setbacks:
  - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
  - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
  - 100 feet away from proposed or existing septic system drainfields
- See comprehensive list of infeasibility criteria in Section C.2.6 of *the 2016 King County Surface Water Design Manual*



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# BIOSWALE
Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

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## ACTION DESCRIPTION

An open, gently sloped, vegetated channel designed for treatment of stormwater. Grass is most common vegetation, but wetland vegetation can be used if soil is saturated. Provides water quality treatment, peak flow reduction, and conveyance. These are designed to “filter” water as it is conveyed through a vegetated swale. While this Action may provide incidental infiltration, that is not the primary treatment mechanism.

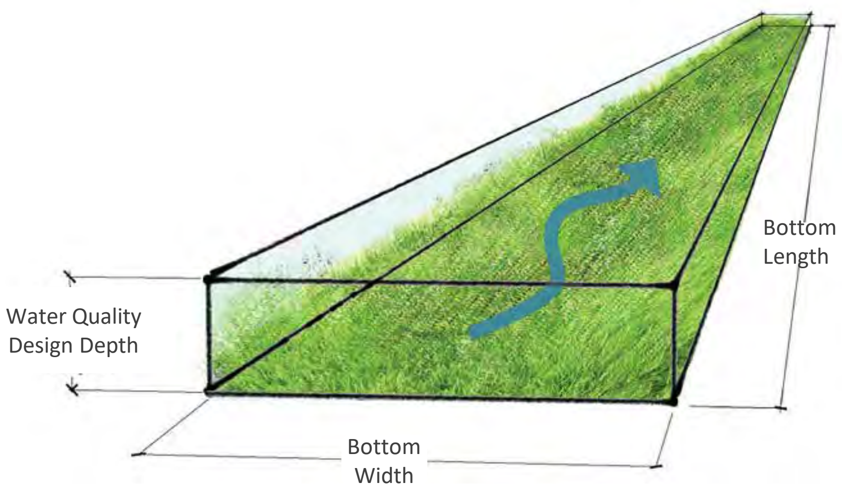
## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Parking Lots
- Arterial Roads
- Local Roads
- Highways

## UNIT ACTION SCHEMATIC




## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 200 SF |
| Unit Drainage Area | 27,878 SF |
| Bottom Length | 100 ft |
| Bottom Width | 2 ft |
| Side Slope | 3H : 1V |
| Water Quality Design Depth | 1.4 in |
| Native Soil Design Infiltration Rate [a] | N/A |
| Water Quality Design Flow Rate (Off-line) | 0.052 cfs |

N/A: Not Applicable
a. Incidental infiltration to native soils neglected.
Note: For Actions with side slopes, see SUSTAIN representation in 439-TM1 Appendix B.

## DESIGN ASSUMPTIONS

- Design is based on the *2016 King County Surface Water Design Manual, "Basic Bioswales",* Section 6.3.1.
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Off-line design assumes flow splitter will be used to divert flows up to the Water Quality Design Flow Rate to the Action.
- Non-engineered soil media consists of 2” compost tilled into 6” native soil.
- Water flows relatively evenly across the entire width of a densely-vegetated area.
- No infiltration to native soils.



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## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**

- Model explicitly represents overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

**Treatment:**

- Water that flows through the bioswale (up to the water quality design flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | 33.9% | 4.8 µg/L |
| Dissolved Copper | 8.99% | 3.6 µg/L |
| Total Zinc | 33.3% | 20.0 µg/L |
| Dissolved Zinc | 29.0% | 15.0 µg/L |
| Total Phosphorus | -37.2% | 0.100 mg/L |
| Total Nitrogen | -7.63% | 0.562 mg/L |
| Total Suspended Solids | 27.9% | 10.0 mg/L |
| Total PCBs | 27.9%[a] | 265 pg/L[a] |
| Total PBDEs | 24.0%[a] | 0.025 ng/L[a] |
| Total PAHs | 27.9%[a] | 0.0012 µg/L[a] |
| Bis(2-ethylhexyl)phthalate | 23.0%[a] | 0.033 µg/L[a] |
| Fecal Coliform | 6.25% | 1775 CFU/100 mL |

a. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property without Acquisition | In Right of Way/ Highway |
|---|---|---|
| Total Project | $16,200 | $29,000 |
| Total Direct Construction | $11,400 | $20,500 |
| Total Indirect Non-Construction | $4,800 | $8,500 |
| Operation and Maintenance | $2,600/year | $2,600/year |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Generally appropriate when there is less than 5 acres of contributing impervious surface.
- Site in areas with a minimum of 6 hours of sunlight daily throughout the year.
- Do not site in high-use areas without oil control, as required in Section 6.6 in the *King County Surface Water Design Manual.*

# MEDIA FILTER DRAIN (MFD)

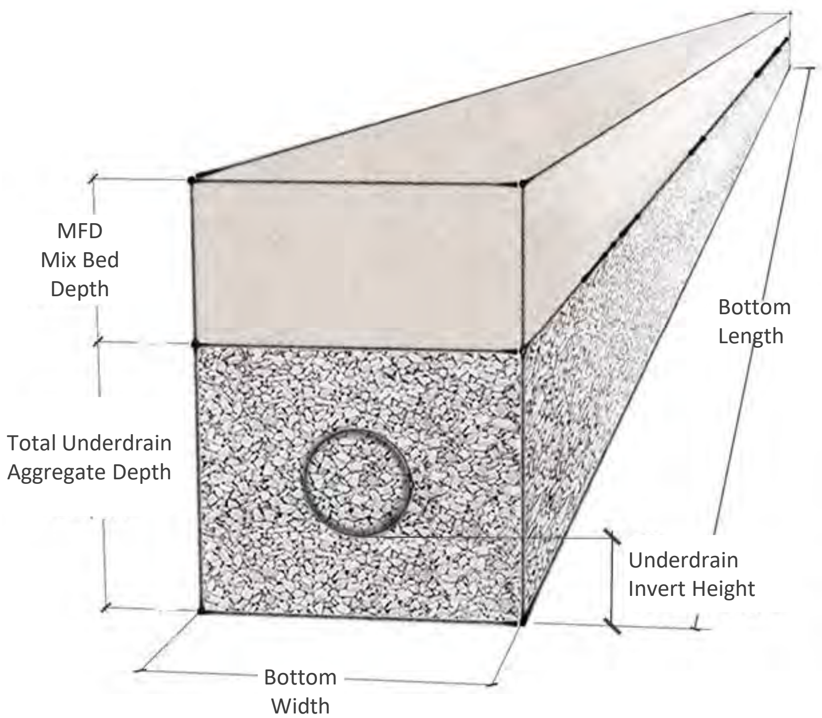
Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

Photo accessed on 7/2/2020 from https://www.wsdot.wa.gov/design/roadside/stormwater-management

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

A linear flow-through stormwater treatment device that can be sited along roadway side slopes (conventional design) and medians, borrow ditches, or other linear depressions. Cut-slope applications may also be considered. MFDs have four basic components: a gravel no-vegetation zone, a vegetated filter strip, the MFD mix bed, and an optional gravel-filled underdrain trench or layer of crushed surfacing base course. Treated water is either infiltrated into the underlying soil or collected by an underdrain and discharged to the drainage system.

## DESIGN PARAMETERS

| Parameter | Soil Type | |
|---|---|---|
| | **Till** | **Outwash** |
| Unit Footprint Area | 200 SF | 200 SF |
| Unit Drainage Area | 2,000 SF | 2,000 SF |
| Lateral Slope | 3H : 1V | 3H : 1V |
| Ponding Depth | 0 in | 0 in |
| Bottom Length | 100 ft | 100 ft |
| Bottom Width | 2 ft | 2 ft |
| MFD Mix Bed Depth | 12 in | 12 in |
| MFD Mix Porosity | 40% | 40% |
| MFD Mix Media Infiltration Rate | 10 in/hr | 10 In/hr |
| Total Underdrain Aggregate Depth | 20 in | N/A |
| Underdrain Invert Height | 6 in | N/A |
| Underdrain Diameter | 8 in | N/A |
| Underdrain Aggregate Porosity | 40% | N/A |
| Native Soil Design Infiltration Rate | 0.3 in/hr | 2.5 in/hr |

N/A: Not Applicable

## AREAS MANAGED

**Land Uses:**
- Highway
- Agricultural

**Property Types:**
- Public Right-of-Way

**Surface Types:**
- Arterial Roads
- Local Roads
- Highway

## DESIGN ASSUMPTIONS

- Design is based on the *2019 Washington State Department of Ecology Stormwater Management Manual for Western WA (SWMMWW)*, Best Management Practice (BMP) T8.40.
- Sizing is based on the *SWMMWW* Table V-6.5.
- The MFD mix consists crushed rock, dolomite, gypsum, and perlite.
- No underdrain included for MFDs installed on outwash soils.
- Treatment steps include:
  - Stormwater runoff enters the media filter drain and is conveyed via sheet flow over a vegetation-free gravel zone for sheet dispersion and to provide some pollutant trapping
  - A grass strip is incorporated into the top of the fill slope to provide pretreatment, further enhancing filtration and extending the life of the system
  - Runoff is then filtered through the treatment media bed and treated water is drained to an approved discharge location



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# MEDIA FILTER DRAIN (MFD)
Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

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## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Model explicitly represents ponding, filtration, underdrain flow, and overflow.

**Treatment:**
- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | 86.2% | 9.45 µg/L |
| Dissolved Copper | 40.8% | 6.25 µg/L |
| Total Zinc | 85.1% | 22.0 µg/L |
| Dissolved Zinc | 80.8% | 16.0 µg/L |
| Total Phosphorus | 85.7% | 0.033 mg/L |
| Total Nitrogen | NF | NF |
| Total Suspended Solids | 94.1% | 2.8 mg/L |
| Total PCBs | 94.1%[a] | 74.3 pg/L[a] |
| Total PBDEs | 80.9%[a] | 0.007 ng/L[a] |
| Total PAHs | 94.1%[a] | 0.00035 µg/L[a] |
| Bis(2-ethylhexyl)phthalate | 76.2%[a] | 0.0091 µg/L[a] |
| Fecal Coliform | NF | NF |

NF: No data found. Assigned a value of 0 in SUSTAIN since no data was found.
a. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | Rural Roadway/Highway | |
|---|---|---|
| | With Underdrain | No Underdrain |
| Total Project | $35,800 | $32,600 |
| Total Direct Construction | $25,300 | $23,100 |
| Total Indirect Non-Construction | $10,500 | $9,500 |
| Operation and Maintenance | $2,400/year | $2,400/year |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Avoid construction on longitudinal slopes steeper than 5%.
- For narrow roadway shoulders, ensure sufficient space available for parking.
- Do not construct in wetlands and wetland buffers.
- Install above the site mean high water table levels to ensure the media filter drain mix bed and the underdrain (if needed) will not become saturated by shallow ground water.
- Do not site in areas of seasonal ground water inundation or basement flooding.
- Meet infiltration siting restrictions, including setbacks:
  - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
  - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
  - 100 feet away from proposed or existing septic system drainfields



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# DRYWELL

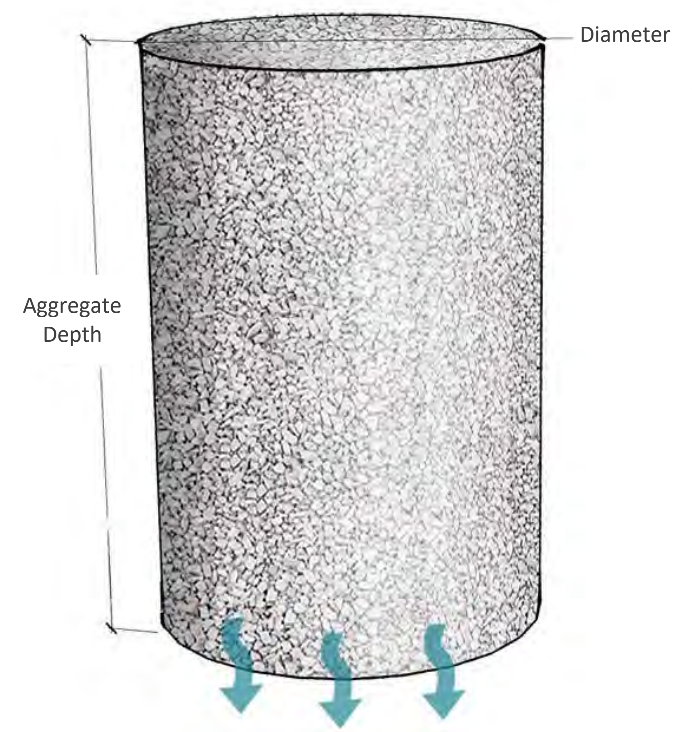
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

Photo accessed on 7/2/2020 from
https://www.thisoldhouse.com/

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

A gravel filled hole that conveys stormwater runoff into the soil matrix. Provides volume and peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Soil Type | |
|---|---|---|
| | **Till** | **Outwash** |
| Unit Footprint Area | 13 SF | 13 SF |
| Unit Drainage Area | 261 SF | 780 SF |
| Ponding Depth | N/A | N/A |
| Diameter | 4 ft | 4 ft |
| Aggregate Depth | 6 ft | 6 ft |
| Aggregate Porosity | 40% | 40% |
| Native Soil Design Infiltration Rate [a] | 0.3 in/hr | 2.5 in/hr |

a. Lateral infiltration assumed to occur through half of the sidewall depth.

## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial
- Industrial
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel

**Surface Types:**
- Roofs
- Sidewalks
- Driveways
- Parking Lots
- Lawns

## DESIGN ASSUMPTIONS

- Design is based on the *2017 Seattle Stormwater Manual*, “Drywells" (Volume 3 Section 5.4.3).
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step. The unit Action was sized to meet a Modified Level 1 Flow Control Standard, in which peak discharge rates were matched to the pre-developed (forested) peak discharge rates for the 2- and 10-year return intervals.
- Pre-treatment via upstream treatment Action will be provided.
- Infiltration to native soil assumes infiltration through the bottom surface and half of the sidewall surface area.
- The installed Action must be registered with Ecology as an Underground Injection Control (UIC).



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## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Model explicitly represents storage, infiltration and overflow.

**Treatment:**
- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | N/A | N/A |
| Dissolved Copper | N/A | N/A |
| Total Zinc | N/A | N/A |
| Dissolved Zinc | N/A | N/A |
| Total Phosphorus | N/A | N/A |
| Total Nitrogen | N/A | N/A |
| Total Suspended Solids | N/A | N/A |
| Total PCBs | N/A | N/A |
| Total PBDEs | N/A | N/A |
| Total PAHs | N/A | N/A |
| Bis(2-ethylhexyl)phthalate | N/A | N/A |
| Fecal Coliform | N/A | N/A |

N/A: Not applicable. See model representation treatment section.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property without Acquisition |
|---|---|
| Total Project | $19,800 |
| Total Direct Construction | $14,000 |
| Total Indirect Non-Construction | $5,800 |
| Operation and Maintenance | $1,000/year |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Minimum spacing between drywells is 10 feet.
- Setback is at least 15 feet from buildings with crawl space or basement elevations that are below the overflow point of the drywell.
- Can be placed under a pervious or impervious surface cover to conserve space.
- A minimum 5’ setback shall be maintained between any part of the action and any structure or property line.
- Locate downgradient of the primary and secondary reserve drainfield areas.
- Locate away from sensitive area buffers.
- Do not direct overflows toward a slope steeper than 15%.
- Meet infiltration siting restrictions, including setbacks:
  - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
  - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
  - 100 feet away from proposed or existing septic system drainfields



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# DEEP UNDERGROUND INJECTION CONTROL (UIC) WELL

## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

**Seattle Public Utilities Delridge Natural Drainage System**
Photo courtesy of RKI

## ACTION DESCRIPTION

A well that extends below an upper confining layer and discharges into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below. This analysis assumes a water-well style UIC downstream of a pre-treatment Action. Provides volume and peak flow reduction.

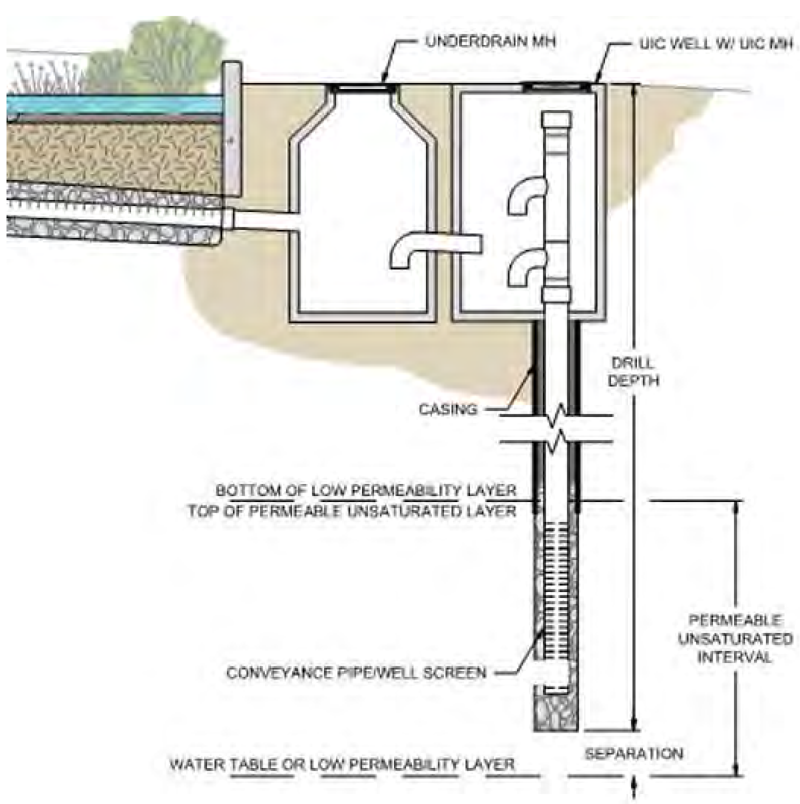
## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Sidewalks
- Lawns
- Local Roads
- Arterial Roads

## UNIT ACTION SCHEMATIC




## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Assumed Maximum Flow Rate | 0.111 cfs |
| Unit Footprint Area | 42 SF |
| Unit Drainage Area [a] | N/A |

N/A: Not Applicable
a. Unit Drainage Area based on drainage area of pre-treatment Action.

## DESIGN ASSUMPTIONS

- Design and sizing based on *King County Wastewater Treatment Division's Barton Basin Combined Sewer Overflow Control Project with Green Stormwater Infrastructure* (Barton).
- Maximum flow rate assumed to be 50 gallons per minute (0.111 cubic feet per second) based on average results presented in the Barton Drainage Report, Section 6.4.
- Well includes the following configuration:
    - Drilling and casing of 12-inch diameter borehole
    - 20-foot long 8-inch diameter pipe-sized well screen with filter pack
    - 5-foot deep stainless-steel well sump containing energy-dissipation rock, allowing water to drain out of well
    - Sand filter pack around well screen and sump, extending 8 feet above the top of the well screen
    - Maintenance hole over wellhead to convey treated stormwater into the well
    - Maximum well depth of 100 feet to accommodate future removal of sediment by vactor equipment
    - Underdrain manhole to provide for additional sediment removal
- Pre-treatment via upstream treatment Action will be provided.
- Includes a surface seal in the final completion of a deep UIC.



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# DEEP UNDERGROUND INJECTION CONTROL (UIC) WELL

## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**

- Model explicitly represents infiltration and overflow

**Treatment:**

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | N/A | N/A |
| Dissolved Copper | N/A | N/A |
| Total Zinc | N/A | N/A |
| Dissolved Zinc | N/A | N/A |
| Total Phosphorus | N/A | N/A |
| Total Nitrogen | N/A | N/A |
| Total Suspended Solids | N/A | N/A |
| Total PCBs | N/A | N/A |
| Total PBDEs | N/A | N/A |
| Total PAHs | N/A | N/A |
| Bis(2-ethylhexyl)phthalate | N/A | N/A |
| Fecal Coliform | N/A | N/A |

N/A: Not applicable. See model representation treatment section.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property without Acquisition | In Right of Way |
|---|---|---|
| Total Project | $57,200 | $81,900 |
| Total Direct Construction | $40,400 | $58,000 |
| Total Indirect Non-Construction | $16,800 | $23,900 |
| Operation and Maintenance | $900/year | $900/year |

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Locate away from wellhead protection area, Critical Aquifer Recharge Area, or a Sole Source Aquifer.
- Submittal of a State Waste Discharge Permit application required and will be determined on a site-by-site basis following the evaluation of the UIC permit application.



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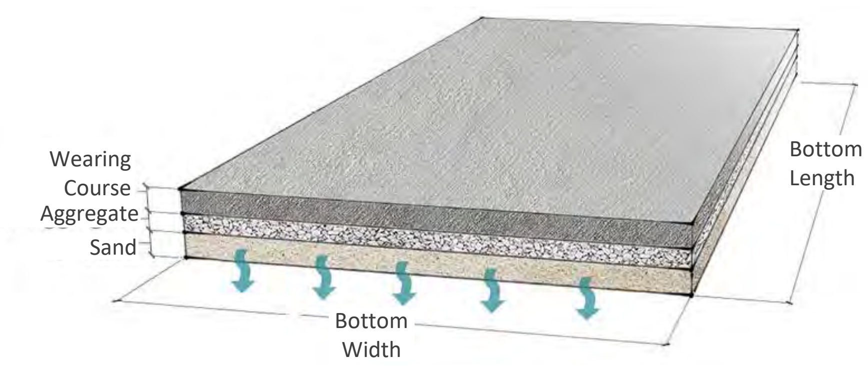
# PERMEABLE PAVEMENT
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

City of Puyallup 9th St NW Porous Asphalt Roadway and Driveway Aprons
Photo courtesy of RKI

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

Includes pervious concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material. Intended to allow passage of water through pavement. Provides volume and peak flow reduction. Provides water quality treatment when sand treatment layer is provided.

## DESIGN PARAMETERS

| Parameter | Soil Type | |
|---|---|---|
| | **Till** | **Outwash** |
| Unit Footprint Area | 200 SF | 200 SF |
| Unit Drainage Area | 200 SF | 200 SF |
| Ponding Depth | 0 in | 0 in |
| Bottom Length | 20 ft | 20 ft |
| Bottom Width | 10 ft | 10 ft |
| Treatment Media Depth [a] | 6 in | 6 in |
| Treatment Media Porosity | 35% | 35% |
| Aggregate Depth | 3 in | 3 in |
| Aggregate Porosity | 40% | 40% |
| Native Soil Design Infiltration Rate | 0.3 in/hr | 2.5 in/hr |

a. Sand treatment layer provided for pollution-generating hard surfaces (i.e., low volume residential driveways) only.

## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial

**Property Types:**
- Private Parcel
- Public Parcel

**Surface Types:**
- Low Volume Residential Driveways
- Sidewalks
- Plazas
- Trails
- Pedestrian and bike paths
- Parking Lots

## DESIGN ASSUMPTIONS

- Design and sizing based on the *2016 King County Surface Water Design Manual, "Permeable Pavement",* Appendix C, Section C.2.7.
- Section consists of 5" wearing course (pervious concrete or porous asphalt) over 3" aggregate. For low volume residential driveways, the section is underlain by 6" sand treatment layer
- Subsurface ponding assumed to include:
  - Ponding in aggregate layer: 3" x 40% porosity = 1.2"
  - Ponding in sand layer: 6" x 35% porosity = 2.1"
  - Storage in wearing course neglected
- The aggregate base contains less than 5% fines (material passing the #200 sieve) based on the fraction passing the #4 sieve.
- No run-on from other areas. The permeable pavement surface manages stormwater runoff from its own footprint only.
- Installation is on flat grades (e.g., <5% slope). No subsurface check dams required.



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A project for Clean Water Healthy Habitat

# PERMEABLE PAVEMENT
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Model explicitly represents subsurface ponding, infiltration, and overflow.

**Treatment:**
- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | N/A | N/A |
| Dissolved Copper | N/A | N/A |
| Total Zinc | N/A | N/A |
| Dissolved Zinc | N/A | N/A |
| Total Phosphorus | N/A | N/A |
| Total Nitrogen | N/A | N/A |
| Total Suspended Solids | N/A | N/A |
| Total PCBs | N/A | N/A |
| Total PBDEs | N/A | N/A |
| Total PAHs | N/A | N/A |
| Bis(2-ethylhexyl)phthalate | N/A | N/A |
| Fecal Coliform | N/A | N/A |

N/A: Not applicable. See model representation treatment section.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | Permeable Paver Plaza (no sand layer) | Pervious Concrete Sidewalk (no sand layer) | Permeable Paver Driveway (with sand layer) | Porous Asphalt Driveway (with sand layer) |
|---|---|---|---|---|
| Total Project | $9,500 | $15,800 | $11,000 | $8,300 |
| Total Direct Construction | $6,700 | $11,200 | $7,800 | $5,900 |
| Total Indirect Non-Construction | $2,800 | $4,600 | $3,200 | $2,400 |
| Operation and Maintenance | $2,300/year | $2,300/year | $2,300/year | $2,300/year |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Limit to sites with 5% or less grade.
- Do not locate in high traffic or heavy load applications such as arterial roads, highways, and industrial/commercial loading areas.
- Do not locate in areas where King County's Permeable Pavement Infeasibility Criteria (see Section C.2.7 in the *2016 King County Surface Water Design Manual*) apply, such as (but not limited to) the following areas:
  - Where ground water drains into an erosion hazard or landslide hazard area
  - Where nearby basements that may be impacted
  - Where seasonal high groundwater or an underlying impermeable/low permeable layer lies within 1 foot of the bottom of the installation
  - Downslope of steep, erosion prone areas that are likely to deliver sediment
  - Within 50 feet from the top of slopes greater than 20%
  - Within 100 feet of a closed or active landfill
  - Within 100 feet of a drinking water well, or a spring used for drinking water supply, for pollution-generating surfaces (e.g., driveways)



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# DEPAVING (REMOVAL OF IMPERVIOUS SURFACES)

## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

**Wheel strips replacing fully impervious driveway**
Photo accessed on 7/2/2020 from https://www.cityofpacificgrove.org/

## ACTION DESCRIPTION

Depaving, or removal of impervious surfaces down to bare soil. The area is amended with compost and planted with low lying ground cover. To allow continued site use, the area may be retrofit with an alternative treatment (e.g., wheel strip driveways) per King County Surface Water Design Manual, "Reduced Impervious Surface Credit". Provides volume and peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 100 SF |
| Existing Surface [a] | Impervious |
| New Surface [a] | Pervious |

a. This Action will be modeled in SUSTAIN by converting the depaved area from an impervious to pervious surface.

## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial
- Industrial

**Property Types:**
- Private Parcel
- Public Parcel

**Surface Types:**
- Driveways
- Sidewalks
- Parking Lots

## DESIGN ASSUMPTIONS

- Designs based on the *2016 King County Surface Water Design Manual*, "Reduced Impervious Surface Credit" (Appendix C, Section C.2.9).
- For wheel strip driveways, assume 10-foot-wide by 10-foot-long driveway converted to two (2) concrete pavement strips, each 2-feet-wide by 10-feet-long, for a total of 40 square feet impervious area (60% impervious area reduction).
- Restored pervious areas amended with 4 inches of well-rotted compost tilled into the upper 8 inches of the soil.



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# DEPAVING (REMOVAL OF IMPERVIOUS SURFACES)

Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Convert the surface type from existing impervious cover to a pervious surface type of the same land use.

**Treatment:**
- While no treatment is provided, pollutant loads will be reduced due to the differences in pollutant concentrations and runoff volumes from the change in surface type.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | N/A | N/A |
| Dissolved Copper | N/A | N/A |
| Total Zinc | N/A | N/A |
| Dissolved Zinc | N/A | N/A |
| Total Phosphorus | N/A | N/A |
| Total Nitrogen | N/A | N/A |
| Total Suspended Solids | N/A | N/A |
| Total PCBs | N/A | N/A |
| Total PBDEs | N/A | N/A |
| Total PAHs | N/A | N/A |
| Bis(2-ethylhexyl)phthalate | N/A | N/A |
| Fecal Coliform | N/A | N/A |

N/A: Not applicable. See model representation treatment section.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | Driveway Depaving with Wheel Strips | Driveway Depaving without Alternative Surface |
|---|---|---|
| Total Project | $2,600 | $2,000 |
| Total Direct Construction | $1,800 | $1,400 |
| Total Indirect Non-Construction | $800 | $600 |
| Operation and Maintenance | $700/year | $700/year |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- The area credited as mitigated must be no more than 10,000 square feet on any one site/lot unless the surface is served by a flow control facility designed by a civil engineer in accordance with Section 1.2.3 of the *2016 King County Surface Water Design Manual.*
- Any runoff from the area credited as mitigated must be directed to vegetated pervious areas on the site/lot or discharged through a perforated pipe connection per Section C.2.11 of the *2016 King County Surface Water Design Manual.*
- Any portion of the area credited as mitigated that is pollution-generating impervious surface must be less than 5,000 square feet on any one site/lot unless the surface is served by a water quality treatment facility designed by a civil engineer in accordance with Section 1.2.8 of the *2016 King County Surface Water Design Manual.*



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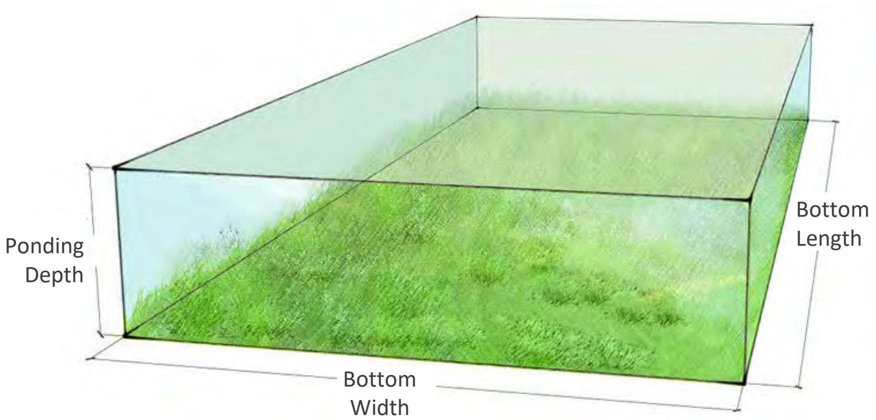
# STORMWATER TREATMENT WETLAND
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

Photo accessed on 7/2/2020 from
https://www.portseattle.org/projects/wetlands-and-habitat-restoration

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

Similar to a wet pond but also provides a shallow marsh area to allow the establishment of emergent wetland aquatic plants, which improves pollutant removal. Provides water quality treatment and peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 503 SF |
| Unit Drainage Area | 62,988 SF |
| Ponding Depth | 48 in |
| Bottom Length | 31.5 ft |
| Bottom Width | 16 ft |
| Side Slope | 3H : 1V |
| Water Quality Design Flow Rate (Off-line) | 0.118 cfs |
| Native Soil Design Infiltration Rate [a] | N/A |

a. Not Applicable, incidental infiltration to native soils neglected.
Note: For Actions with side slopes, see SUSTAIN representation in 439-TM1 Appendix B.

## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Sidewalks
- Driveway
- Parking Lots
- Local Roads
- Arterial Roads
- Highways

## DESIGN ASSUMPTIONS

- Design and sizing are based on *2016 King County Surface Water Design Manual* Section 6.4.3 "Stormwater Wetlands".
- Off-line Water Quality Design Flow Rate is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Sized and designed as a Basic facility.
- Two-cell facility includes:
  - Pre-settling cell with volume equal to one-third the volume of the entire facility and minimum sediment storage depth of 1 foot
  - 1-foot freeboard over entire surface area
  - Dividing berm submerged 1 foot below the WQ design water surface
- No infiltration to native soil.
- 12-inch-diameter outlet pipe back-sloped and extended 1 foot below the WQ design water surface.



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# STORMWATER TREATMENT WETLAND
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Model explicitly represents ponding and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

**Treatment:**
- Water that flows through the Action (up to the water quality design flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | 25.0% | 3.0 µg/L |
| Dissolved Copper | 0.0% | 2.0 µg/L |
| Total Zinc | 45.9% | 12.0 µg/L |
| Dissolved Zinc | 0.0% | 10.0 µg/L |
| Total Phosphorus | 24.2% | 0.071 mg/L |
| Total Nitrogen | 5.81% | 0.932 mg/L |
| Total Suspended Solids | 52.4% | 6.81 mg/L |
| Total PCBs | 78.1% | 165 pg/L |
| Total PBDEs | 45.1%[a] | 0.017 ng/L[a] |
| Total PAHs | 85.6% | 0.024 µg/L |
| Bis(2-ethylhexyl)phthalate | 42.4%[a] | 0.022 µg/L[a] |
| Fecal Coliform | 19.1% | 425 CFU/100 mL |

a. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property with Acquisition | On Property/Highway without Acquisition |
|---|---|---|
| Total Project | $1,537,200 | $815,000 |
| Total Direct Construction | $463,100 | $463,100 |
| Total Indirect Non-Construction | $1,074,100 | $351,900 |
| Operation and Maintenance | $2,500/year | $2,500/year |
| Property Acquisition [c] | $555,554 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Areas with high winter groundwater levels are ideal for wetland siting.
- Potential site evapotranspiration must be considered as sufficient water must be retained in facility to supply adequate water for aquatic vegetation.
- The pre-settling cell must retain a permanent pool of water throughout the wet season, and the second cell must retain water for at least 10 months of the year.
- Setback required from tract line is 5-feet from emergency overflow water surface.
- Access and maintenance roads are required and must extend to both the wetland inlet and outlet structures.
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 6.2.3 and Section 6.4.2.



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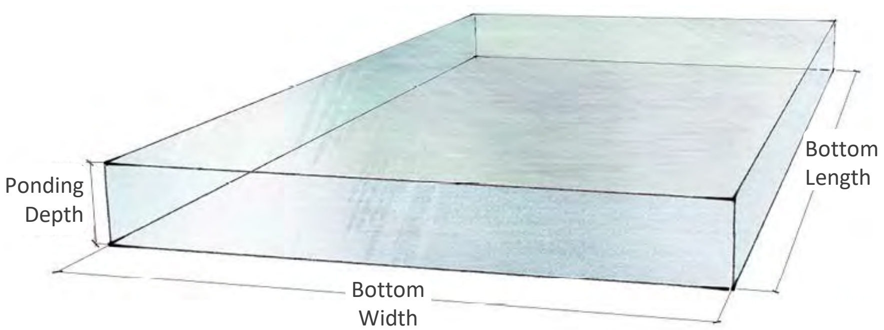
# DETENTION VAULT
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

Photo accessed on 7/2/2020 from https://csengineermag.com/

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

A box-shaped underground facility that provides temporary storage of stormwater runoff. The stored stormwater runoff is then released through a control structure at an attenuated rate. Provides peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 2,592 SF |
| Unit Drainage Area | 28,658 SF |
| Ponding Depth | 72 in |
| Bottom Length | 54 ft |
| Bottom Width | 48 ft |
| Side Slope | Vertical |
| Orifice Diameter | 1.16 in |
| Orifice Height | 0 ft |
| Notch Width | 0.37 in |
| Notch Height | 2.40 ft |

## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads
- Highways

## DESIGN ASSUMPTIONS

- Design is based on *2016 King County Surface Water Design Manual*, "Detention Vaults" (Chapter 5, Section 5.1.3).
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step. The unit Action was sized to meet the Level 2 Flow Control standard with pre-developed forest condition.
- The invert elevation of the outlet is elevated above the bottom of the vault to provide an average 6 inches of sediment storage over the entire bottom.
- The outlet is also elevated a minimum of 2 feet above the orifice to retain oil within the vault.
- Access is provided by a 5-foot by 10-foot removable, locking panel.
- Internal height of 7 feet.



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# DETENTION VAULT
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Model explicitly represents ponding and overflow.

**Treatment:**
- Water that flows through the orifice will be assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. While not designed for treatment, there will be some pollutant removal via sedimentation (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | 26.2%[b] | 4.2 µg/L[b] |
| Dissolved Copper | 3.23%[b] | 3.0 µg/L[b] |
| Total Zinc | 44.0%[b] | 18.0 µg/L[b] |
| Dissolved Zinc | 13.6%[b] | 16.1 µg/L[b] |
| Total Phosphorus | 17.7%[b] | 0.113 mg/L[b] |
| Total Nitrogen | 7.80%[b] | 0.674 mg/L[b] |
| Total Suspended Solids | 57.6%[b] | 12.9 mg/L[b] |
| Total PCBs | 57.6%[a] | 342 pg/L[a] |
| Total PBDEs | 56.9% | 93.5 ng/L |
| Total PAHs | 52.1% | 0.228 µg/L |
| Bis(2-ethylhexyl)phthalate | 46.7%[a] | 0.042 µg/L[a] |
| Fecal Coliform | 31.5%[b] | 500 CFU/100 mL[b] |

a. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.
b. Performance based on detention pond performance which provide similar unit processes for pollutant removal.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property with Acquisition | On Property without Acquisition | In Right of Way/ Highway |
|---|---|---|---|
| Total Project | $6,324,900 | $5,775,500 | $6,302,400 |
| Total Direct Construction | $3,281,800 | $3,281,800 | $3,638,400 |
| Total Indirect Non-Construction | $3,043,100 | $2,493,700 | $2,664,000 |
| Operation and Maintenance | $5,200/year | $5,200/year | $5,200/year |
| Property Acquisition [c] | $422,603 | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Setbacks to tract/easement lines for vaults shall be 5 feet; adjacent building setback lines shall be 10 feet.
- For privately owned and maintained vaults, building foundations may serve as one or more of the vault walls.





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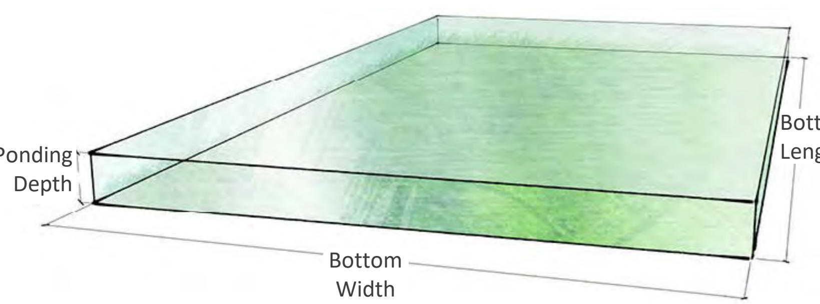
# DETENTION POND
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

Photo courtesy of Paradigm

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

A surface basin that provides temporary storage of stormwater runoff. The stored stormwater runoff is then released through a control structure at an attenuated rate, allowing the basin to dry out between storm events. Provides peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 4,500 SF |
| Unit Drainage Area | 36,569 SF |
| Ponding Depth | 48 in |
| Bottom Length | 95 ft |
| Bottom Width | 47.4 ft |
| Side Slope | 3H : 1V |
| Orifice Diameter | 1.41 in |
| Orifice Elevation | 0 ft |
| Notch Width | 0.87 in |
| Notch Height | 1.44 ft |

Note: For Actions with side slopes, see SUSTAIN representation in 439-TM1 Appendix B.

## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Local Roads
- Arterial Roads
- Highways

## DESIGN ASSUMPTIONS

- Design is based on *2016 King County Surface Water Design Manual,* Chapter 5, Section 5.1.1 “Detention Ponds”.
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region precipitation time series with a 15-minute model time step. The Unit Action was sized to meet the Level 2 Flow Control standard with a pre-developed forest condition.



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# DETENTION POND

Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**

- Model explicitly represents ponding and overflow.
- Design Parameters were modified to accurately represent the Unit Action's performance in SUSTAIN.

**Treatment:**

- Water that flows through the orifice will be assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. While not designed for treatment, there will be some pollutant removal via sedimentation (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | 26.2% | 4.2 µg/L |
| Dissolved Copper | 3.23% | 3.0 µg/L |
| Total Zinc | 44.0% | 18.0 µg/L |
| Dissolved Zinc | 13.6% | 16.1 µg/L |
| Total Phosphorus | 17.7% | 0.113 mg/L |
| Total Nitrogen | 7.80% | 0.674 mg/L |
| Total Suspended Solids | 57.6% | 12.9 mg/L |
| Total PCBs | 57.6%[a] | 342 pg/L[a] |
| Total PBDEs | 56.9%[b] | 93.5 ng/L[b] |
| Total PAHs | 52.1%[b] | 0.228 µg/L[b] |
| Bis(2-ethylhexyl)phthalate | 46.7%[a] | 0.042 µg/L[a] |
| Fecal Coliform | 31.5% | 500 CFU/100 mL |

a. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.
b. Performance based on detention vault performance which provide similar unit processes for pollutant removal.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property with Acquisition | On Property/Highway without Acquisition |
|---|---|---|
| Total Project | $2,709,600 | $1,222,400 |
| Total Direct Construction | $694,200 | $694,600 |
| Total Indirect Non-Construction | $2,015,400 | $527,800 |
| Operation and Maintenance | $10,000/year | $10,000/year |
| Property Acquisition [c] | $1,144,543 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Do not locate in dedicated public road right-of-way.
- Must meet the following setbacks:
  - Tract or property line must be setback 5 feet from the emergency overflow water surface
  - The water surface at the pond outlet invert elevation must be setback 100 feet from proposed or existing septic system drainfields
  - Design water surface must be a minimum of 200 feet from any steep slope hazard area or landslide hazard area
  - Design water surface must be setback a minimum distance from top of slope equal to the total vertical height of a slope area that is steeper than 15%
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 5.1.1.



Visit kingcounty.gov/WQBE for more information.

# INFILTRATION POND

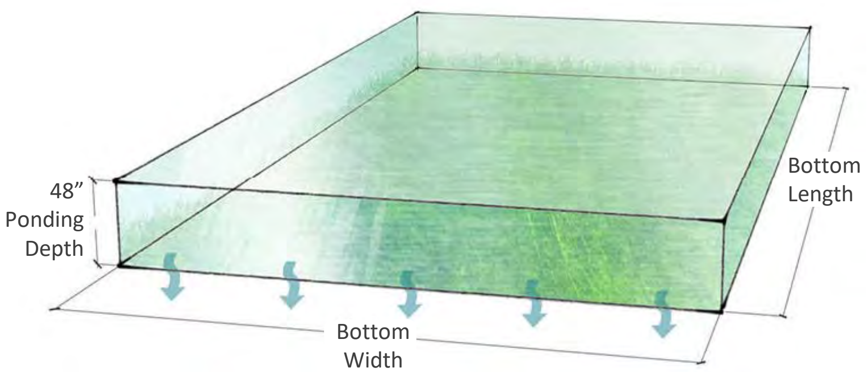
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

Photo accessed on 7/2/2020 from https://www.stormwater.pca.state.mn.us

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

A surface basin that temporarily stores stormwater runoff similar to a detention pond, but also provides infiltration. Provides volume and peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Soil Type | |
|---|---|---|
| | **Till** | **Outwash** |
| Unit Footprint Area | 2,785 SF | 1,479 SF |
| Unit Drainage Area | 36,595 SF | 46,396 SF |
| Ponding Depth | 48 in | 48 in |
| Bottom Length | 74.6 ft | 54.4 ft |
| Bottom Width | 37.3 ft | 27.2 ft |
| Side Slope | 3H : 1V | 3H : 1V |
| Native Soil Design Infiltration Rate | 0.3 in/hr | 2.5 in/hr |

Note: For Actions with side slopes, see SUSTAIN representation in 439-TM1 Appendix B.

## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Local Roads
- Arterial Roads
- Highways

## DESIGN ASSUMPTIONS

- Design based on *2016 King County Surface Water Design Manual* Chapter 5, Section 5.2.2 "Infiltration Ponds"
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region precipitation time series with a 15-minute model time step. The Unit Action was sized to meet the Level 2 Flow Control standard with a pre-developed forest condition.
- Length-to-width ratio assumed to be 2:1
- Pre-treatment via upstream treatment Action will be provided
- Maintenance access roads must be provided to the control structure and other drainage structures associated with the pond
- An overflow structure and emergency spillway shall be provided



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# INFILTRATION POND
Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Model explicitly represents ponding, infiltration, and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

**Treatment:**
- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | N/A | N/A |
| Dissolved Copper | N/A | N/A |
| Total Zinc | N/A | N/A |
| Dissolved Zinc | N/A | N/A |
| Total Phosphorus | N/A | N/A |
| Total Nitrogen | N/A | N/A |
| Total Suspended Solids | N/A | N/A |
| Total PCBs | N/A | N/A |
| Total PBDEs | N/A | N/A |
| Total PAHs | N/A | N/A |
| Bis(2-ethylhexyl)phthalate | N/A | N/A |
| Fecal Coliform | N/A | N/A |

N/A: Not applicable. See model representation treatment section.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property with Acquisition | | On Property/Highway without Acquisition | |
|---|---|---|---|---|
| | In Till Soil | In Outwash Soil | In Till Soil | In Outwash Soil |
| Total Project | $2,039,300 | $1,947,300 | $880,800 | $788,800 |
| Total Direct Construction | $500,500 | $448,200 | $500,500 | $448,200 |
| Total Indirect Non-Construction | $1,538,800 | $1,499,100 | $380,300 | $340,600 |
| Operation and Maintenance | $5,900/year | $3,700/year | $5,900/year | $3,700/year |
| Property Acquisition [c] | $891,189 | $891,189 | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Not allowed on slopes greater than 25% (4H:1V).
- Must meet infiltration siting restrictions, including setbacks:
    - The tract, easement or property line must be set back 5 feet from the emergency overflow water surface
    - Design water surface must be set back 100 feet from proposed or existing septic system drainfields
    - Design water surface must be minimum 200 feet from any steep slope hazard area or landslide hazard area
    - Design water surface must be set back 20 feet from external tract, easement or property lines
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 5.2.2.



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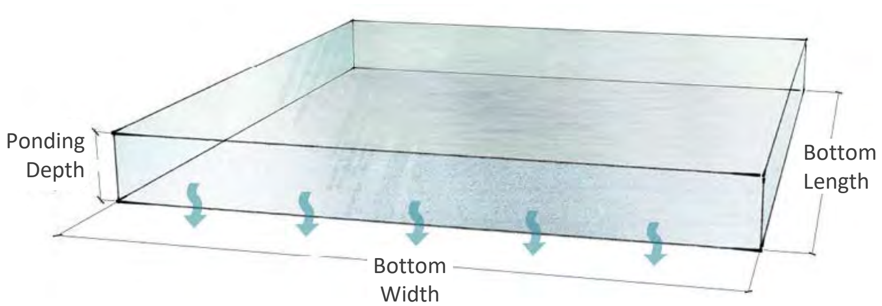
# INFILTRATION VAULT
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

**City of Redmond Overlake Village Infiltration Vault**
Photo accessed on 7/2/2020 from
https://content.govdelivery.com/accounts/WAREDMOND/bulletins/1e5d116

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

An open bottomed, box-shaped underground facility that stores stormwater runoff similar to detention vaults, but also provides infiltration via an open bottom. Provides volume reduction and peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Soil Type: Till | Soil Type: Outwash |
|---|---|---|
| Unit Footprint Area | 1,836 SF | 1,156 SF |
| Unit Drainage Area | 28,719 SF | 39,365 SF |
| Ponding Depth | 72 in | 72 in |
| Bottom Length | 51 ft | 34 ft |
| Bottom Width | 36 ft | 34 ft |
| Side Slope | Vertical | Vertical |
| Native Soil Design Infiltration Rate | 0.3 in/hr | 2.5 in/hr |

## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads
- Highways

## DESIGN ASSUMPTIONS

- Design based on *2016 King County Surface Water Design Manual* Chapter 5, Section 5.2.4 “Infiltration Vaults”.
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region precipitation time series with a 15-minute model time step. The Unit Action was sized to meet the Level 2 Flow Control standard with a pre-developed forest condition.
- Pre-treatment via upstream treatment Action will be provided.
- Designs include a solid bottom riser (with clean-out gate) and outflow system for safely discharging overflows to the downstream conveyance system or acceptable discharge point.
- Energy dissipation at the inlet is required to prevent scour and will be accomplished by using the detail for the sand filter vault (see Figure 6.5.3.A in the 2016 King County Surface Water Design Manual).
- Access roads are required to the vault access panel.



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# INFILTRATION VAULT
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Model explicitly represents ponding, infiltration, and overflow.

**Treatment:**
- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | N/A | N/A |
| Dissolved Copper | N/A | N/A |
| Total Zinc | N/A | N/A |
| Dissolved Zinc | N/A | N/A |
| Total Phosphorus | N/A | N/A |
| Total Nitrogen | N/A | N/A |
| Total Suspended Solids | N/A | N/A |
| Total PCBs | N/A | N/A |
| Total PBDEs | N/A | N/A |
| Total PAHs | N/A | N/A |
| Bis(2-ethylhexyl)phthalate | N/A | N/A |
| Fecal Coliform | N/A | N/A |

N/A: Not applicable. See model representation treatment section.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property with Acquisition | | On Property without Acquisition | | In Right of Way/ Highway | |
|---|---|---|---|---|---|---|
| | In Till Soil | In Outwash Soil | In Till Soil | In Outwash Soil | In Till Soil | In Outwash Soil |
| Total Project | $4,423,500 | $3,733,400 | $3,981,300 | $3,291,300 | $4,821,100 | $3,956,300 |
| Total Direct Construction | $2,262,300 | $1,870,200 | $2,262,300 | $1,870,200 | $2,782,300 | $2,282,500 |
| Total Indirect Non-Construction | $2,161,200 | $1,863,200 | $1,719,000 | $1,421,100 | $2,038,800 | $1,673,800 |
| Operation and Maintenance | $4,800/year | $4,800/year | $4,800/year | $4,800/year | $4,800/year | $4,800/year |
| Property Acquisition [c] | $340,082 | $340,082 | $0 | $0 | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- The proposed vault bottom shall be at least 3 feet above the seasonal high groundwater level and have at least 3 feet of permeable soil beneath the bottom.
- Not allowed on slopes greater than 25% (4H:1V).
- Must meet infiltration siting restrictions, including setbacks:
  - The tract, easement or property line must be set back 5 feet from the emergency overflow water surface
  - Design water surface must be set back 100 feet from proposed or existing septic system drainfields
  - Design water surface must be minimum 200 feet from any steep slope hazard area or landslide hazard area
  - Design water surface must be set back 20 feet from external tract, easement or property lines
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 5.2.4.



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# CISTERN

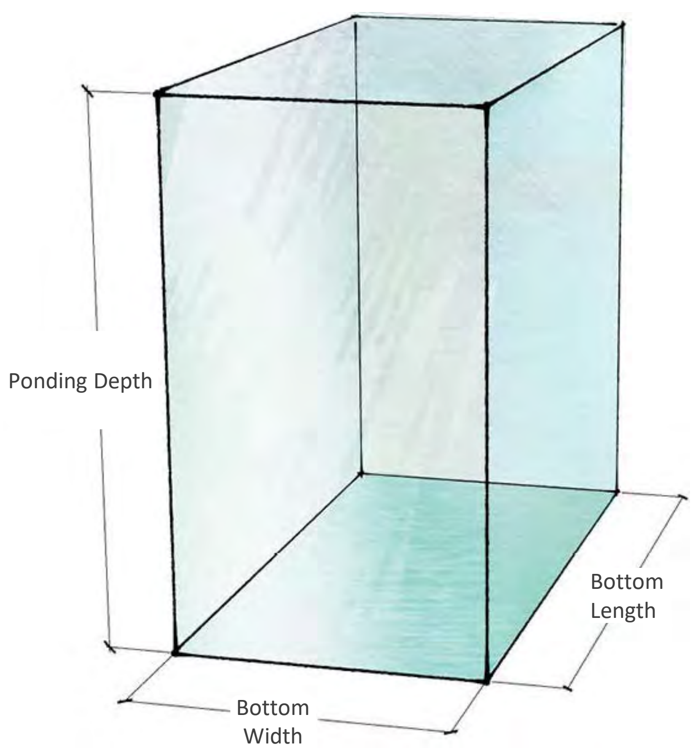
Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

**Freelard RainCatchers**
Photo courtesy of RKI

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

A tank designed to provide temporary storage and slow release of rooftop stormwater runoff. Provides peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 18 SF |
| Unit Drainage Area | 1,300 SF |
| Ponding Depth | 60 in |
| Bottom Length | 6 ft |
| Bottom Width | 3 ft |
| Orifice Diameter | 0.25 in |
| Orifice Elevation | 4 in |

## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial
- Industrial

**Property Types:**
- Private Parcel
- Public Parcel

**Surface Types:**
- Roofs

## DESIGN ASSUMPTIONS

- Design is based on *2017 Seattle SW Manual*, Volume 3 Section 5.5.2 "Single Family Residential (SFR) Cisterns".
- Sizing is based on sizing factors for the On-site Performance Standard from the *2017 Seattle Stormwater Manual* Section 5.5.2.6.
- Flow control orifice assumed to be 0.25-inch-diameter at 4-inch-elevation.
- Designs include a filter screen or other debris barrier to prevent insects, leaves, and other larger debris from entering the system.
- Overflow conveyance to an approved discharge or another Action (e.g., bioretention installation, etc.) provided by gravity flow pipe.



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## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Model explicitly represents ponding, orifice flow, and overflow.

**Treatment:**
- Model will assume no treatment provided unless Program includes manual operation of orifice valve by property owner.
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS*

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | -- | -- |
| Dissolved Copper | -- | -- |
| Total Zinc | -- | -- |
| Dissolved Zinc | -- | -- |
| Total Phosphorus | -- | -- |
| Total Nitrogen | -- | -- |
| Total Suspended Solids | -- | -- |
| Total PCBs | -- | -- |
| Total PBDEs | -- | -- |
| Total PAHs | -- | -- |
| Bis(2-ethylhexyl)phthalate | -- | -- |
| Fecal Coliform | -- | -- |

* Action provides negligible water quality benefit

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property without Acquisition |
|---|---|
| Total Project | $30,600 |
| Total Direct Construction | $21,600 |
| Total Indirect Non-Construction | $9,000 |
| Operation and Maintenance | $700/year |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Contributing drainage areas must not be pollution-generating.
- Cisterns are subject to local code requirements, such as Seattle Municipal Code Title 23 – Land Use Code due to height in excess of 4.5 feet.
- Rainwater shall be used for outdoor irrigation uses only.
- Additional feasibility and siting considerations can be found in the *2017 Seattle Stormwater Manual* Volume 3 Section 5.5.2 and Appendix C.



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10/1/2024

Photo accessed on 7/2/2020 from
https://www.redmond.gov/487/Stormwater-Ponds

## ACTION DESCRIPTION

A constructed stormwater pond that retains a permanent pool of water ("wetpool"), at least during the wet season, for settling of particulate pollutants. Provides water quality treatment and peak flow reduction.

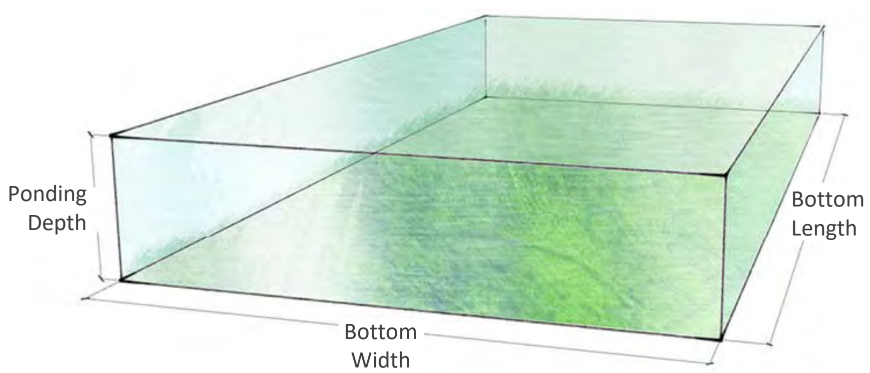
## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Lawns
- Sidewalks
- Driveway
- Parking Lots
- Local Roads
- Arterial Roads
- Highways

## UNIT ACTION SCHEMATIC




## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 553 SF |
| Unit Drainage Area | 63,075 SF |
| Ponding Depth | 48 in |
| Bottom Length | 33.3 ft |
| Bottom Width | 16.6 ft |
| Side Slope | 3H : 1V |
| Water Quality Design Flow Rate (Off-line) | 0.118 cfs |

Note: For Actions with side slopes, see SUSTAIN representation in 439-TM1 Appendix B.

## DESIGN ASSUMPTIONS

- Design and sizing are based on *2016 King County Surface Water Design Manual* Section 6.4.1 “Wetponds”.
- Sized as Basic facility.
- Off-line design assumes flow splitter will be used to divert flows up to the Water Quality Design Flow Rate to the Action.
- Off-line Water Quality Design Flow Rate is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Two-celled facility:
  - Pre-settling cell requires minimum sediment storage depth of 1-foot
  - Diving berm is submerged 1-foot below the Water Quality design water surface
- No infiltration to native soil.
- 12-inch-diameter outlet pipe back-sloped and extended 1 foot below the WQ design water surface.





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## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**

- Model explicitly represents ponding and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

**Treatment:**

- Water that flows through the Action (up to the water quality design flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | 45.0% | 3.0 μg/L |
| Dissolved Copper | 22.7% | 3.0 μg/L |
| Total Zinc | 62.5% | 13.0 μg/L |
| Dissolved Zinc | 36.8% | 10.0 μg/L |
| Total Phosphorus | 49.5% | 0.071 mg-P/L |
| Total Nitrogen | 27.6% | 0.904 mg/L |
| Total Suspended Solids | 76.2% | 7.5 mg/L |
| Total PCBs | 76.2%[a] | 199 pg/L[a] |
| Total PBDEs | 65.5%[a] | 0.019 ng/L[a] |
| Total PAHs | 76.2%[a] | 0.00093 μg/L[a] |
| Bis(2-ethylhexyl)phthalate | 61.7%[a] | 0.025 μg/L[a] |
| Fecal Coliform | 60.0% | 85.5 CFU/100 mL |

a. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property with Acquisition | On Property/Highway without Acquisition |
|---|---|---|
| Total Project | $1,669,300 | $869,200 |
| Total Direct Construction | $493,900 | $493,900 |
| Total Indirect Non-Construction | $1,175,400 | $375,300 |
| Operation and Maintenance | $2,200/year | $2,200/year |
| Property Acquisition [c] | $615,475 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Both cells of the wetpond must retain a permanent pool of water throughout the wet season.
- Setback is required from tract line is 5 feet from emergency overflow water surface.
- Access and maintenance roads are required and must extend to both the wetpond inlet and outlet structures.
- See comprehensive list of infeasibility criteria in Section 6.2.3 and Section 6.4.1.2 of the *2016 King County Surface Water Design Manual.*

# WETVAULT

## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

Photo accessed on 7/2/2020 from:
http://romtecutilities.com/wet-dry-panel-vault-installation

## ACTION DESCRIPTION

An underground structure similar to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants. Provides water quality treatment and peak flow reduction.

## AREAS MANAGED

**Land Uses:**

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

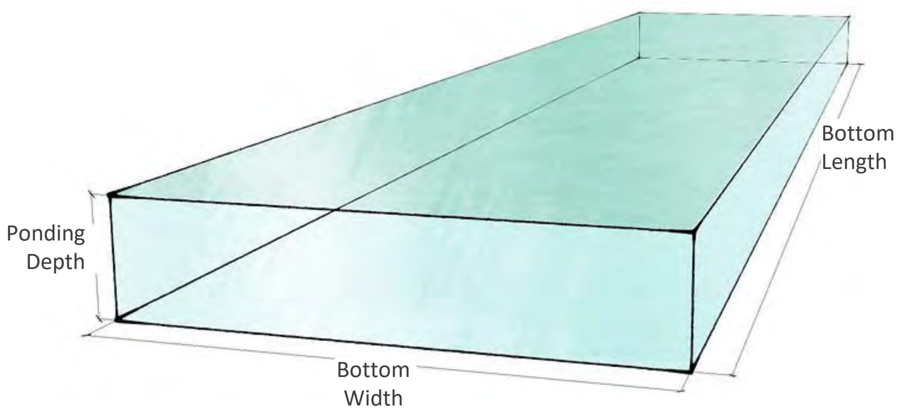
**Property Types:**

- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**

- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads
- Highways

## UNIT ACTION SCHEMATIC




## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 1,615 SF |
| Unit Drainage Area | 63,010 SF |
| Ponding Depth | 48 in |
| Bottom Length | 80 ft |
| Bottom Width | 20.2 ft |
| Side Slope | Vertical |
| Water Quality Design Flow Rate (Off-line) | 0.118 cfs |

## DESIGN ASSUMPTIONS

- Design and sizing are based on *2016 King County Surface Water Design Manual* Section 6.4.2 “Basic Wetvaults”.
- Off-line Water Quality Design Flow Rate is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Off-line design assumes flow splitter will be used to divert flows up to the Water Quality (WQ) Design Flow Rate to the Action
- Additional minimum sediment storage of 6 inches required.
- Two-celled facility with cells separated by baffle wall.
- Lockable grates instead of solid manhole covers included in design to increase air contact with the wetpool.
- 12-inch-diameter outlet pipe back-sloped and extended 1 foot below the WQ design water surface.
- 8-inch-diameter gravity drain controlled by a valve.



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# WETVAULT

## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Model explicitly represents ponding and overflow.

**Treatment:**
- Water that flows through the Action (up to the water quality design flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | 45.0%[b] | 3.0 μg/L[b] |
| Dissolved Copper | 22.7%[b] | 3.0 μg/L[b] |
| Total Zinc | 62.5%[b] | 13.0 μg/L[b] |
| Dissolved Zinc | 36.8%[b] | 10.0 μg/L[b] |
| Total Phosphorus | 49.5%[b] | 0.071 mg/L[b] |
| Total Nitrogen | 27.6%[b] | 0.904 mg/L[b] |
| Total Suspended Solids | 76.2%[b] | 7.5 mg/L[b] |
| Total PCBs | 76.2%[a] | 199 pg/L[a] |
| Total PBDEs | 65.5%[a] | 0.019 ng/L[a] |
| Total PAHs | 76.2%[a] | 0.00093 μg/L[a] |
| Bis(2-ethylhexyl)phthalate | 61.7%[a] | 0.025 μg/L[a] |
| Fecal Coliform | 60.0%[b] | 85.5 CFU/100 mL[b] |

a. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.
b. Performance based on wet pond performance which provide similar unit processes for pollutant removal.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property with Acquisition | On Property without Acquisition | In Right of Way/ Highway |
|---|---|---|---|
| Total Project | $5,698,800 | $5,246,700 | $5,790,300 |
| Total Direct Construction | $2,981,300 | $2,981,300 | $3,342,400 |
| Total Indirect Non-Construction | $2,717,500 | $2,265,400 | $2,447,900 |
| Operation and Maintenance | $3,100/year | $3,100/year | $3,100/year |
| Property Acquisition [c] | $347,803 | $0 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Relatively small catchments (less than 10 acres of impervious surface) with high land values typically most practical because vaults are relatively expensive.
- Must have a flow length-to-width ratio greater than 3:1 minimum.
- 5-foot setback to tract/easement lines required.
- 10-foot setback for buildings adjacent to the vault required.
- For privately owned and maintained vaults, building foundations may serve as one or more of the vault walls.
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 5.1.3 and Section 6.4.



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HIGH RATE UNDERGROUND FILTER SYSTEM

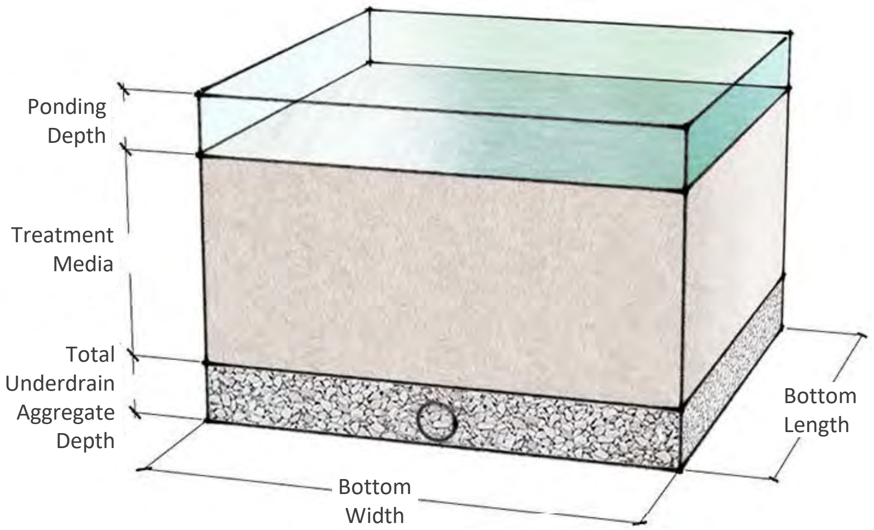
Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024


Filterra® Bioretention System
Photo accessed on 7/2/2020 from [www.conteches.com](www.conteches.com)

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in highly urbanized settings and may be proprietary. Provides water quality treatment.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 16 SF |
| Unit Drainage Area | 34,956 SF |
| Ponding Depth | 2 in |
| Bottom Length | 4 ft |
| Bottom Width | 4 ft |
| Side Slope | Vertical |
| Treatment Media Depth | 21 in |
| Treatment Media Porosity | 40% |
| Treatment Media Design Infiltration Rate | 175 in/hr |
| Total Underdrain Aggregate Depth | 6 in |
| Underdrain Invert Height | 0 in |
| Underdrain Diameter | 4 in |
| Underdrain Aggregate Porosity | 40% |
| Native Soil Design Infiltration Rate [a] | N/A |
| Water Quality Design Flow Rate (Off-line) | 0.081 cfs |

N/A: Not Applicable

a. Liner prevents infiltration to native soil

## AREAS MANAGED

**Land Uses:**
- Commercial
- Industrial
- Highway

**Property Types:**
- Private Parcel
- Public Parcel
- Public Right-of-Way

**Surface Types:**
- Roofs
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads

## DESIGN ASSUMPTIONS

- Design is based on standards for Contech® Filterra® Bioscape External Bypass configuration.
- Sizing is based on Washington Department of Ecology (Ecology) General Use Level Designation (GULD) approved infiltration rate of 175 inches/hour for Enhanced Water Quality Treatment.
- Off-line Water Quality Design Flow Rate based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Proprietary Filterra® engineered media assumed. Other proprietary media and facilities may be used. Refer to Ecology's Emerging stormwater treatment technologies (TAPE) for a full list of GULD approved media for Enhanced Water Quality Treatment.
- No infiltration to native soil.



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# HIGH RATE UNDERGROUND FILTER SYSTEM

## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**

- Model explicitly represents ponding, underdrain flow, and overflow.

**Treatment:**

- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal [a] | 25th Percentile Effluent Concentration [a] |
|---|---|---|
| Total Copper | 51.6% | 3.1 µg/L |
| Dissolved Copper | 34.2% | 2.0 µg/L |
| Total Zinc | 56.4% | 20.1 µg/L |
| Dissolved Zinc | 53.4% | 26.0 µg/L |
| Total Phosphorus | 42.4% | 0.034 mg/L |
| Total Nitrogen | 45.8% | 0.422 mg/L |
| Total Suspended Solids | 86.4% | 2.5 mg/L |
| Total PCBs | 84.1% | 414 pg/L |
| Total PBDEs | 74.3%[b] | 0.0061 ng/L[b] |
| Total PAHs | 86.4%[b] | 0.00031 µg/L[b] |
| Bis(2-ethylhexyl)phthalate | 70.0%[b] | 0.008 µg/L[b] |
| Fecal Coliform | NF [c] | NF [c] |

NF: No data found

a. Performance based on proprietary Filterra® engineered media.

b. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

c. Assigned a value of 0 in SUSTAIN since no data was found.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | Public Right of Way with Portland Cement Concrete Pavements | | Public Right of Way with Hot Mix Asphalts | |
|---|---|---|---|---|
| | Urban ROW | Highway ROW | Urban ROW | Highway ROW |
| Total Project | $208,300 | $153,300 | $149,700 | $135,700 |
| Total Direct Construction | $147,500 | $108,500 | $106,000 | $96,100 |
| Total Indirect Non-Construction | $60,800 | $44,800 | $43,700 | $39,600 |
| Operation and Maintenance | $2,500/year | $2,500/year | $2,500/year | $2,500/year |

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Must be designed, assembled, installed, operated and maintained according to the manufacturer's manuals, documents, and Ecology GULD approval.
- The distance from the point of entry of water to the most distant point on the surface of the treatment media shall not exceed 12-feet.
- 5-foot setback to tract/easement lines.
- 10-foot setback for buildings adjacent to stormwater facility.
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 5.1.3 and Section 6.7.



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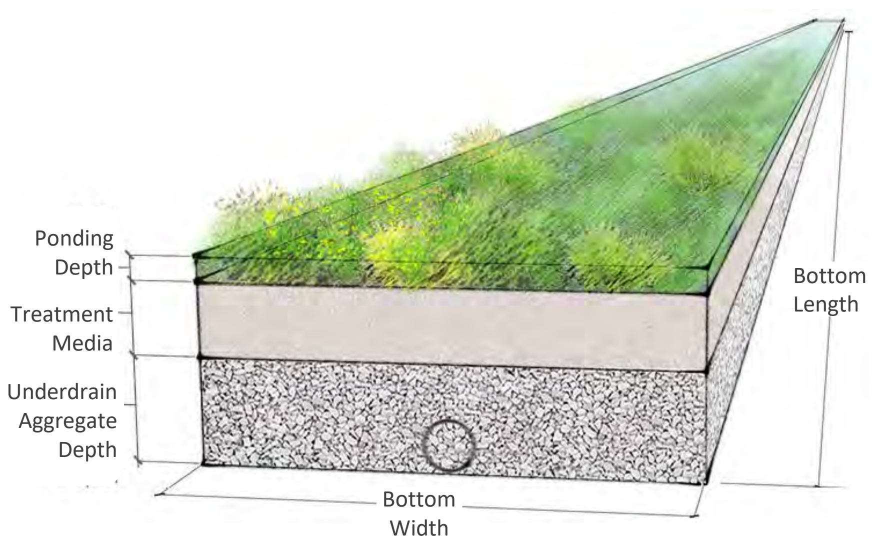
# STORMWATER PARK (WATER QUALITY TREATMENT)
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

**Manchester Stormwater Park**
Photo accessed on 7/2/2020 from
http://nwcascade.com/projects/manchester-stormwater-park/

## UNIT ACTION SCHEMATIC




## ACTION DESCRIPTION

A large-scale vegetated media filtration facility designed to treat stormwater runoff from a large drainage area. Provides water quality treatment.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 5,940 SF |
| Unit Drainage Area | 17,249,760 SF |
| Ponding Depth | 8.4 in |
| Bottom Length | 84.9 ft |
| Bottom Width | 70 ft |
| Treatment Media Depth | 21.6 in |
| Treatment Media Porosity | 40% |
| Treatment Media Design Infiltration Rate | 175 in/hr |
| Total Underdrain Aggregate Depth | 18 in |
| Underdrain Invert Height | 0 in |
| Underdrain Diameter | 12 in |
| Underdrain Aggregate Porosity | 40% |
| Native Soil Design Infiltration Rate [a] | N/A |

N/A: Not Applicable

a. Liner prevents infiltration to native soil

## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural
- Forest

**Property Types:**
- Private Parcel
- Public Parcel

**Surface Types:**
- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads
- Highways

## DESIGN ASSUMPTIONS

- Design based on *Kitsap County Manchester Stormwater Retrofit Drainage Report, April 2014* (Manchester).
- Manchester design used proprietary Filterra® treatment media. Refer to Ecology's Emerging stormwater treatment technologies (TAPE) website for additional media types that are General Use Level Designation (GULD) approved for Enhanced Water Quality Treatment.
- Unit Footprint Area matches Manchester design bottom footprint area.
- Unit Drainage Area based on Manchester contributing drainage area, scaled as follows:
  - Scaled up by factor of approximately 7 based on the ratio of Ecology's currently approved GULD infiltration rate for Filterra® media for Enhanced Water Quality Treatment of 175 inches/hour to the infiltration rate of 24.8 inches/hour used for Manchester design
  - Scaled down by factor of safety of 1.3 to account for commercial and transportation areas within the Manchester contributing drainage area
- No infiltration to native soil (Manchester facility is concrete-lined).



Visit kingcounty.gov/WQBE for more information.

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# STORMWATER PARK
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Model explicitly represents ponding, underdrain flow, and overflow.

**Treatment:**
- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal [a] | 25th Percentile Effluent Concentration [a] |
|---|---|---|
| Total Copper | 51.6% | 3.1 µg/L |
| Dissolved Copper | 34.2% | 2.0 µg/L |
| Total Zinc | 56.4% | 20.1 µg/L |
| Dissolved Zinc | 53.4% | 26.0 µg/L |
| Total Phosphorus | 42.4% | 0.034 mg/L |
| Total Nitrogen | 45.8% | 0.422 mg/L |
| Total Suspended Solids | 86.4% | 2.5 mg/L |
| Total PCBs | 84.1% | 414 pg/L |
| Total PBDEs | 74.3%[b] | 0.0061 ng/L[b] |
| Total PAHs | 86.4%[b] | 0.00031 µg/L[b] |
| Bis(2-ethylhexyl)phthalate | 70.0%[b] | 0.008 µg/L[b] |
| Fecal Coliform | NF [c] | NF [c] |

NF: No data found
a. Performance based on proprietary Filterra® engineered media.
b. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.
c. Assigned a value of 0 in SUSTAIN since no data was found.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property with Acquisition | On Property without Acquisition |
|---|---|---|
| Total Project | $8,452,600 | $7,694,000 |
| Total Direct Construction | $4,021,600 | $4,021,600 |
| Total Indirect Non-Construction | $4,431,000 | $3,672,400 |
| Operation and Maintenance | $11,300/year | $11,300/year |
| Property Acquisition [c] | $583,580 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Must be designed, assembled, installed, operated and maintained according to the manufacturer's manuals, documents, and Ecology GULD approval.
- The distance from the point of entry of water to the most distant point on the surface of the treatment media shall not exceed 12-feet.
- 5-foot setback to tract/easement lines.
- 10-foot setback for buildings adjacent to stormwater facility.
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 6.7.



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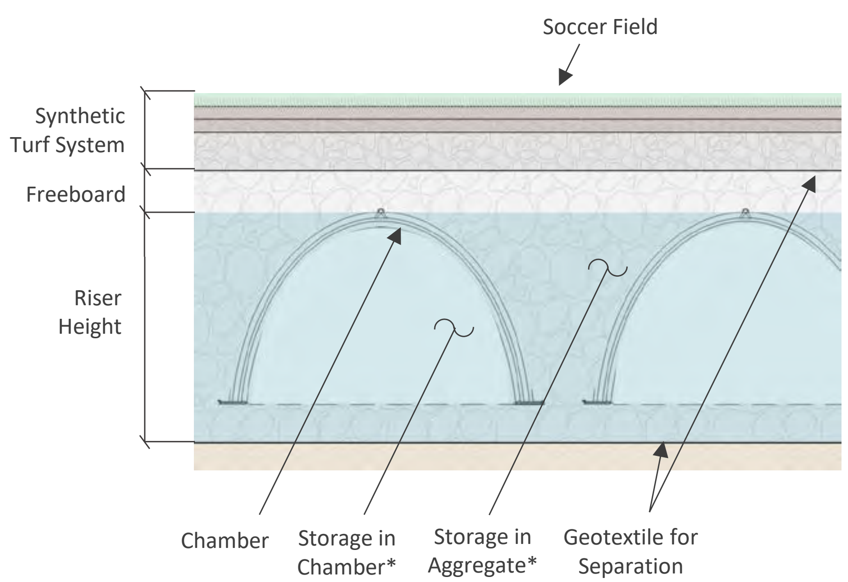
# SPORTS FIELD AND PARK DETENTION
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

Photo accessed on 10/11/23 from https://milford-global.com/

## UNIT ACTION SCHEMATIC




* Storage capacity varies by stage. Design represented in SUSTAIN using an FTABLE.

## ACTION DESCRIPTION

Subsurface storage at existing sport field or park to provide flow control while preserving recreational site use. An underground chamber array will detain the water draining from the overlying area and offsite contributing drainage area. The stored stormwater runoff is released through a control structure at an attenuated rate. Provides peak flow reduction.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area (1/2 soccer field) | 29,600 SF |
| Unit Drainage Area (incl. overlying field) | 103,800 SF |
| Chamber Height / Width | 2.5 ft / 4.25 ft |
| Chamber Row Spacing | 0.5 ft |
| Chamber Rows / Total Chamber Length | 38 / ~5,700 ft |
| Aggregate Depth Below/Above Chambers | 0.5 ft / 0.5 ft |
| Aggregate Porosity | 0.4 |
| Orifice Diameter | 0.84 in |
| Orifice Elevation | 0 ft |
| Notch Width | 0.33 in |
| Notch Height | 14.4 in |
| Riser Height | 3 ft |
| Native Soil Design Infiltration Rate [a] | N/A |

N/A: Not Applicable

a. Liner prevents infiltration to native soil

## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial
- Industrial
- Highway
- Agricultural
- Forest

**Property Types:**
- Private Parcel
- Public Parcel

**Surface Types:**
- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads
- Highways

## DESIGN ASSUMPTIONS

- Representative Action assumes an array of subsurface storage chambers under one half of a standard soccer field to detain water draining from the overlying area and offsite contributing drainage area. Implementation includes:
  - ADS StormTech Chambers (SC-740)
  - Field restoration with artificial turf and paint
  - Conveyance from upstream drainage area and to downstream drainage system
- No infiltration to underlying soil
- No additional site improvements (e.g., lighting, seating) are included
- No property acquisition
- The unit Action was sized to meet the Level 2 Flow Control standard with pre-developed forest condition. Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.

# SPORTS FIELD AND PARK DETENTION

Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**

- Stage-storage-discharge routing (FTABLE).

**Treatment:**

- Water that flows through the orifice will be assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. While not designed for treatment, there will be some pollutant removal via sedimentation (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | 26.2%[c] | 4.2 µg/L[c] |
| Dissolved Copper | 3.23%[c] | 3.0 µg/L[c] |
| Total Zinc | 44.0%[c] | 18.0 µg/L[c] |
| Dissolved Zinc | 13.6%[c] | 16.1 µg/L[c] |
| Total Phosphorus | 17.7%[c] | 0.113 mg/L[c] |
| Total Nitrogen | 7.80%[c] | 0.674 mg/L[c] |
| Total Suspended Solids | 57.6%[c] | 12.9 mg/L[c] |
| Total PCBs | 57.6%[a] | 342 pg/L[a] |
| Total PBDEs | 56.9%[b] | 93.5 ng/L[b] |
| Total PAHs | 52.1%[b] | 0.228 µg/L[b] |
| Bis(2-ethylhexyl)phthalate | 46.7%[a] | 0.042 µg/L[a] |
| Fecal Coliform | 31.5%[c] | 500 CFU/100 mL[c] |

a. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.
b. Performance based on detention vault performance which provide similar unit processes for pollutant removal.
c. Performance based on detention pond performance which provide similar unit processes for pollutant removal.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property without Acquisition |
|---|---|
| Total Project | $17,993,900 |
| Total Direct Construction | $10,224,600 |
| Total Indirect Non-Construction | $7,769,300 |
| Operation and Maintenance | $33,300 /year |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- May be difficult to find willing partners for publicly-owned parcels or willing sellers for privately-owned parcels
- Requires sufficient upstream drainage area that can be captured on site; sufficient feasible space outside of critical areas with mild slope; sufficient clearance to groundwater; and feasible downstream tie-in to drainage infrastructure. Note: design assumes relatively shallow depth of ~ 5.3 feet to mitigate some of these limitations.
- More likely to find willing partners where sports field or park requires upgrade (e.g., poor drainage, interest in artificial turf). Note: Costs assume that artificial turf will be installed (or similar improvements provided) to increase participation.
- Does not change or reduce useable field or park area
- Because this action assumes no infiltration to underlying soils, infiltration-related restrictions do not apply



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# BLUE ROOF

## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

Photo accessed on 01/22/24 from https://water.phila.gov/gsi/tools/blue-roof/

## ACTION DESCRIPTION

Rooftop detention designed to provide temporary storage and slow release of stormwater runoff. This technique is most commonly used in dense urban areas where other methods of stormwater detention are impractical. Provides peak flow reduction.

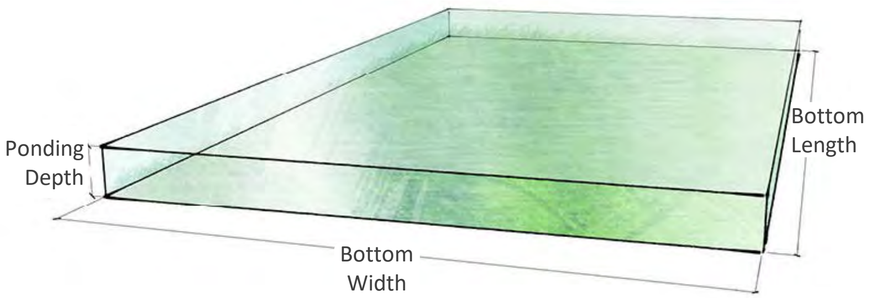
## AREAS MANAGED

**Land Uses:**
- Commercial
- Industrial

**Property Types:**
- Private Parcel
- Public Parcel

**Surface Types:**
- Roofs

## UNIT ACTION SCHEMATIC




## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 1,000 SF |
| Unit Drainage Area | 1,000 SF |
| Ponding Depth | 4 in |
| Bottom Length | 40 ft |
| Bottom Width | 25 ft |
| Orifice Diameter | 0.25 in |
| Orifice Elevation | 0 in |

## DESIGN ASSUMPTIONS

- Representative Action[a] assumes retrofitting an existing flat roof (with parapet) to provide up to 4 inches of storage. Implementation includes:
  - Waterproof lining installed
  - Roof drainage reconfigured to direct runoff from 1,000 sf to control structure at roof drain
  - HVAC/utilities on roof raised 6 inches
  - Control structure has 0.25-inch orifice and redundant overflow with protective screening (e.g., sand filter to protect orifice from clogging)
- Building does not require structural upgrades
- No property acquisition

[a] Other blue roof configurations can include check dams across the roofs deck, modular tray systems, hybrid green/blue roofs, and water harvesting for reuse.



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10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Model explicitly represents ponding, orifice flow, and overflow.

**Treatment:**
- Model will assume no treatment provided.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | -- | -- |
| Dissolved Copper | -- | -- |
| Total Zinc | -- | -- |
| Dissolved Zinc | -- | -- |
| Total Phosphorus | -- | -- |
| Total Nitrogen | -- | -- |
| Total Suspended Solids | -- | -- |
| Total PCBs | -- | -- |
| Total PBDEs | -- | -- |
| Total PAHs | -- | -- |
| Bis(2-ethylhexyl)phthalate | -- | -- |
| Fecal Coliform | -- | -- |

* Action provides negligible water quality benefit

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property without Acquisition |
|---|---|
| Total Project | $116,500 |
| Total Direct Construction | $82,300 |
| Total Indirect Non-Construction | $34,200 |
| Operation and Maintenance | $2,600/year |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Project sites will be limited to King County–owned buildings and buildings owned by willing partners/property owner partners
- Requires flat, or nearly flat, roof with parapet of at least 6 inches
- Assumes that the structure can readily support the loading of a blue roof and no structural upgrades are required
- Note: Costs assume that the roof will be waterproofed to increase uptake.



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# COMPOST AMENDMENT
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

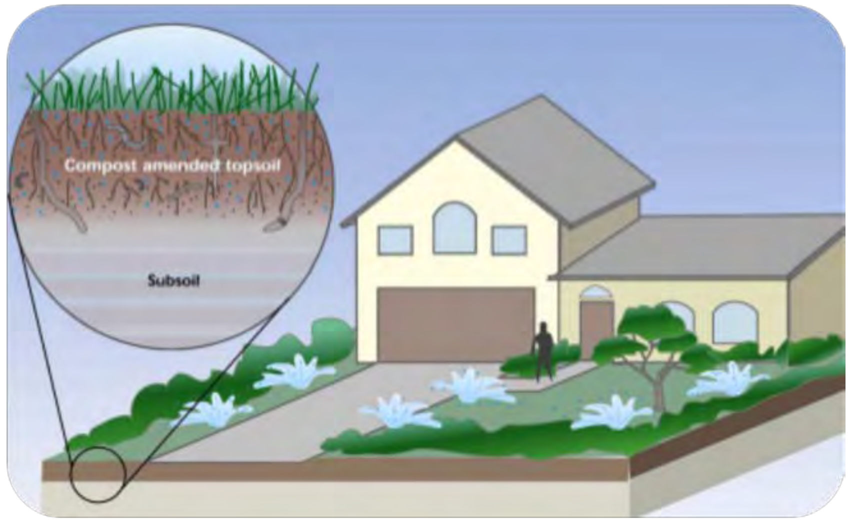


Photo accessed from Washington State Department of Ecology's "Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13"

## ACTION DESCRIPTION

Amend soil under existing lawn surfaces with compost to increase water holding capacity and infiltration. Amended area is revegetated with turf. Reduces runoff volume and peak flows.

## DESIGN PARAMETERS

| | Soil Type | |
|---|---|---|
| **Parameter** | **Till** | **Outwash** |
| Unit Footprint Area | 500 SF | 500 SF |
| Treatment Media Depth [a] | 8 in | 8 in |
| Treatment Media Porosity [a] | 25% | 25% |
| Native Soil Design Infiltration Rate | 0.3 in/hr | 2.5 in/hr |

N/A: Not Applicable

a. The Treatment Media is non-engineered and does not provide Basic Water Quality treatment. Infiltration through the Treatment Media is assumed to occur at the Native Soil Design Infiltration Rate

## AREAS MANAGED

**Land Uses:**
- Residential
- Commercial
- Industrial

**Property Types:**
- Private Parcel
- Public Parcel

**Surface Types:**
- Lawns

## DESIGN ASSUMPTIONS

- Representative Action assumes amending soil under existing lawn and revegetating with turf. implementation includes:
  - Remove lawn vegetation and scarify (loosen) subgrade to 8 inches depth
  - Place 1.75 inches of compost and rototill into 6.25 inches of soil (a total amended depth of about 9.5 inches, for a settled depth of 8 inches)
  - Scarify (loosen) subsoil 4 inches below the amended layer to produce a 12-inch depth of uncompacted soil
  - Water or roll to compact to 85% of maximum dry density
  - Rake to level and remove surface woody debris and rocks larger than 1 inch diameter
  - Revegetate with turf lawn (not seeded)
- Design is based on Washington State Department of Ecology's "Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13" Option 2 (amending existing site soil or subsoil).



Visit kingcounty.gov/WQBE for more information.

# COMPOST AMENDMENT
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**

- Convert the surface type from existing lawn to pasture (to represent the runoff characteristics of compost amended lawn as described in *2019 Washington State Department of Ecology Stormwater Management Manual for Western WA (SWMMWW)).*

**Treatment:**

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | N/A | N/A |
| Dissolved Copper | N/A | N/A |
| Total Zinc | N/A | N/A |
| Dissolved Zinc | N/A | N/A |
| Total Phosphorus | N/A | N/A |
| Total Nitrogen | N/A | N/A |
| Total Suspended Solids | N/A | N/A |
| Total PCBs | N/A | N/A |
| Total PBDEs | N/A | N/A |
| Total PAHs | N/A | N/A |
| Bis(2-ethylhexyl)phthalate | N/A | N/A |
| Fecal Coliform | N/A | N/A |

N/A: Not applicable. See model representation treatment section.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property without Acquisition |
|---|---|
| Total Project | $5,900 |
| Total Direct Construction | $4,200 |
| Total Indirect Non-Construction | $1,700 |
| Operation and Maintenance | $300/year |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Project sites will be limited to King County–owned land and sites owned by willing property owners
- Few other technical constraints apply (e.g., soil contamination may prohibit, very steep slopes may be infeasible)
- Does not change or reduce lawn area (expect for establishment period)



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# REFOREST HIGH DENSITY DEVELOPMENT
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

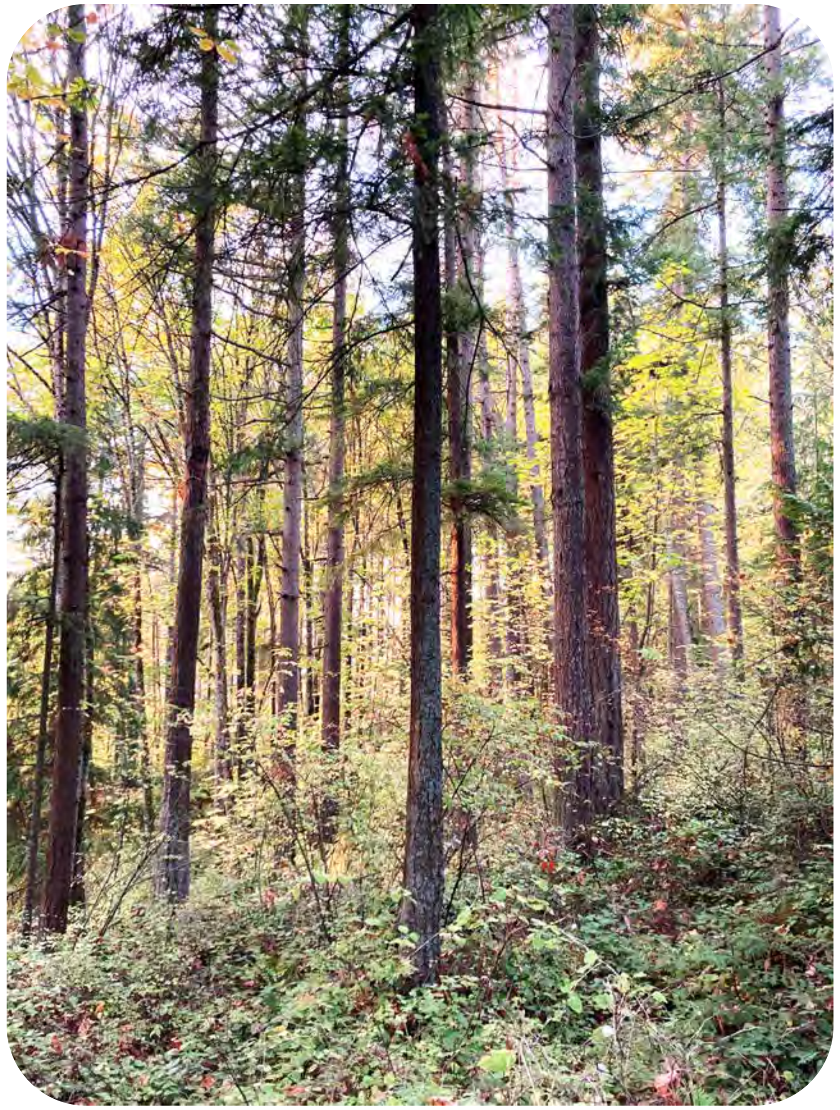

Photo courtesy of Herrera

## ACTION DESCRIPTION

Convert existing impervious surface and buildings to forest by uncompacting/ amending soil and planting trees and understory vegetation. While the benefits of this Action would increase over time as the trees and vegetation become established, the performance is represented as a mature forest. Reduces runoff volume and peak flows.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 43,560 SF |
| Existing Surface [a] | Impervious |
| New Surface [a] | Forest |

a. This Action will be modeled in SUSTAIN by converting the reforested area from an impervious to forested surface.

## AREAS MANAGED

**Land Uses:**
- Commercial
- Industrial

**Property Types:**
- Private Parcel
- Public Parcel

**Surface Types:**
- Parking lots
- Walkways
- Driveways
- Buildings
- Lawn

## DESIGN ASSUMPTIONS

- Representative Action assumes replacing a typical strip mall building and parking lot with forest. Implementation includes:
    - Property acquisition, if on private property
    - Demolish/remove structure and parking lot surface
    - Scarify subsoil to 6” depth and place 18 inches of topsoil type A
    - Plant multi-layer native plant communities and trees
    - Build simple trail through forested area and install signage
    - Maintain plants during 2-year plant establishment period
- Assumes one acre parcel coverage is 60% parking and 40% structure
- Benefits of mature forest are modeled



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10/1/2024

## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Convert the land surface type from existing impervious surfaces (building and parking lot) to forest over underlying soil type (till or outwash). Action is modeled as a mature forest.

**Treatment:**
- While no treatment is provided, pollutant loads will be reduced due to the differences in pollutant concentrations and runoff volumes from the change in surface type.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | N/A | N/A |
| Dissolved Copper | N/A | N/A |
| Total Zinc | N/A | N/A |
| Dissolved Zinc | N/A | N/A |
| Total Phosphorus | N/A | N/A |
| Total Nitrogen | N/A | N/A |
| Total Suspended Solids | N/A | N/A |
| Total PCBs | N/A | N/A |
| Total PBDEs | N/A | N/A |
| Total PAHs | N/A | N/A |
| Bis(2-ethylhexyl)phthalate | N/A | N/A |
| Fecal Coliform | N/A | N/A |

N/A: Not applicable. See model representation treatment section.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property with Acquisition | On Property without Acquisition |
|---|---|---|
| Total Project | $24,045,100 | $19,490,500 |
| Total Direct Construction | $11,075,000 | $11,075,000 |
| Total Indirect Non-Construction | $12,970,100 | $8,415,500 |
| Operation and Maintenance | $3,300/year | $3,300/year |
| Property Acquisition [c] | $3,503,531 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- May be difficult to find willing partners for publicly-owned parcels (with unprogrammed space that can be forested) or willing sellers for privately-owned parcels
- Other technical constraints include soil contamination may prohibit and very steep slopes may be infeasible.

# REFOREST PERVIOUS AREA

## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

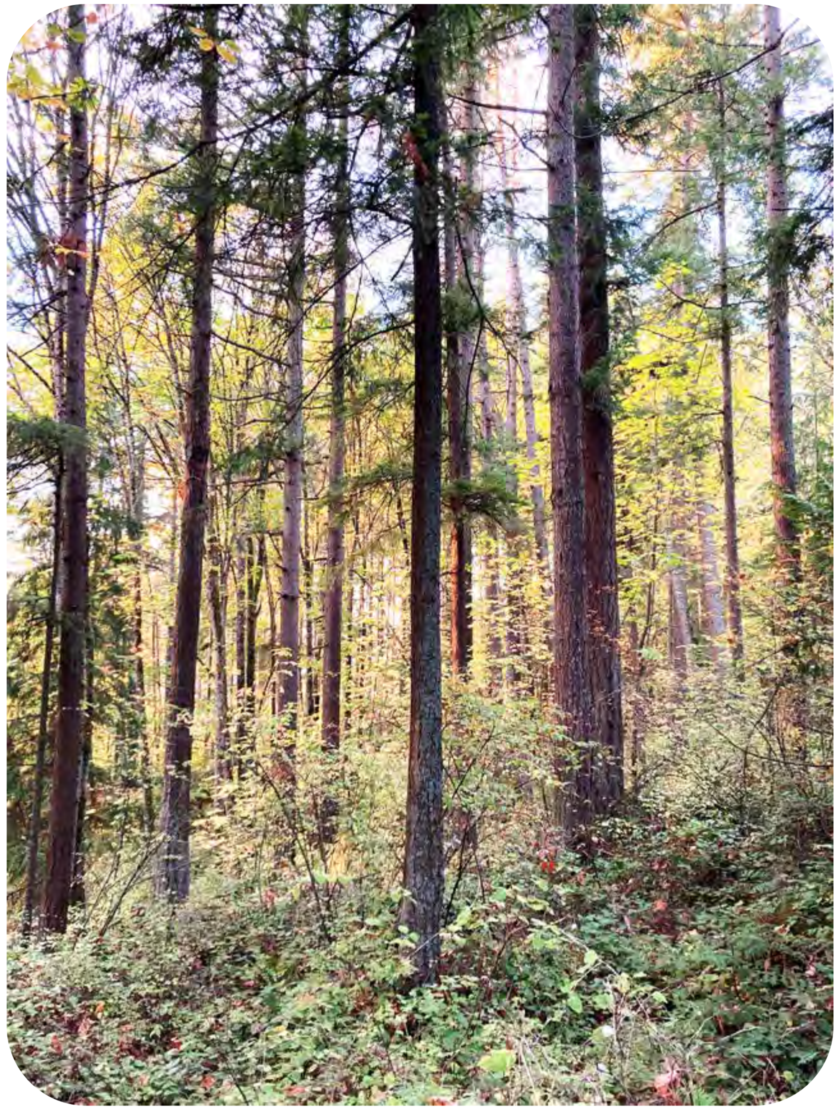

Photo courtesy of Herrera

## ACTION DESCRIPTION

Convert existing pervious surface to forest by uncompacting/ amending soil and planting trees and understory vegetation. While the benefits of this Action would increase over time as the trees and vegetation become established, the performance is represented as a mature forest. Reduces runoff volume and peak flows.

## DESIGN PARAMETERS

| Parameter | Value |
|---|---|
| Unit Footprint Area | 43,560 SF |
| Existing Surface [a] | Pervious |
| New Surface [a] | Forest |

a. This Action will be modeled in SUSTAIN by converting the reforested area from a pervious to forested surface.

## AREAS MANAGED

**Land Uses:**
- Residential

**Property Types:**
- Private Parcel

**Surface Types:**
- Lawn

## DESIGN ASSUMPTIONS

- Representative Action assumes replacing a pervious area with forest. Implementation includes:
  - ½ of the area will require scarification and topsoil application. Scarify subsoil to 6” depth and place 12 inches of topsoil type A.
  - Plant multi-layer native plant communities and trees
  - Maintain plants during 1-year plant establishment period
- Benefits of mature forest are modeled



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# REFOREST PERVIOUS AREA
## Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

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## SUSTAIN MODEL REPRESENTATION

**Hydrologic:**
- Convert the land surface type from existing pervious surfaces to forest over underlying soil type (till or outwash). Action is modeled as a mature forest.

**Treatment:**
- While no treatment is provided, pollutant loads will be reduced due to the differences in pollutant concentrations and runoff volumes from the change in surface type.

## TREATMENT PERFORMANCE PARAMETERS

| Target Pollutants | Median Percent Removal | 25th Percentile Effluent Concentration |
|---|---|---|
| Total Copper | N/A | N/A |
| Dissolved Copper | N/A | N/A |
| Total Zinc | N/A | N/A |
| Dissolved Zinc | N/A | N/A |
| Total Phosphorus | N/A | N/A |
| Total Nitrogen | N/A | N/A |
| Total Suspended Solids | N/A | N/A |
| Total PCBs | N/A | N/A |
| Total PBDEs | N/A | N/A |
| Total PAHs | N/A | N/A |
| Bis(2-ethylhexyl)phthalate | N/A | N/A |
| Fecal Coliform | N/A | N/A |

N/A: Not applicable. See model representation treatment section.

## UNIT ACTION COSTS

| Costs/Unit Action [a, b] | On Property with Acquisition | On Property without Acquisition |
|---|---|---|
| Total Project | $6,302,000 | $1,747,400 |
| Total Direct Construction | $992,900 | $992,900 |
| Total Indirect Non-Construction | $5,309,100 | $754,500 |
| Operation and Maintenance | $0/year | $0/year |
| Property Acquisition [c] | $3,503,531 | $0 |

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

## PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Project sites will be limited to those owned by willing property owners.
- Other technical constraints include soil contamination may prohibit and very steep slopes may be infeasible.



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# Appendix H

## Phase 3 Program Fact Sheets

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# GSI INCENTIVE FLOW CONTROL PROGRAM

## Water Quality Benefits Evaluation Program Fact Sheet

10/1/2024

## PROGRAM OVERVIEW

The GSI Incentive Flow Control Program would provide incentives for property owners to install small scale green stormwater infrastructure (GSI) practices to help manage the rain that falls on their roofs and other impervious surfaces, such as parking lots and driveways. The Program would provide grants, rebates, or other financial incentives to eligible property owners for installing and maintaining GSI on their properties.

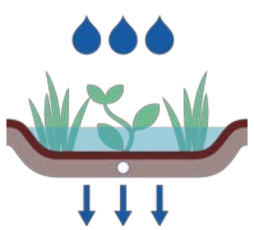
The objective of the Program would be to provide flow control for stormwater runoff in separated drainage basins to more closely mimic predeveloped hydrology for receiving waterbodies in Puget Sound Nearshore, Elliott Bay, Green/Duwamish, Lake Union/Ship Canal, and Lake Washington basins. The Program could be adapted for combined drainage basins with the objective to reduce combined sewer overflows.

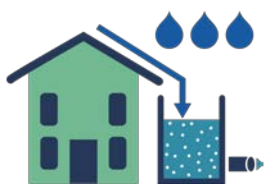
The Program could include the GSI practices ("Actions") listed below. The most cost-effective combinations of Actions for this Program could be identified using the SUSTAIN model. Modeling inputs for the Actions, including design, performance, and cost assumptions, are provided in companion Action Fact Sheets.

The following pages include key assumptions and an overview the Program. See 439-TM1 Appendix F for more detailed information regarding the methods used.

## ACTIONS INCLUDED IN PROGRAM

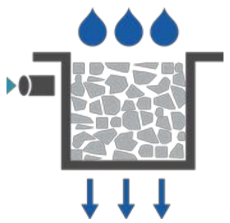

RAIN GARDEN

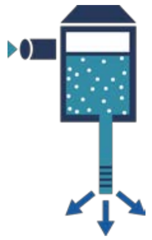

BIORETENTION *

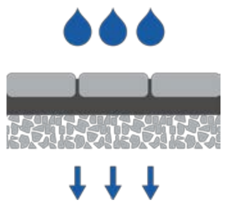

CISTERN


DEPAVING


COMPOST AMENDMENT


DRYWELL **


DEEP UIC WELL ***


PERMEABLE PAVEMENT

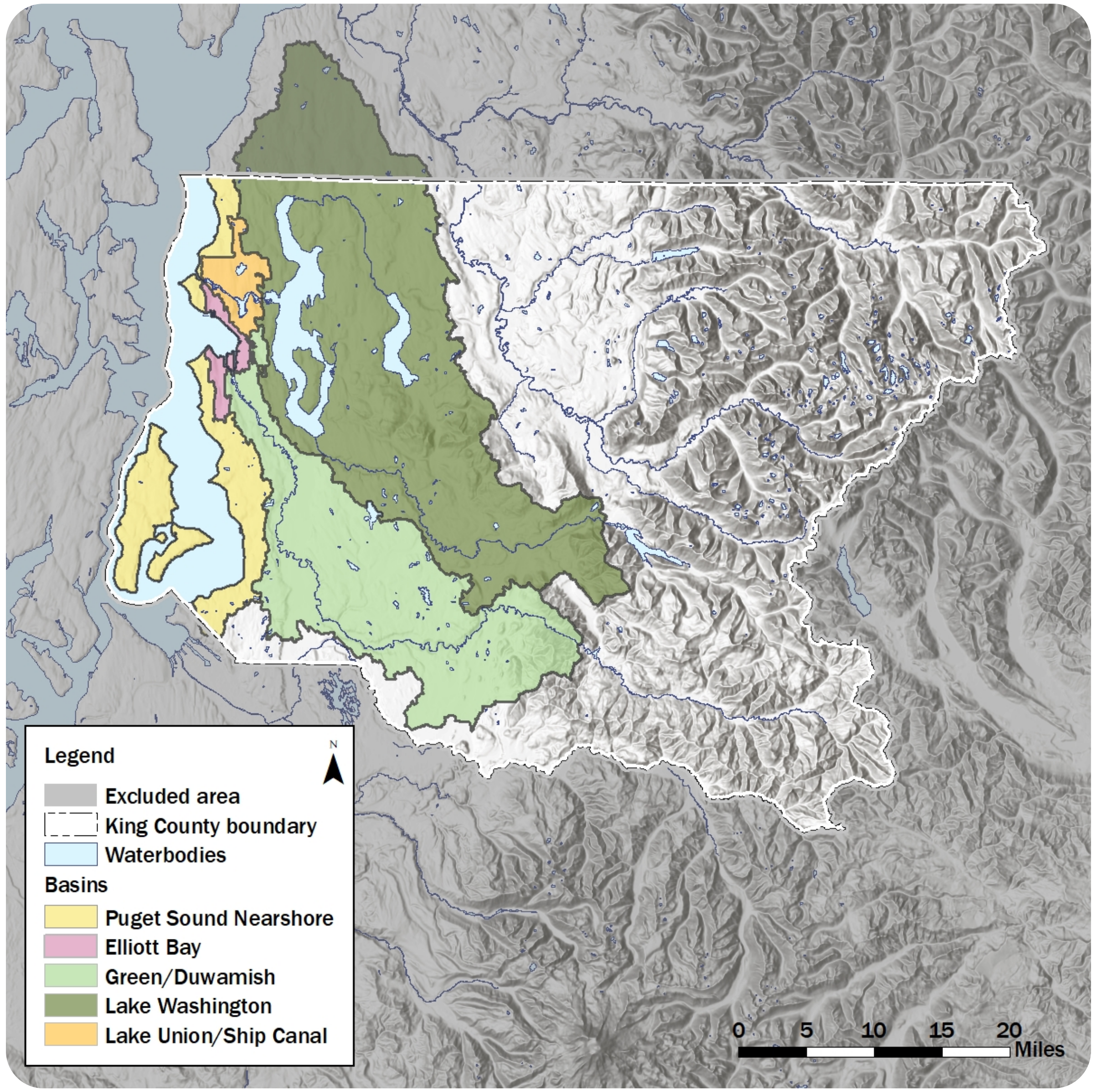

BLUE ROOF

* Not including bioretention facilities with underdrains on till soil due to minimal flow control benefits

** Paired with upstream bioretention planter for pre-treatment

*** Paired with upstream high-rate filter for pre-treatment

## PROGRAM IMPLEMENTATION AREA




## PROGRAM APPLICABILITY

- Basins in implementation area (see map above)
- Unincorporated King County and cities
- Separated drainage basins
- Residential, commercial, industrial land uses
- Private and public parcels



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# GSI INCENTIVE FLOW CONTROL PROGRAM

## Water Quality Benefits Evaluation Program Fact Sheet

Phase 3

## SUSTAIN MODELING APPROACH

10/1/2024

**Runoff routing:**
This diagram shows how stormwater runoff is routed through GSI Actions in the SUSTAIN model. The arrows characterize the routing of runoff from each land use and surface type to the Actions or Action treatment trains. The compost amendment and depave Actions are represented in the model by converting the modeled surface type. Some Actions are only applied to certain soil and slope conditions (see the Implementation Constraints Table on page 3). Overflow from the Actions and unmanaged runoff is routed to the catchment outlet. SUSTAIN provides an assessment of the most cost-effective combination of Actions within a treatment train to achieve different levels of flow control.

**SUSTAIN Program optimization:**
SUSTAIN could be used to evaluate and optimize the most cost-effective Actions for this Program.

- For performance, Actions can be optimized for runoff volume reduction on days in the timeseries where runoff exceeds a threshold that represents an unnatural hydrograph. The associated pollutant load reduction provided by the optimized Actions can be estimated.
- For costs, optimization can be based on Action lifecycle costs. Program development and implementation costs can be scaled and applied to modeling results.
- SUSTAIN models these Actions as a lumped representation at the bottom of each catchment. The cost-effective Actions identified by SUSTAIN are assumed to be distributed throughout the defined drainage area.

LEGEND

HIGHWAY Land use

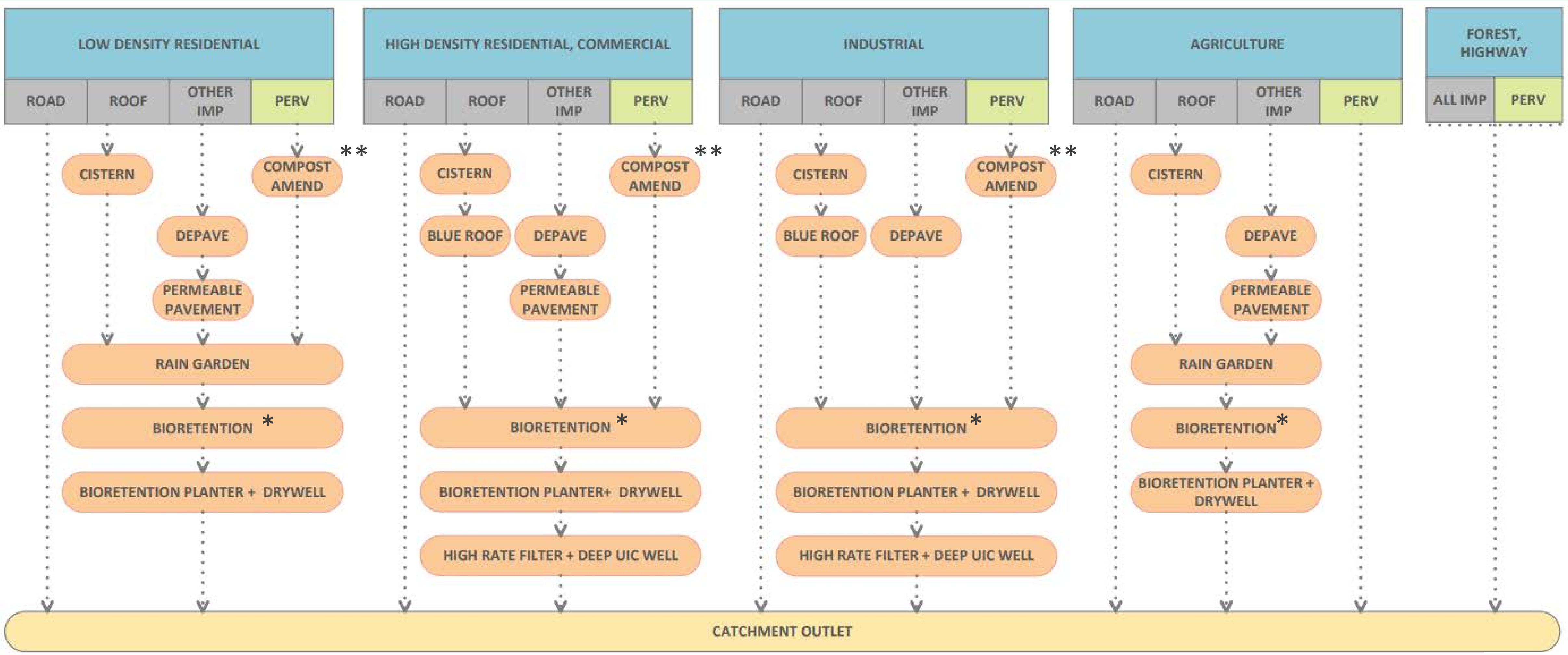
Impervious surface

Pervious surface

BIORETENTION Action

SUSTAIN will select best option in box

Runoff routing




* Not including bioretention facilities with underdrains on till soil due to minimal flow control benefits

** Compost amendment is only applied for lawn surfaces



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# GSI INCENTIVE FLOW CONTROL PROGRAM
## Water Quality Benefits Evaluation Program Fact Sheet

Phase 3

10/1/2024

## PROGRAM DESCRIPTION/ASSUMPTIONS

**Program description:**

- The GSI Flow Control Incentive Program would provide financial incentives in the form of rebates, grants, or other forms of funding to property owners to install GSI practices (Actions) to provide flow control for currently unmanaged stormwater runoff from roofs and other impervious surfaces, such as parking lots and driveways.
- The Program would be applicable to private parcels in residential, commercial, and industrial, agricultural areas with separated drainage systems. Eligible areas would include unincorporated King County and cities in the implementation area. GSI Actions would be implemented across the eligible areas based on the assumed technical and participation factors shown in the table to the right.
- The Program would be administered by King County in partnership with other jurisdictions and nongovernmental agencies.
- Program elements would include:
    - Public outreach
    - Website with eligibility maps, design tools, and incentive calculator
    - Application processing and site/construction inspection
    - Contractor recruitment/trainings
    - Annual inspections and maintenance
- Modeling will determine full costs of design, construction, maintenance and replacement. A separate evaluation will determine rebates/grants for incentivizing participation. Costs of Program development and administration, would be borne by the County, or potentially shared with other partners.

**Key assumptions:**

- Factors influencing technical feasibility and participation are based on professional judgement and assumed to be the same across all eligible areas.
- Because this is a retrofit Program, Action sizing is not based on redevelopment requirements (i.e., contributing drainage area to each unit Action is not constrained).

**Key risks and challenges:**

- Relies, in part, on cooperation between King County and partners
- Relies on interested property owners
- Requires alignment with varied local codes
- Requires development of qualified contractor base
- Requires ongoing maintenance efforts and costs

## PROGRAM IMPLEMENTATION CONSTRAINTS

Max Drainage Area = Total Implementation Area (reduced by infeasible areas) x "Technical Factor" x "Participation Factor"
= Total Implementation Area (reduced by infeasible areas) x "Composite Factor"

| GSI Action | Infeasible Areas [1] | Technical Factor [2] | | | | | | | | Participation Factor [3] | Composite Factor (Technical x Participation) [4] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Low Density Residential | | | High Density Residential, Commercial, and Industrial | | | Agricultural | | | |
| | | Roof | Other Imp | Perv | Roof | Other Imp | Perv | Roof | Other Imp | | |
| Rain garden on till | Outwash soil, slopes > 10% | 30% | 30% | 30% | | | | 30% | 30% | 20% | 6.0% |
| Rain garden on outwash | Till soil, slopes > 10% | 50% | 50% | 50% | | | | 50% | 50% | 20% | 10.0% |
| Bioretention on outwash | Till soil, slopes > 10% | 50% | 50% | 50% | 40% | 40% | 40% | 50% | 50% | 20% | 8.0% - 10.0% |
| Cisterns | -- | 50% | | | 50% | | | 50% | | 25% | 12.5% |
| Bioretention planter to drywell | Till soil | 30% | 30% | 30% | 30% | 30% | 30% | 30% | 30% | 15% | 4.5% |
| High rate filter to deep UIC well | Outwash soil, gw protection areas | | | | 20% | 20% | 20% | | | 5% | 1.0% |
| Depaving | -- | | 20% | | | 10% | | | 20% | 5% | 0.5% - 1.0% |
| Permeable pavement | Slopes > 3% | | 30% | | | 30%[5] | | | 10% | 2% | 0.2% - 0.6% |
| Blue roof | | | | | 20% | | | | | 2% | 0.4% |
| Compost amendment | | | | 80% | | | 80% | | | 30% | 24% |

1. "Infeasible Areas" are areas where the Action will not be applied.
2. "Technical Factor" represents the estimated fraction of the implementation area that could feasibly be managed based on technical considerations like space constraints, utility conflicts, existing runoff patterns, and site uses.
3. "Participation Factor" represents the anticipated participation in the Program.
4. "Composite Factor" is the combined factor applied to estimate the maximum drainage area.
5. Not applied to industrial land use.

LEGEND

| | |
|---|---|
| Action not applied | |
| High Implementation | ≥30% |
| Medium Implementation | 15 to <30% |
| Low Implementation | ≤15% |

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10/1/2024

## PROGRAM COSTS

Program costs include:

- Lifecycle costs for Actions sited on private property (see table below).
- Upfront Program development costs (develop website, standards, requirements)
- Average annual Program administration costs (outreach, application processing, construction inspections, maintenance education, annual inspections)

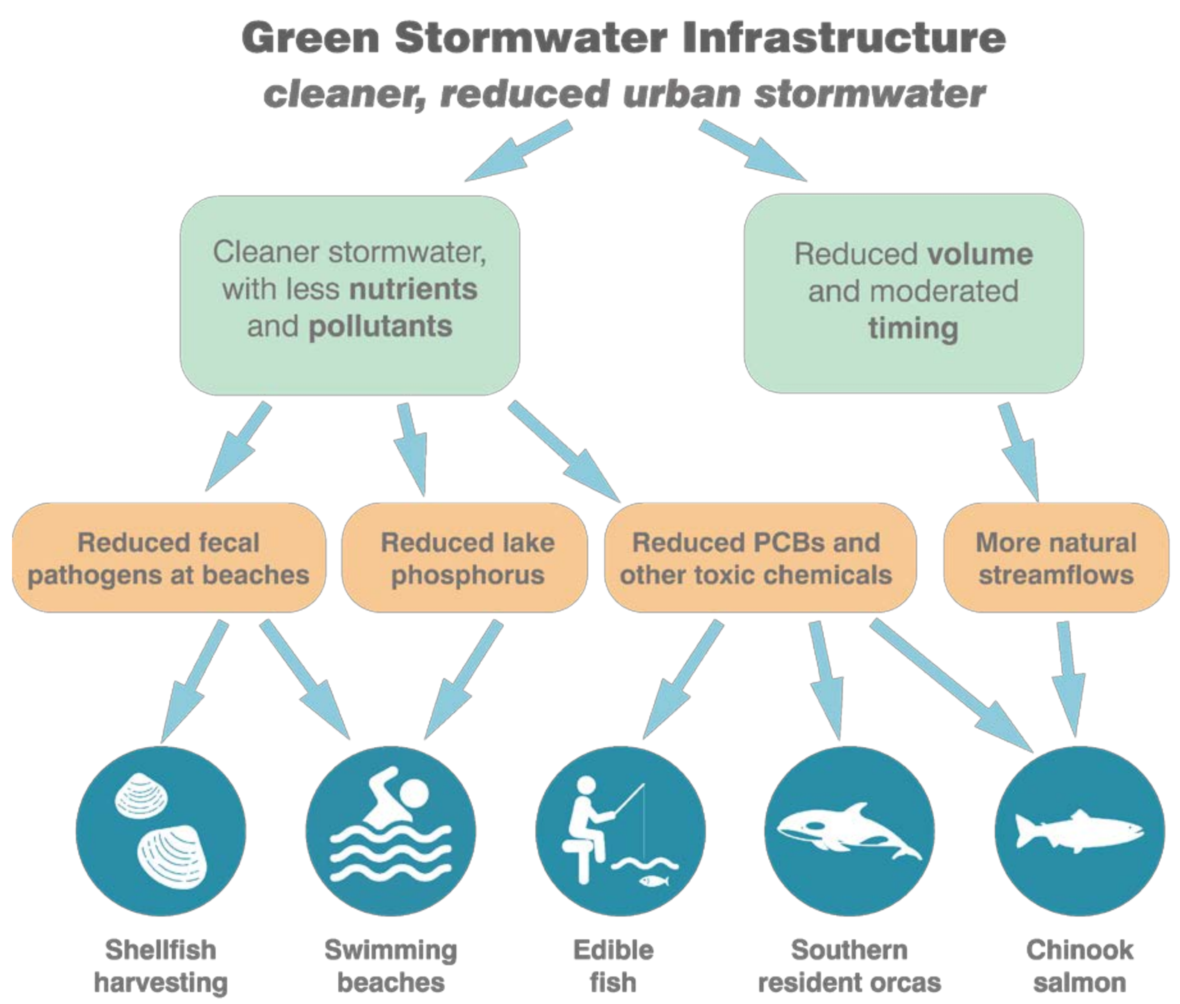
Program development and administration costs are not included in the table and can be applied separately. See 439-TM1 Appendix I for examples.

| Unit Action | Lifecycle Cost/Unit Action[1,2,3] |
|---|---|
| Rain garden | $56,700 |
| Bioretention without underdrain | $117,900 |
| Cisterns | $46,100 |
| Bioretention planter to drywell | $76,000 |
| High-rate filter to deep UIC well | $250,000 |
| Depaving[4] | $16,800 |
| Permeable pavement[5] | $68,400 |
| Blue roof | $170,900 |
| Compost amendment | $13,400 |

1. All costs are per unit of Action installed on private property without property acquisition.
2. Costs are presented in 2023 dollars. Life-cycle include initial capital, operations and maintenance, and capital replacement costs over a 30-year life-cycle.
3. Annual O&M costs are included in the life-cycle costs with periodic replacements. For details on the total project costs and O&M cost development, see 439-TM1 Appendix E.
4. Costs based on driveway depaving with wheel strips
5. Costs based on permeable paver driveway with sand layer.

## LINKAGES TO CAUSAL MODELS

The GSI Incentive Flow Control Program could be evaluated using causal models to assess benefits to a suite of human and ecological health endpoints. The graphic below illustrates the types of factors that might be influenced by a Program and how changes in those factors might improve outcomes for shellfish harvest, swimming beaches, edible fish, Chinook salmon, and Southern Resident orcas. Causal model inputs for the evaluation would be based on the factors shown here. A detailed list of potential causal model inputs are included as an appendix to technical memorandum #420-TM1.



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# ROADWAY RETROFIT FLOW CONTROL PROGRAM
## Water Quality Benefits Evaluation Program Fact Sheet

Phase 3

10/1/2024

## PROGRAM OVERVIEW

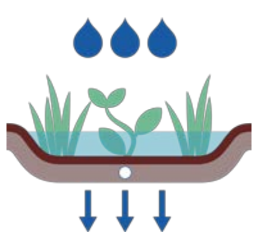
The Roadway Stormwater Flow Control Program would fund, plan, and implement capital improvement projects to construct flow control practices to manage runoff from roads and highways in King County. The Program would be administered by King County in partnership with Washington State Department of Transportation (WSDOT), other jurisdictions and nongovernmental agencies.

The objective of the Program would be to provide flow control for roadway stormwater runoff in separated drainage basins to more closely mimic predeveloped hydrology for receiving waterbodies in the Puget Sound Nearshore, Elliott Bay, Green/Duwamish, Lake Union/Ship Canal, and Lake Washington basins. The Program could be adapted for combined drainage basins with the objective to reduce combined sewer overflows.

The Program could include the flow control practices ("Actions") listed below. The most cost-effective combinations of Actions for this Program could be identified using the SUSTAIN model. Modeling inputs for the Actions, including design, performance, and cost assumptions, are provided in companion Action Fact Sheets.

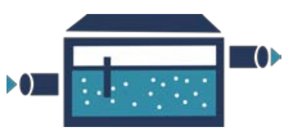
The following pages include key assumptions and an overview of the Program. See 439-TM1 Appendix F for more detailed information regarding the methods used.

## ACTIONS INCLUDED IN PROGRAM

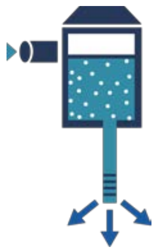


BIORETENTION *

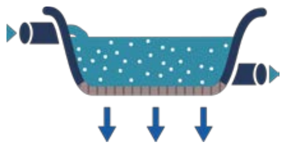
DETENTION POND



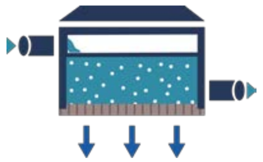
DETENTION VAULT



DEEP UIC WELL **



INFILTRATION POND **

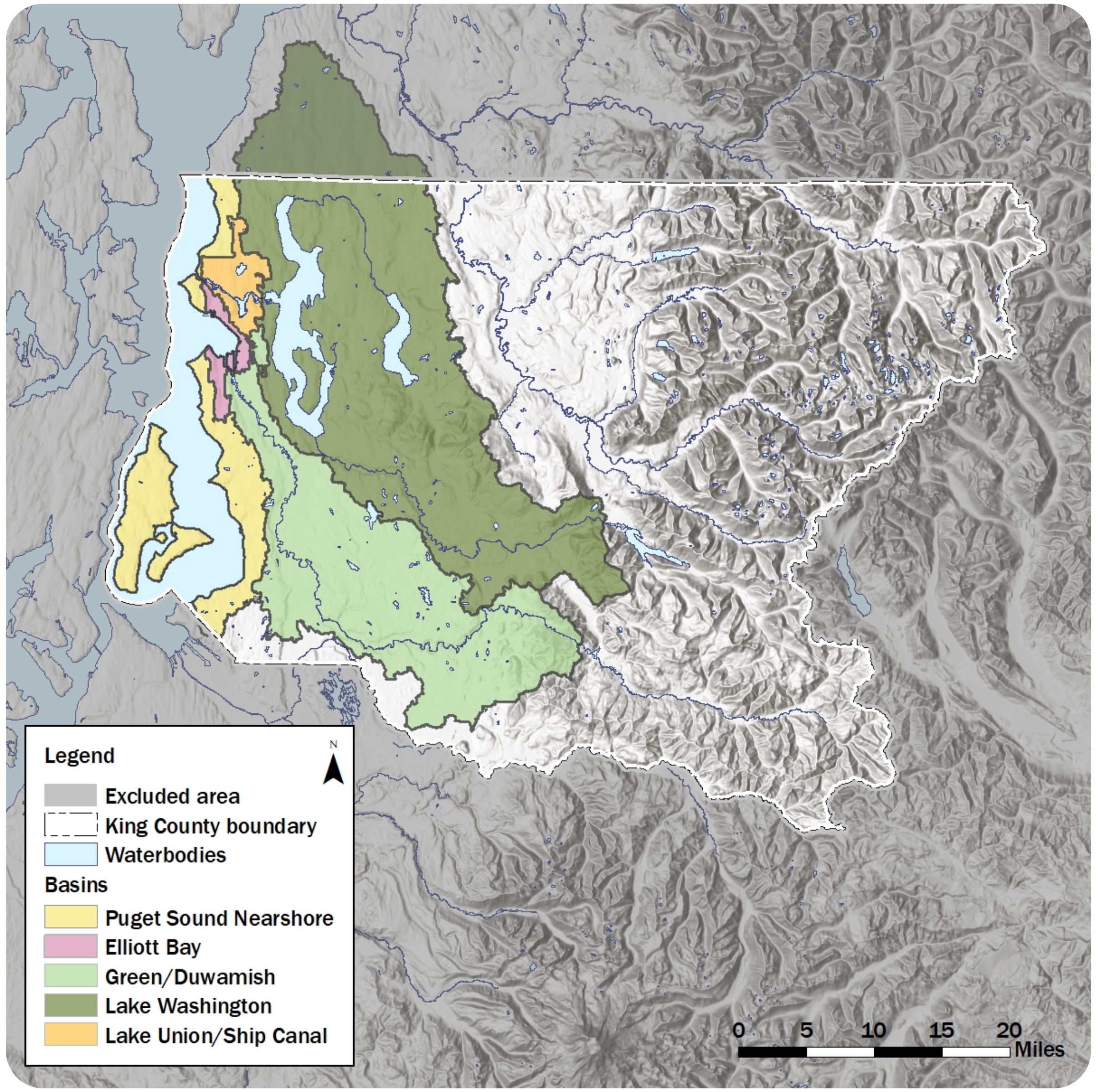


INFILTRATION VAULT **

* Not including bioretention facilities with underdrains on till soil due to minimal flow control benefits

** Paired with upstream high-rate filter for pre-treatment

## PROGRAM IMPLEMENTATION AREA




## PROGRAM APPLICABILITY

- Basins in implementation area (see map above)
- Unincorporated King County and cities
- Separated drainage basins
- Residential, commercial, industrial, agricultural, highway land uses
- Public right-of-way (local roads, arterial/collector roads, and highways)



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# ROADWAY RETROFIT FLOW CONTROL PROGRAM

## Water Quality Benefits Evaluation Program Fact Sheet

Phase 3

10/1/2024

## SUSTAIN MODELING APPROACH

**Runoff routing:**

This diagram shows how stormwater runoff is routed through flow control Actions in the SUSTAIN model. The arrows characterize the routing of runoff from each land use and surface type to the Actions or Action treatment trains. Some Actions are only applied to certain soil and slope conditions (see the Implementation Constraints Table on page 3). Overflow from the Actions and unmanaged runoff is routed to the catchment outlet. SUSTAIN provides an assessment of the most cost-effective combination of Actions within a treatment train to achieve different levels of flow control.

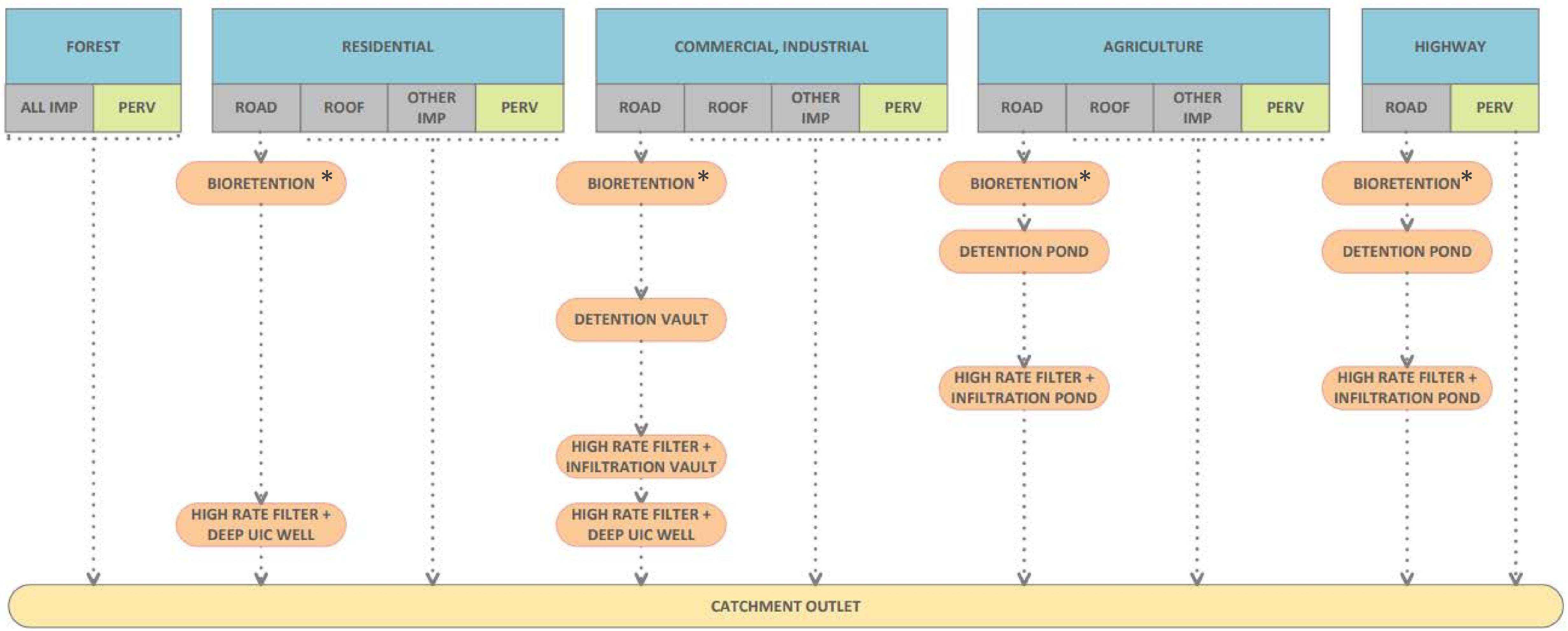
**SUSTAIN Program optimization:**

SUSTAIN could be used to evaluate and optimize the most cost-effective Actions for this Program.

- For performance, Actions can be optimized for runoff volume reduction on days in the timeseries where runoff exceeds a threshold that represents an unnatural hydrograph. The associated pollutant load reduction provided by the optimized Actions can be estimated.
- For costs, optimization can be based on Action lifecycle costs. Program development and implementation costs can be scaled and applied to modeling results.
- SUSTAIN models these Actions as a lumped representation at the bottom of each catchment. The cost-effective Actions identified by SUSTAIN are assumed to be distributed throughout the catchment.

LEGEND

| | |
|---|---|
| HIGHWAY | Land use |
| | Impervious surface |
| | Pervious surface |
| BIORETENTION | Action |
| | SUSTAIN will select best option in box |
| ······> | Runoff routing |




* Not including bioretention facilities with underdrains on till soil due to minimal flow control benefits

10/1/2024

## PROGRAM DESCRIPTION/ASSUMPTIONS

**Program description:**

- The Roadway Stormwater Flow Control Program would fund, plan, and implement capital improvement projects to construct Actions to provide flow control for currently unmanaged stormwater runoff from roads and highways in King County.
- The Program would be applicable to highways, and local, collector, and arterial roads in residential, commercial and agricultural areas with separated drainage systems. Eligible areas would include unincorporated King County and cities in the implementation area.
- Actions would be implemented across the eligible areas based on the assumed technical and participation factors shown in the table to the right.
- The Program would be administered by King County in partnership with Washington State Department of Transportation (WSDOT), other jurisdictions and nongovernmental agencies.
- Program elements would include:
    - Outreach to WSDOT, other jurisdictions and nongovernmental agencies
    - Interagency agreements for implementation and maintenance
    - County-wide planning effort to identify and prioritize best retrofit opportunities
    - Capital improvement project planning, design, and construction
    - Ongoing project inspections and maintenance
- King County would be responsible for the cost of Action design and construction, as well as the costs of Program development and administration.
- Long-term Action maintenance and replacement costs would be borne by the site jurisdiction (King County, city or state).

**Key assumptions:**

- Factors influencing technical feasibility and participation are based on professional judgement and assumed to be the same across all eligible areas.
- Actions would be sited in County or partner agency right of way and property acquisition would not be required.
- Because this is a retrofit Program, Action sizing is not based on redevelopment requirements (i.e., contributing drainage area to each unit Action is not constrained).

**Key risks and challenges:**

- Relies, in part, on cooperation between King County and other entities to agree on project priorities, locations, details, funding, and implementation strategies
- Requires ongoing maintenance efforts and costs, which would be borne, at least in part, by the County

## PROGRAM IMPLEMENTATION CONSTRAINTS

Max Drainage Area = Total Implementation Area (reduced by infeasible areas) x "Technical Factor" x "Participation Factor"
= Total Implementation Area (reduced by infeasible areas) x "Composite Factor"

| Flow Control Action | Infeasible Areas[1] | Technical Factor[2] | | | | | Participation Factor[3] | Composite Factor (Technical x Participation)[4] |
|---|---|---|---|---|---|---|---|---|
| | | Residential, Commercial, Industrial | | | Agriculture | Highway | | |
| | | Local Road in City | Local Road Outside City | Arterial | All Roads | Highway | | |
| Bioretention on outwash | Till soil, slopes > 10% | 30% | 40% | 30% | 40% | 40% | 30% | 9% - 12% |
| Detention pond | | | | | 20% | 5% | 30% | 2% - 6% |
| Detention vault[5] | | 40% | 40% | 40% | | | 30% | 12% |
| High-rate filter to infiltration vault[5] | Till soil | 30% | 30% | 30% | | | 30% | 9% |
| High-rate filter to infiltration pond | Till soil | | | | 20% | 5% | 30% | 2% - 6% |
| High-rate filter to deep UIC well | Outwash soil, gw protection areas | 10% | 10% | 10% | | | 20% | 2% |

1. "Infeasible Areas" are areas where the Action will not be applied.
2. "Technical Factor" represents the estimated fraction of the implementation area that could feasibly be managed based on technical considerations like space constraints, utility conflicts, existing runoff patterns, and site uses.
3. "Participation Factor" represents the anticipated participation in the Program.
4. "Composite Factor" is the combined factor applied to estimate the maximum drainage area.
5. Action not applied for residential land use.

LEGEND

| | |
|---|---|
| Action not applied | |
| High Implementation | ≥30% |
| Medium Implementation | 15 to <30% |
| Low Implementation | ≤15% |



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10/1/2024

## PROGRAM COSTS

Program costs include:
- Lifecycle costs for Actions sited in the public right of way (see table below). While lifecycle costs include maintenance, some maintenance costs could be borne by partnering jurisdictions, nongovernmental agencies and WSDOT.
- Upfront Program development costs (outreach, interagency agreements, planning study)
- Average annual Program administration costs (partner coordination, project oversight, maintenance)

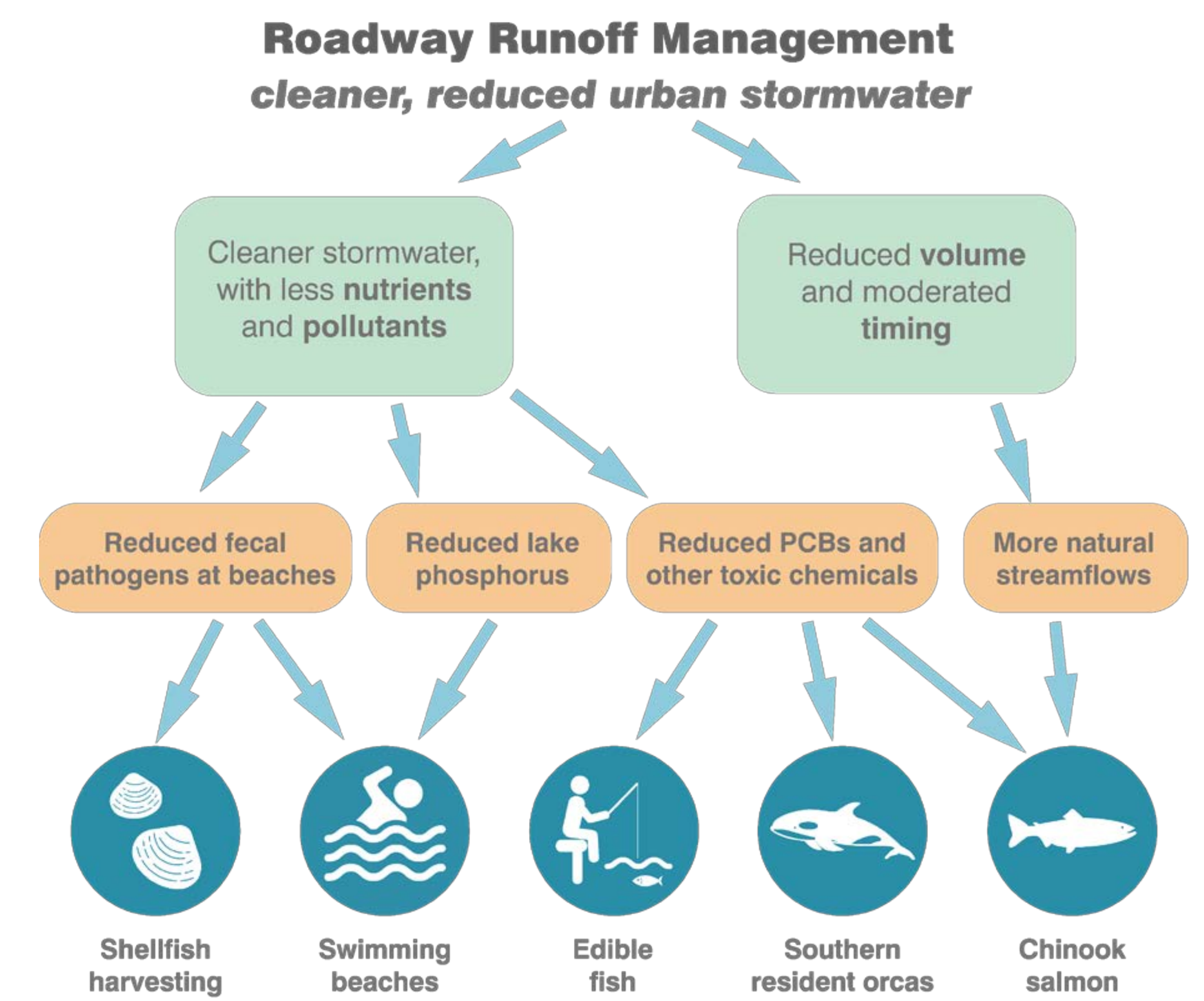
Program development and administration costs are not included in the table and can be applied separately. See 439-TM1 Appendix I for examples.

| Unit Action | Lifecycle Cost/Unit Action[1,2,3] |
|---|---|
| Bioretention without underdrain (outwash, in right-of-way/highway) | $161,400 |
| Detention pond (in right of way/highway) | $1,444,200 |
| Detention vault (in right of way) | $6,432,100 |
| High-rate filter to infiltration pond (outwash, in right of way/highway) | $1,082,700 |
| High-rate filter to infiltration vault (outwash, in right of way) | $3,992,400 |
| High-rate filter to deep UIC well (till, in right of way) | $274,000 |

1. All costs are per unit of Action. Costs do not include property acquisition.
2. Costs are presented in 2023 dollars. Life-cycle include initial capital, operations and maintenance, and capital replacement costs over a 30-year life-cycle.
3. Annual O&M costs are included in the life-cycle costs with periodic replacements. For details on the total project costs and O&M cost development, see 439-TM1 Appendix E.

## LINKAGES TO CAUSAL MODELS

The Roadway Retrofit Flow Control Program could be evaluated using causal models to assess benefits to a suite of human and ecological health endpoints. The graphic below illustrates the types of factors that might be influenced by a Program and how changes in those factors might improve outcomes for shellfish harvest, swimming beaches, edible fish, Chinook salmon, and Southern Resident orcas. Causal model inputs for the evaluation would be based on the factors shown here. A detailed list of potential causal model inputs are included as an appendix to technical memorandum #420-TM1.



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# REGIONAL FACILITY FLOW CONTROL PROGRAM
## Water Quality Benefits Evaluation Program Fact Sheet

Phase 3

10/1/2024

## PROGRAM OVERVIEW

The Regional Stormwater Flow Control Program would fund, plan, and implement capital improvement projects to construct regional stormwater flow control facilities to manage runoff from large subbasins. The Program would be administered by King County in partnership with other jurisdictions and nongovernmental agencies.

The objective of the Program would be to provide flow control for stormwater runoff in separated drainage basins to more closely mimic predeveloped hydrology for receiving waterbodies in the Puget Sound Nearshore, Elliott Bay, Green/Duwamish, Lake Union/Ship Canal, and Lake Washington basins. The Program could be adapted for combined drainage basins with the objective to reduce combined sewer overflows.

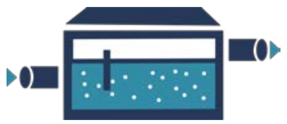
The Program could include the flow control practices ("Actions") listed below on publicly- and privately owned parcels. The most cost-effective combinations of Actions for this Program could be identified using the SUSTAIN model. Modeling inputs for the Actions, including design, performance, and cost assumptions, are provided in companion Action Fact Sheets.

The following pages include key assumptions and an overview of the Program. See 439-TM1 Appendix Ffor more detailed information regarding the methods used.

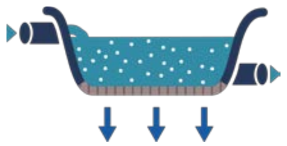
## ACTIONS INCLUDED IN PROGRAM

SPORTS FIELD AND PARK DETENTION

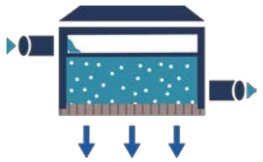
DETENTION POND



DETENTION VAULT



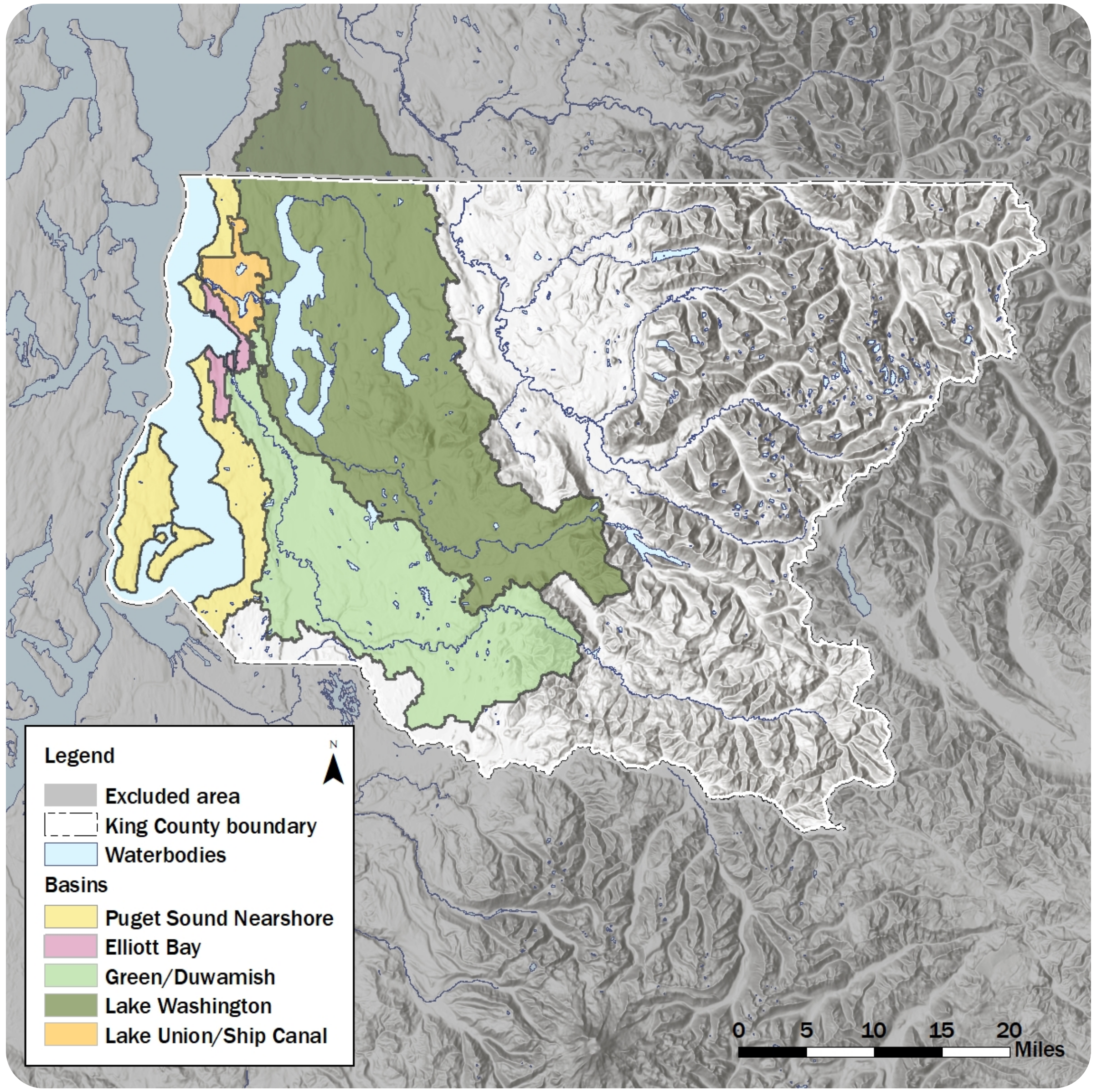
INFILTRATION* POND



INFILTRATION* VAULT

*Paired with upstream high-rate underground filter for pre-treatment

## PROGRAM IMPLEMENTATION AREA




## PROGRAM APPLICABILITY

- Basins in implementation area (see map above)
- Unincorporated King County and cities
- Separated drainage basins
- Residential, commercial, industrial, agricultural, highway land uses
- All surface types

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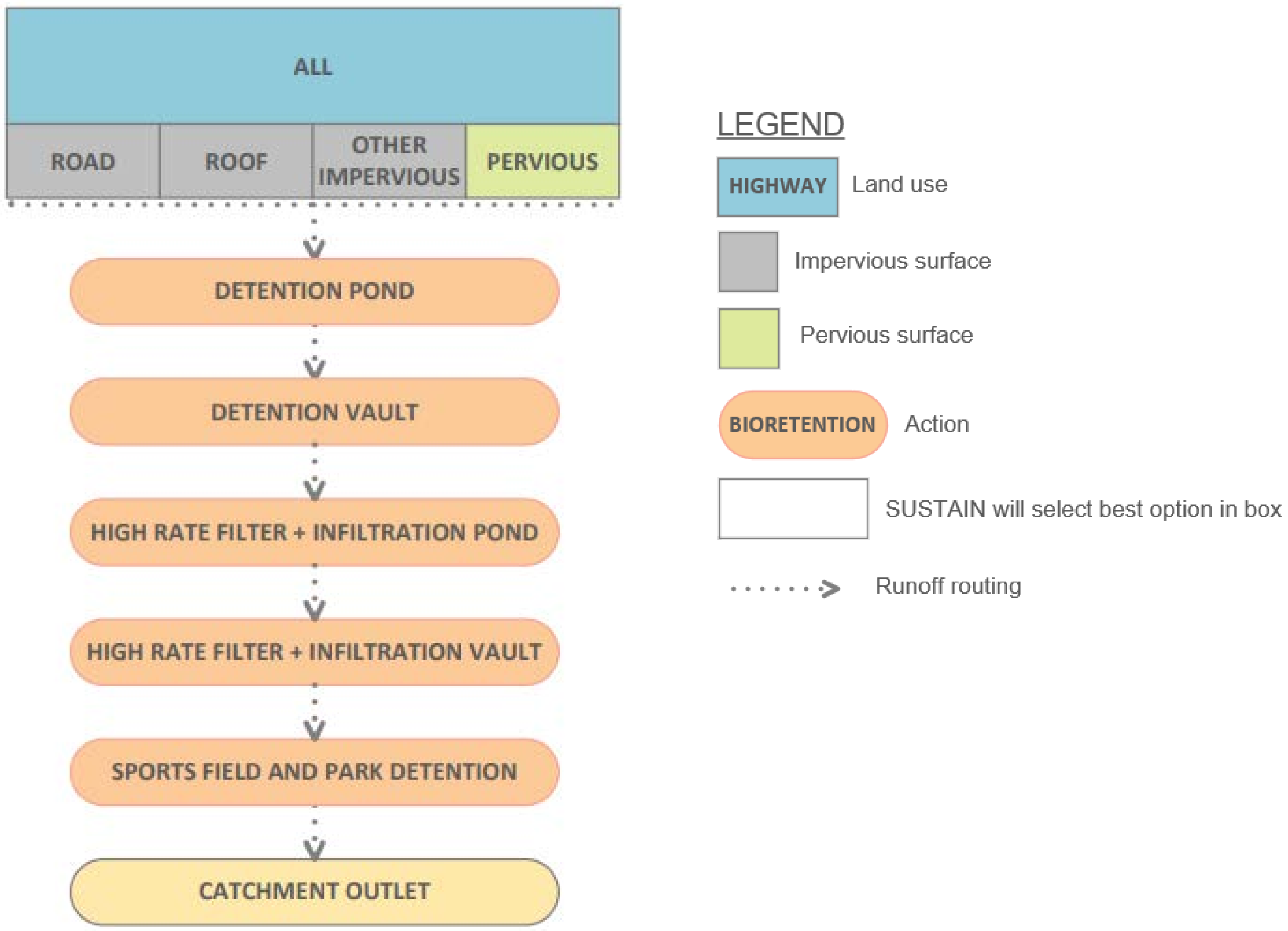
## SUSTAIN MODELING APPROACH

**Runoff routing:**
This diagram shows how stormwater runoff is routed in the SUSTAIN model. The arrows characterize the routing of stormwater runoff from each land use and surface type in the drainage area upstream of a potential regional facility on public parcels or private parcels. Overflow from the regional facilities and unmanaged runoff is routed to the catchment outlet.

**SUSTAIN Program optimization:**
Regional stormwater flow control facilities on publicly- and privately owned parcels could be evaluated by the SUSTAIN model to optimize the most cost-effective facilities for this Program.

- For performance, Actions can be optimized for runoff volume reduction on days in the timeseries where runoff exceeds a threshold that represents an unnatural hydrograph. The associated pollutant load reduction provided by the optimized Actions can be estimated.
- For costs, optimization can be based on Action lifecycle costs. Program development and implementation costs can be scaled and applied to modeling results.
- Maximum potential footprint areas for regional facilities were calculated for each catchment based on screening criteria described on page 3. SUSTAIN models these facilities as a lumped representation at the bottom of each catchment. The cost-effective Actions identified by SUSTAIN could be distributed throughout the catchment.



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# REGIONAL FACILITY FLOW CONTROL PROGRAM
## Water Quality Benefits Evaluation Program Fact Sheet

Phase 3

10/1/2024

## PROGRAM DESCRIPTION/ASSUMPTIONS

**Program description:**
- The Regional Stormwater Flow Control Program would fund, plan, and implement capital improvement projects to construct regional stormwater facilities to manage stormwater runoff from large subbasins.
- Eligible areas for regional facilities include private and public parcels in separated drainage systems in unincorporated King County and partnering cities.
- The Program would be administered by King County.
- Program elements would include:
  - Outreach to other jurisdictions and nongovernmental agencies to form partnerships
  - Interagency agreements for implementation and maintenance
  - County-wide planning effort to identify and prioritize best regional stormwater flow control opportunities
  - Recruit private parcel owners in highly feasible, beneficial locations
  - Property acquisition (for privately-owned parcels)
  - Capital improvement project planning, design, and construction
  - Ongoing project inspections and maintenance
- King County would be responsible for the cost of Action design, construction, maintenance and replacement, as well as the costs of Program development and administration. There is a potential for cost sharing with the site jurisdiction.

**Key assumptions:**
- Factors influencing technical feasibility and participation are based on professional judgement and assumed to be the same across all eligible areas
- Because this is a retrofit Program, Action sizing is not based on redevelopment requirements (i.e., contributing drainage area to each unit Action is not constrained)
- Facilities considered on County or partnering city property would not require property acquisition
- Facilities considered on private property would require property acquisition

**Key risks and challenges:**
- Relies, in part, on cooperation between County and partners to agree on project priorities, locations, details, funding, and implementation strategies
- Requires ongoing maintenance efforts and costs, which would be borne, at least in part, by the County
- Acquiring land for facilities on private parcels relies on willing sellers

## SCREENING CRITERIA FOR MAXIMUM FOOTPRINT AREA

Potential feasible footprint area for regional stormwater flow control facilities would be identified in GIS based on the following screening criteria:

| Criteria Category | Screening Criteria |
|---|---|
| Parcel Type/Ownership | • For publicly owned parcels: publicly-owned parcels, excluding airports, cemeteries, and trail corridors<br>• For privately-owned parcels: privately owned parcels |
| Outside Critical Areas/ Floodplain/ Sloped Areas | Located outside of:<br>• 100-year FEMA floodplain<br>• Areas with slope exceeding 10%<br>• Critical areas (steep slopes and buffers, wetlands, etc.) |

LEGEND

| | |
|---|---|
| Action not applied | |
| High Implementation | ≥30% |
| Medium Implementation | 15 to <30% |
| Low Implementation | ≤15% |

## PROGRAM IMPLEMENTATION CONSTRAINTS

Max Footprint Area = Candidate Footprint Area (reduced by screening criteria) x “Technical Factor” x "Participation Factor“
= Candidate Footprint Area (reduced by screening criteria x “Composite Factor“

| Flow Control Action | Infeasible Areas [1] | Private Parcels | | | Public Parcels | | |
|---|---|---|---|---|---|---|---|
| | | Technical Factor [2] | Participation Factor [3] | Composite Factor (Technical x Participation) [4] | Technical Factor [2] | Participation Factor [3] | Composite Factor (Technical x Participation) [4] |
| Detention pond | See screening criteria | 10% | 2% | 0.2% | 20% | 30% | 6% |
| Detention vault | See screening criteria | 10% | 2% | 0.2% | 20% | 30% | 6% |
| High-rate filter to infiltration vault | See screening criteria, till soil | 10% | 2% | 0.2% | 20% | 30% | 6% |
| High-rate filter to infiltration pond | See screening criteria, till soil | 10% | 2% | 0.2% | 20% | 30% | 6% |
| Sports Field / Park Detention | See screening criteria, areas other than public sports fields or parks | | | | 20% | 30% | 6% |

1. "Infeasible Areas" are Areas where the Action will not be applied.
2. “Technical Factor” represents the estimated fraction of the sites that would prove to be feasible during planning
3. “Participation Factor” represents the anticipated participation in the Program.
4. “Composite Factor” is the combined factor applied to estimate the maximum number of sites where regional facilities could be implemented.



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## PROGRAM COSTS

Program costs include:

- Lifecycle costs for Actions sited on public property and private property (see table below). While lifecycle costs include maintenance, some maintenance costs could be borne by partnering jurisdictions and nongovernmental agencies.
- Upfront Program development costs (outreach, interagency agreements, planning study)
- Average annual Program administration costs (partner coordination, project oversight, maintenance)

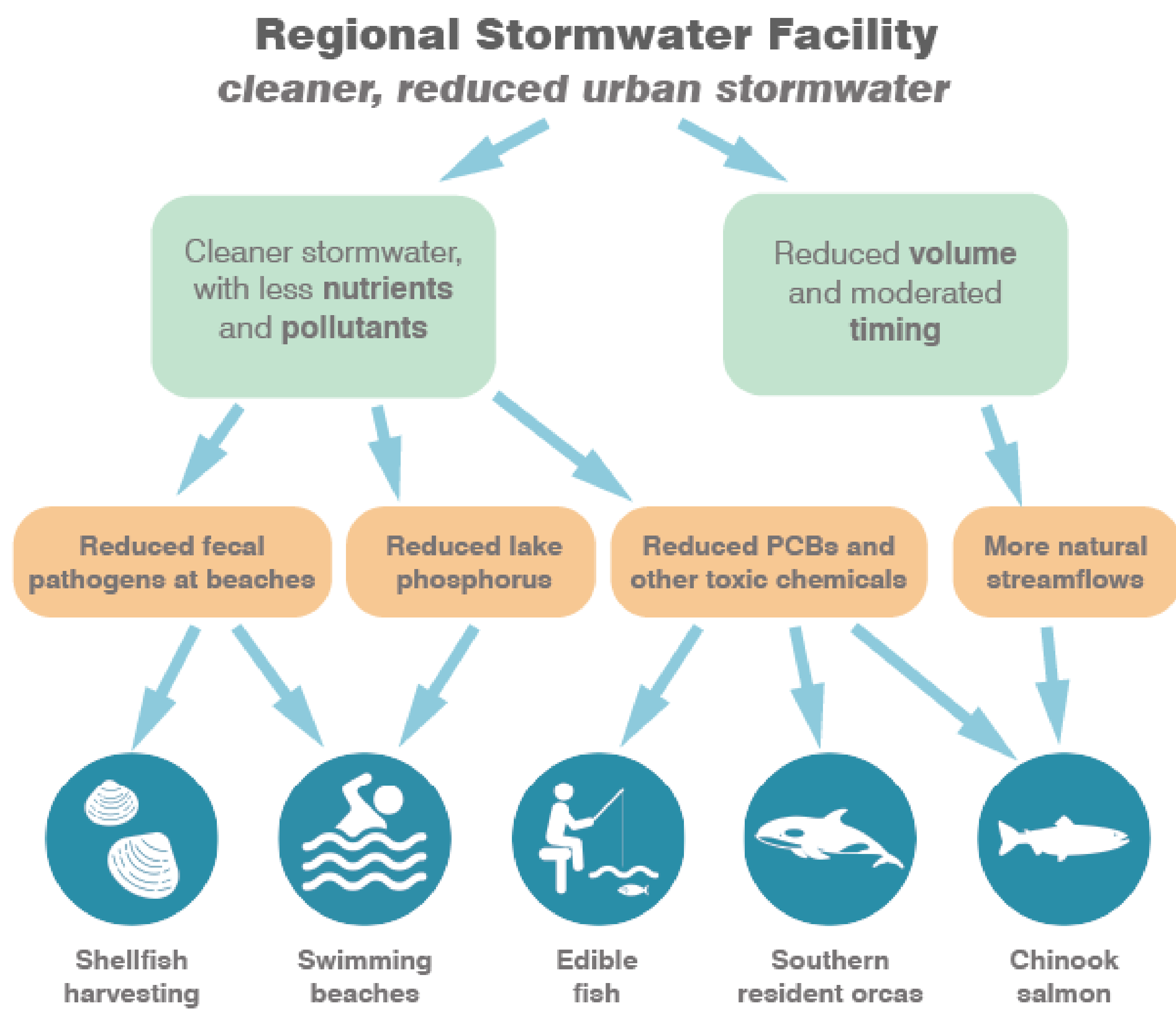
Program development and administration costs are not included in the table and can be applied separately. See 439-TM1 Appendix I for examples.

| Unit Action | Lifecycle Cost/Unit Action[1,2,3] |
|---|---|
| Detention pond on public parcel | $1,444,200 |
| Detention pond on private parcel | $2,931,400 |
| Detention vault on public parcel | $5,905,200 |
| Detention vault on private parcel | $6,454,600 |
| High-rate filter to infiltration vault on public parcel | $3,930,800 |
| High-rate filter to infiltration vault on private parcel | $4,375,400 |
| High-rate filter to infiltration pond on public parcel | $1,082,700 |
| High-rate filter to infiltration pond on private parcel | $2,243,700 |
| Sports field / park detention on public parcel | $18,700,900 |

1. All costs are per unit of Action. Lifecycle costs for Actions sited on public property do not include land acquisition costs, while Actions sited on private property include an added cost for land acquisition. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table includes medium acquisition costs. See 439-TM1 Appendix E for low and high property acquisition costs.
2. Costs are presented in 2023 dollars. Life-cycle include initial capital, operations and maintenance, and capital replacement costs over a 30-year life-cycle.
3. Annual O&M costs are included in the life-cycle costs with periodic replacements. For details on the total project costs and O&M cost development, see 439-TM1 Appendix E.

## LINKAGES TO CAUSAL MODELS

The Regional Flow Control Facility Program could be evaluated using causal models to assess benefits to a suite of human and ecological health endpoints. The graphic below illustrates the types of factors that might be influenced by a Program and how changes in those factors might improve outcomes for shellfish harvest, swimming beaches, edible fish, Chinook salmon, and Southern Resident orcas. Causal model inputs for the evaluation would be based on the factors shown here. A detailed list of potential causal model inputs are included as an appendix to technical memorandum #420-TM1.



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## PROGRAM OVERVIEW

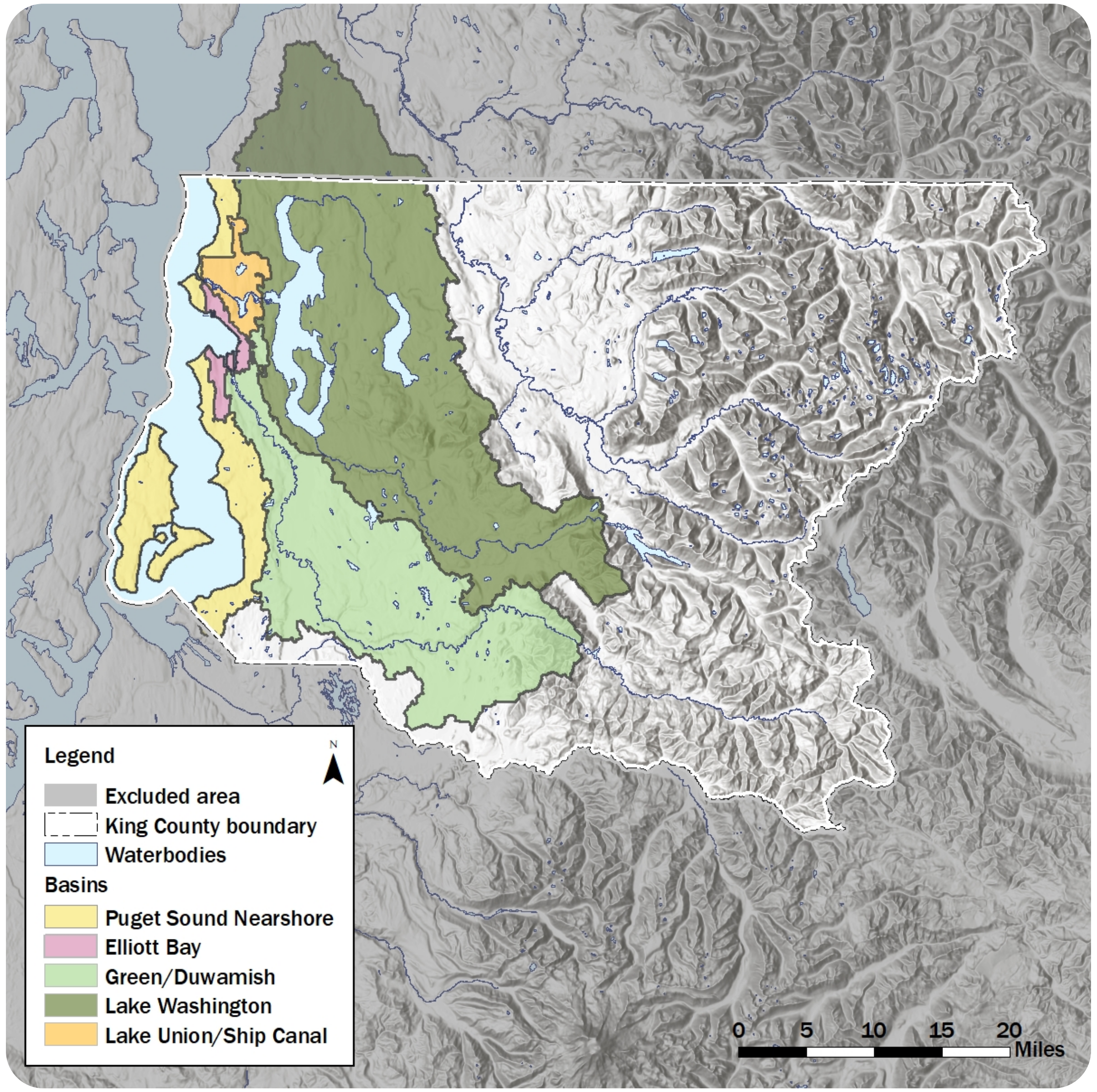
The Reforestation Flow Control Program would fund, plan, and implement reforestation projects on public lands and acquired private parcels in King County. The Program would be administered by King County, potentially in partnership with other jurisdictions and nongovernmental agencies.

The objective of the Program would be to provide flow control for stormwater runoff in separated drainage basins to more closely mimic predeveloped hydrology for receiving waterbodies in the Puget Sound Nearshore, Elliott Bay, Green/Duwamish, Lake Union/Ship Canal, and Lake Washington basins. The Program could be adapted for combined drainage basins with the objective to reduce combined sewer overflows.

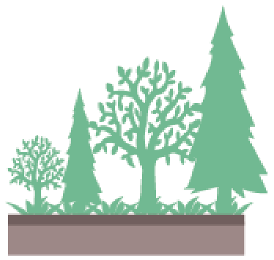
The Program could include reforestation of high density development and pervious areas ("Actions") shown below. The cost-effectiveness of the Program could be evaluated using the SUSTAIN model. Modeling inputs for the Actions, including design, performance, and cost assumptions, are provided in a companion Action Fact Sheets.

The following pages include key assumptions and an overview of the Program. See 439-TM1 Appendix F for more detailed information regarding the methods used.

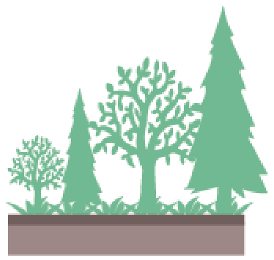
## PROGRAM IMPLEMENTATION AREA




## ACTIONS INCLUDED IN PROGRAM



REFOREST HIGH DENSITY DEVELOPMENT



REFOREST PERVIOUS AREA

## PROGRAM APPLICABILITY

- Basins in implementation area (see map above)
- Unincorporated King County and cities
- Separated drainage basins
- Commercial and industrial land uses
- Private and public parcels

10/1/2024

## SUSTAIN MODELING APPROACH

**Runoff routing/land conversion:**
This diagram shows how runoff characteristics are changed by converting some land use and surface type combinations to forest in the SUSTAIN model. Flows from the forest and unmanaged runoff is routed to the catchment outlet.

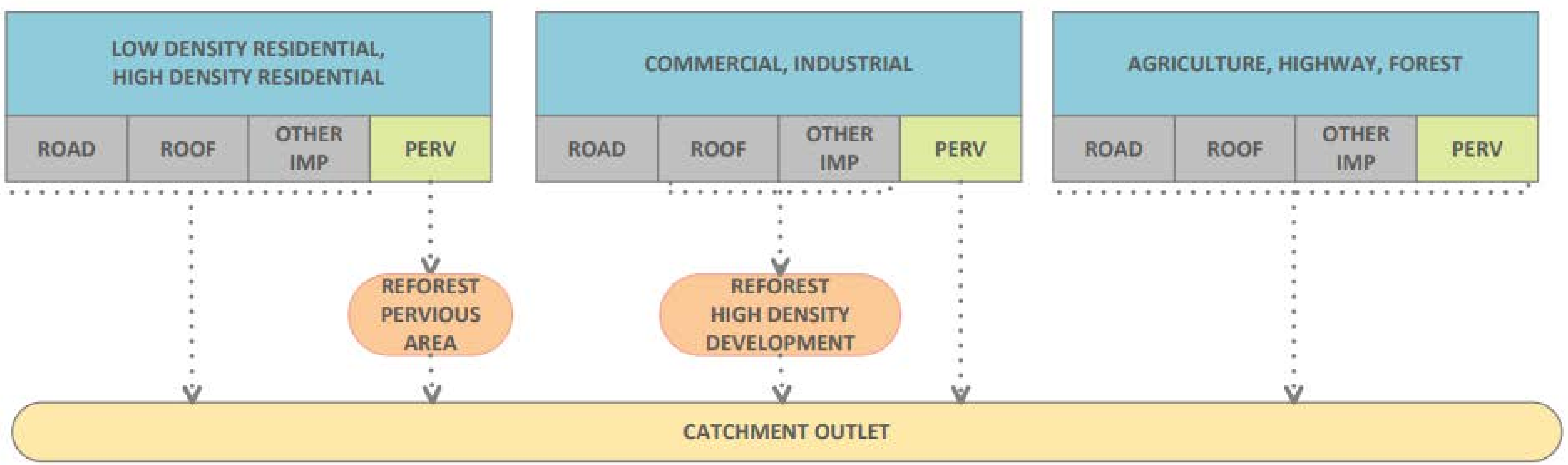
**SUSTAIN Program optimization:**

SUSTAIN could be used to evaluate the cost-effectiveness of the Actions in this Program.

- For performance, the Actions can be evaluated for runoff volume reduction on days in the timeseries where runoff exceeds a threshold that represents an unnatural hydrograph. The associated pollutant load reduction provided by the Actions can be estimated.
- For costs, evaluation can be based on Action lifecycle cost. Program development and implementation costs can be scaled and applied to modeling results.
- SUSTAIN models this Action as a lumped representation at the bottom of each catchment. The cost-effective Actions identified by SUSTAIN are assumed to be distributed throughout the catchment.

LEGEND

| | |
|---|---|
| HIGHWAY | Land use |
| | Impervious surface |
| | Pervious surface |
| BIORETENTION | Action |
| | SUSTAIN will select best option in box |
| · · · · · · > | Runoff routing |



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## PROGRAM DESCRIPTION/ASSUMPTIONS

**Program description:**

- The Reforestation Flow Control Program would fund, plan, and implement reforestation projects on public lands and acquired private parcels in commercial, industrial and residential areas of King County.
- Reforestation would be implemented based on the assumed technical and participation factors shown in the table to the right.
- The Program would be administered by King County.
- Program elements would include:
    - Outreach to other jurisdictions and nongovernmental agencies to form partnerships
    - County-wide planning effort to identify and prioritize best reforestation opportunities on public lands and private land for sale
    - Property acquisition (for privately-owned parcels)
    - Design and implement reforestation project (e.g., remove structures, depave, scarify and amend soil, plant trees and understory, and install simple recreational trail)
    - Maintain vegetation during 3-year establishment period and annual thereafter
- King County would be responsible for the cost of Action design, construction, and maintenance, as well as the costs of Program development and administration. There is a potential for cost sharing with the site jurisdiction.

**Key assumptions:**

- Factors influencing technical feasibility and participation are based on professional judgement and assumed to be the same across all eligible areas.
- Reforestation projects on private property would require property acquisition.

**Key risks and challenges:**

- Requires ongoing maintenance efforts and costs, which would be borne, at least in part, by the County.
- Acquiring land for reforestation of private parcels relies on willing sellers.

## PROGRAM IMPLEMENTATION CONSTRAINTS

Max Drainage Area = Total Implementation Area (reduced by infeasible areas) x "Technical Factor" x "Participation Factor"
= Total Implementation Area (reduced by infeasible areas) x "Composite Factor"

| Action | Infeasible Areas [1] | Technical Factor [2] | | | | | | | | Participation Factor [3] | Composite Factor (Technical x Participation) [4] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential | | Commercial | | | Industial | | | | |
| | | Perv Inside City | Perv Outside City | Roof | Other Imp | Perv | Roof | Other Imp | Perv | | |
| Reforest High Density Development on private parcel | Publicly-owned parcel | | | 80% | 80% | 80% | 40% | 40% | 40% | 2% | 1% - 2% |
| Reforest High Density Development on public parcel | Privately-owned parcel | | | 80% | 80% | 80% | 40% | 40% | 40% | 5% | 2% - 4% |
| Reforest Pervious Area on private parcel | Publicly-owned parcel | 2% | 10% | | | | | | | 2% | 0.04% - 0.2% |

1. "Infeasible Areas" are areas where the Action will not be applied.
2. "Technical Factor" represents the estimated fraction of the implementation area that could feasibly be managed based on technical considerations like space constraints, utility conflicts, existing runoff patterns, and site uses.
3. "Participation Factor" represents the anticipated participation in the Program.
4. "Composite Factor" is the combined factor applied to estimate the maximum drainage area.

LEGEND

| | |
|---|---|
| Action not applied | |
| High Implementation | ≥30% |
| Medium Implementation | 15 to <30% |
| Low Implementation | ≤15% |



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10/1/2024

## PROGRAM COSTS

Program costs include:

- Lifecycle costs for Actions sited on public property and private property (see table below). While lifecycle costs include maintenance, some maintenance costs could be borne by partnering jurisdictions and nongovernmental agencies.
- Upfront Program development costs (partnering, planning study)
- Average annual Program administration costs (partner coordination, project design, maintenance)

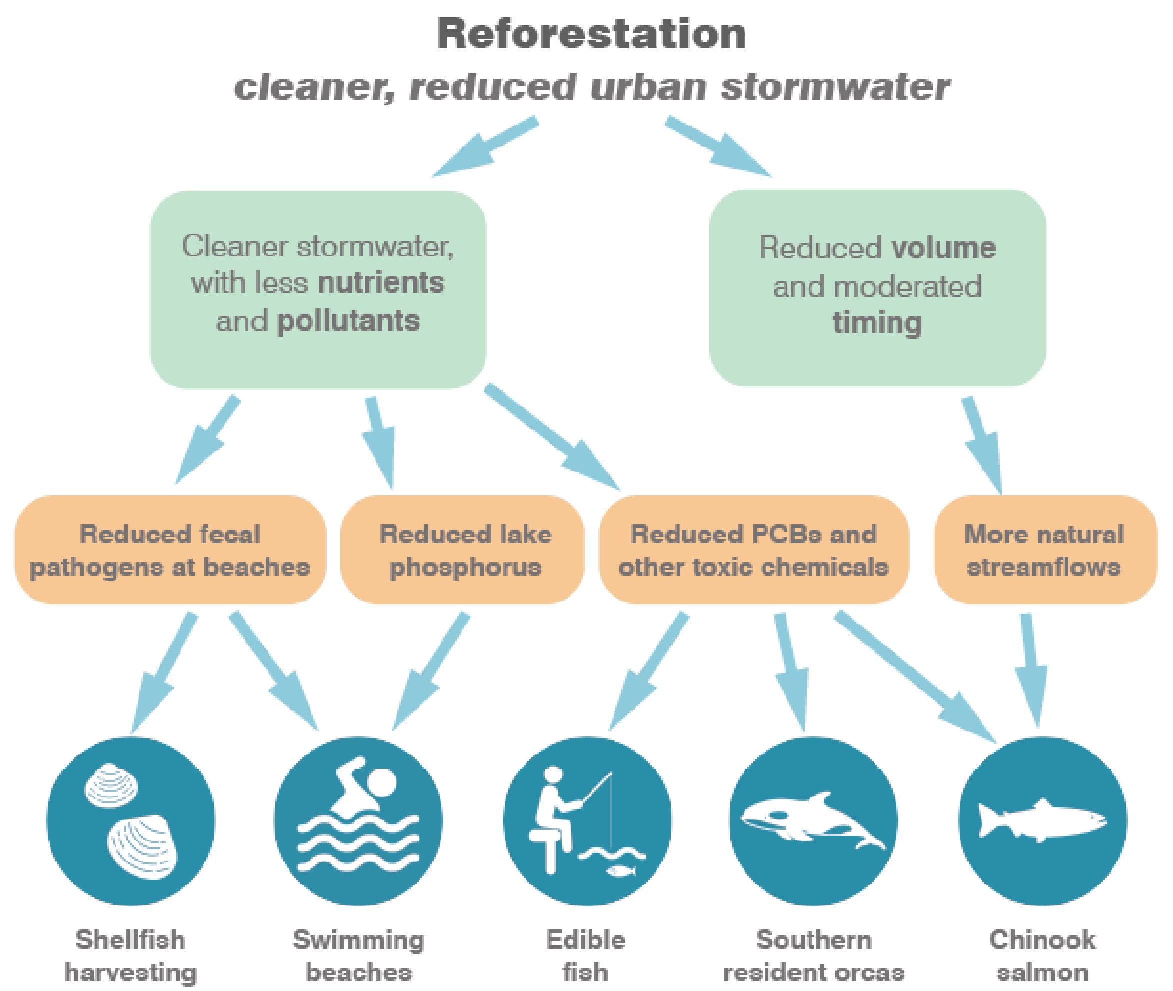
Program development and administration costs are not included in the table and can be applied separately. See 439-TM1 Appendix I for examples.

| Unit Action | Lifecycle Cost/Unit Action[1,2] |
|---|---|
| Reforest High Density Development on private parcel[3] | $24,131,700 |
| Reforest High Density Development on public parcel[3] | $19,577,100 |
| Reforest Pervious Area on private parcel[4] | $1,747,400 |

1. All costs are per unit of Action. Costs are presented in 2023 dollars. Life-cycle include initial capital, operations and maintenance, and capital replacement costs over a 30-year life-cycle.
2. Annual O&M costs are included in the life-cycle costs with periodic replacements. For details on the total project costs and O&M cost development, see 439-TM1 Appendix E.
3. Lifecycle costs for Actions sited on public property do not include land acquisition costs, while Actions sited on private property include an added cost for land acquisition. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table includes medium acquisition costs. See 439-TM1 Appendix E for low and high property acquisition costs.
4. Costs assume willing property owners and do not include property acquisition.

## LINKAGES TO CAUSAL MODELS

The Reforestation Flow Control Program could be evaluated using causal models to assess benefits to a suite of human and ecological health endpoints. The graphic below illustrates the types of factors that might be influenced by a Program and how changes in those factors might improve outcomes for shellfish harvest, swimming beaches, edible fish, Chinook salmon, and Southern Resident orcas. Causal model inputs for the evaluation would be based on the factors shown here. A detailed list of potential causal model inputs are included as an appendix to technical memorandum #420-TM1.





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# Appendix I

## Program Implementation Costs

Herrera
Science + Planning + Design

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# TECHNICAL MEMORANDUM

**Date:** October 4, 2024

**To:** Carly Greyell, King County Water and Land Resources Division
Jim Simmonds, King County Wastewater Treatment Division

**From:** Rebecca Dugopolski, PE, Herrera Environmental Consultants, Inc
Olivia Wright, Herrera Environmental Consultants, Inc
John Lenth, Herrera Environmental Consultants, Inc

**Subject:** WQBE Program Implementation Cost Development (Appendix I to 439-TM1)

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# Contents

# Appendices



# Tables

# Introduction

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes for selecting cost-effective water quality investments, reducing pollutant load and improving ecological and human health outcomes. The WQBE Toolkit will include a set of computational models:

- Integrated pollutant loading models, which estimate pollutant loads for major King County waterbodies taking into account major pollutant pathways and sources.
- System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) models, which identify cost-effective combinations of potential water quality for reduction of pollutant loads or stormwater volumes.
- Qualitative causal models, which define relationships between potential water quality projects and programs and five ecological/human health endpoints (southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches).

The WQBE Toolkit provides information that will be used in planning and prioritization of water quality investments. However, it is not the only information that informs these decisions. These efforts will also consider information not provided by the WQBE Toolkit, including how well different actions would advance equity and social justice, meet regulatory requirements, impact the cost of wastewater rates, and reflect other regional priorities (e.g., sustainability, community well-being, and more).

Part of this effort has involved the development of model inputs for "Actions" composed of structural or nonstructural stormwater controls that improve water quality and/or provide flow control. These Actions provide the unit building blocks (or "unit Actions") that are aggregated and combined to develop "Programs," or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. SUSTAIN models are then developed for each Program to evaluate cost effectiveness combinations of Actions, or "Packages", for improving water quality or providing flow control.

The WQBE Toolkit is being developed in three phases over a period extending from 2020 through 2024.

- **Phase 1 (2020)**: Assumptions for a preliminary set of nineteen Actions and three Programs focused on improving water quality were developed to be modeled with the WQBE Toolkit.
- **Phase 2 (2021-2022):** Preliminary Actions and Programs from Phase 1 were refined to improve their representation in SUSTAIN (Herrera 2022). The three water quality Programs from Phase 1 were subsequently modeled with SUSTAIN (Paradigm and Herrera 2022).
- **Phase 3 (2023-2024):** An additional five Actions and four Programs focused on providing flow control were developed and the Phase 2 Action costs were refined using a simplified approach that allows for more direct comparison to similar planning level cost estimates in the region.

The SUSTAIN model develops cost-effectiveness curves for each Program based on 30-year lifecycle costs for individual Actions. The lifecycle costs include the cost to design and construct the Actions within a Program as well as maintain and replace the Actions over a 30-year period. Additionally, property acquisition was included in the lifecycle costs when acquisition was required to implement an Action (i.e., regional facilities on private property). These costs were included in the SUSTAIN model to reflect the total cost incurred by all parties rather than solely King County.

However, the overarching implementation costs for the Program are generally not captured in these 30-year lifecycle costs. Therefore, it is anticipated that Program implementation costs would be developed outside of the SUSTAIN model. Ideally, these Program implementation costs would reflect potential "economies of scale" or shifts to more efficient implementation models depending on the size and complexity of the Package that is selected for a particular Program.

Program implementation approach and costs will vary based on the type of Program and the size of the selected Package from the SUSTAIN model results. Given this consideration, this memorandum provides example Program implementation assumptions and planning level costs for the following three Programs based on Packages selected from the Phase 2 SUSTAIN modeling:

- Green Stormwater Infrastructure (GSI) Incentive Program
- Roadway Stormwater Treatment Program
- Regional Stormwater Treatment Program

# Methodology

To develop example implementation assumptions and planning costs, the following information was compiled and/or estimated for each of the three Programs identified above:

- Program implementation elements and cost components
- Scales of program implementation (Small and Large)
- Applicable program delivery models
- Planning level cost estimate for program development for each program delivery model
- Planning level cost estimate for ongoing program implementation for each program delivery model

The three Programs developed in Phase 2 were modeled in SUSTAIN using the 30-year life cycle costs to identify the most cost-effective Actions that achieve different levels of water quality improvement at different costs (Paradigm and Herrera 2022). Two program scales (small and large) were evaluated using results from the SUSTAIN modeling:

- **Small**: $200M Package from SUSTAIN results reflecting 30-year life cycle costs
- **Large**: Package representing the "knee" of the cost-effectiveness curve from SUSTAIN results reflecting 30-year life cycle costs

The SUSTAIN lifecycle costs do not include costs required for implementing the Programs. Therefore, planning level program implementation costs were developed outside of the SUSTAIN model for initial program development and ongoing program implementation for each of the two program scales. The programmatic costs are predominately focused on County staff (with support from consultants as the program scale increases in size), with additional funding allotted to supplies and materials needed for implementing the program.

Program implementation costs for the Small program scale with the smaller number of Actions were estimated and then scaled up for the Large program scale which had larger numbers of Actions. In the process, economies of scale were considered in connection with this scaling. These planning level costs were estimated based on a review of program implementation costs from similar existing programs in the region and best professional judgement. Costs were also adjusted based on the applicable program delivery models that were selected for each Program. The delivery models identified in Table 1 were specifically considered in this evaluation.

**Table 1. Delivery Models used for Developing Program Implementation Costs.**

| Model | Applicable Program Delivery Models |
|---|---|
| 1. Capital Program | 1.1: County led |
| | 1.2: County led with consultant support |
| 2. Incentive Program | 2.1: County led rebate/reimbursement program |
| | 2.2: County led rebate/reimbursement program with consultant support |
| 3. Public-Private Partnership | 3.1: County led, design-build by landowner |
| | 3.2: Community Based Public-Private Partnership (CBP3) |

For each of the Programs, the following sections provide the Program description, the Program implementation elements not included in the SUSTAIN lifecycle costs, and the potential delivery models for implementing the Programs.

# Program Delivery Cost Estimates

## GSI Incentive Program

The GSI Incentive Program would provide incentives for property owners to install small scale green stormwater infrastructure (GSI) practices to help manage the rain that falls on their roofs and other impervious surfaces, such as parking lots and driveways. The Program would provide rebates, reimbursements, or other financial incentives to eligible property owners for designing, constructing, and maintaining GSI on their properties.

## Program Development Components

The program development planning level cost estimate for the GSI Incentive Program includes direct labor and overhead and material costs for staff to develop:

- Program web page with eligibility maps
- Design tools
- Incentive calculator
- Education and outreach materials
- Contractor training materials

## Ongoing Program Implementation Components

The ongoing program implementation planning level cost estimate for the GSI Incentive Program includes direct labor and overhead and material costs for staff to:

Advertise the program to eligible property owners/contractors

- Process applications
- Provide contractor training for GSI installation

## SUSTAIN Lifecycle Cost Elements

The following lifecycle cost considerations have already been developed as part of the SUSTAIN modeling:

- Design GSI BMPs
- Construct GSI BMPs
- Maintain GSI BMPs
- Replace GSI BMPs

The GSI Incentive Program is intended to provide a rebate or reimbursement to cover a portion of the design, construction, and/or maintenance costs to incentivize property owners for implementing Actions on their property. This technical memorandum does not identify the amount needed to incentivize property owners, but this would be evaluated as part of the program development.

## Program Size

For the planning level cost evaluation, our team evaluated two program sizes for the GSI Incentive Program:

- **Small:** $200M Package from SUSTAIN results reflecting 30-year life cycle costs
- **Large:** $683M Package representing the “knee” of the cost-effectiveness curve from SUSTAIN results reflecting 30-year life cycle costs

## Applicable Program Delivery Models

The following program delivery models were selected for evaluation for the GSI Incentive Program:

### Model 2: Incentive Program

- Model 2.1: County led rebate/reimbursement program
- Model 2.2: County led rebate/reimbursement program with consultant support

Table 2 provides a summary of the GSI Incentive Program description, the numbers and types of Actions included in the small and large scale programs, and the planning level cost estimates for different Program delivery models.

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## Table 2. GSI Incentive Program.

| Program Description and Cost Components | Short Program Description | Program Cost Components: Program Development | Program Cost Components: Ongoing Program Implementation | SUSTAIN Lifecycle Cost Components: Ongoing BMP Implementation | Combined Program and SUSTAIN Lifecycle Cost Components |
|---|---|---|---|---|---|
|  | The GSI Incentive Program would provide incentives for property owners to install small scale green stormwater infrastructure (GSI) practices to help manage the rain that falls on their roofs and other impervious surfaces, such as parking lots and driveways. The Program would provide rebates, reimbursements, or other financial incentives to eligible property owners for designing, installing, and/or maintaining GSI on their properties. | Direct labor and overhead and material costs for staff to develop:<br>• Program web page with eligibility maps<br>• Design tools<br>• Incentive calculator<br>• Education and outreach materials<br>• Contractor training materials | Direct labor and overhead and material costs for staff to:<br>• Advertise the program to eligible property owners/contractors<br>• Process applications<br>• Provide contractor training for GSI installation | Direct labor and overhead and material costs for staff to:<br>• Design GSI BMPs<br>• Construct GSI BMPs<br>• Maintain GSI BMPs<br>• Replace GSI BMPs<br>• Provide rebate/reimbursement (towards GSI BMP construction cost and ~1-2 yrs maintenance) | Includes Program Development, Ongoing Program Implementation, and Ongoing BMP Implementation |

| Program Delivery Model and Planning Level Program Implementation Costs | | | | Program Development | | Ongoing Program Implementation | | | | Ongoing BMP Implementation | | Program + SUSTAIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scale | Description of Actions Included[a] | Model | Applicable Program Delivery Models | Initial Cost (including staff)[b] | County Staff | Approx. Annual Cost (including staff)[c] | Approx. Program Cost per BMP | Total 30-Year Cost (including staff)[d] | County Staff | Approximate Annual Cost[c] | Total 30-Year Lifecycle Cost[e] | Total 30-Year Lifecycle Cost[d] |
| Small | 2,544 bioretention units | 2. Incentive Program | *2.1:* County led rebate/reimbursement program | $300,000 | 2 FTE | $540,000 | $6,368 | $11M | 2 FTE | $6.7M | $200M | $211M |
| | | | *2.2:* County led rebate/reimbursement program with consultant support (25%) | $308,000 | 1.5 FTE | $548,000 | $6,462 | $12M | 1.5 FTE | | | $212M |
| Large | 7,530 bioretention units<br>410 rain gardens<br>405 bioretention planters<br>264 cisterns<br>12 bioretention planter to deep UIC wells | 2. Incentive Program | *2.1:* County led rebate/reimbursement program | $900,000 | 6 FTE | $1,620,000 | $5,637 | $34M | 6 FTE | $23M | $683M | $717M |
| | | | *2.2:* County led rebate/reimbursement program with consultant support (75%) | $966,000 | 1.5 FTE | $1,686,000 | $5,867 | $36M | 1.5 FTE | | | $719M |

[a] The following BMPs were removed from the SUSTAIN results to simplify implementation of the Small Program: 1 bioretention planter, 1 bioretention planter drywell, and 1 permeable pavement area
The following BMPs were removed from the SUSTAIN results to simplify implementation of the Large Program: 2 bioretention planter drywells and 1 permeable pavement area

[b] Initial cost is based on 2023 dollars.

[c] The 30-year lifecycle cost was divided evenly among 30 years. Actual costs may be higher or lower each year than what is presented here for the initial planning level cost estimates.

[d] Total 30-year cost is based on 2023 dollars. A 3% labor cost escalation and 5.25% discount rate was incorporated into these initial planning level cost estimates.

[e] Small Program was defined as the SUSTAIN 30-year lifecycle cost for a GSI realistic, sediment optimization, Lake Washington $200M Package.

Large Program was defined as the SUSTAIN 30-year lifecycle cost for a GSI realistic, sediment optimization, Lake Washington Package selected to represent the "knee" of the cost-effectiveness curve ($683M).

BMP = best management practice

FTE = full-time equivalent

GSI = green stormwater infrastructure

UIC = underground injection control

# Roadway Stormwater Treatment Program

The Roadway Stormwater Treatment Program would fund, plan, and implement capital improvement projects to construct treatment practices (Actions) to treat runoff from roads and highways in King County. The Program would be administered by King County in partnership with cities and the Washington State Department of Transportation (WSDOT).

## Program Development Components

The program development planning level cost estimate for the Roadway Stormwater Treatment Program includes direct labor and overhead and material costs for staff to:

- Implement a County-wide planning effort to identify and prioritize best retrofit opportunities
- Conduct outreach to cities and WSDOT to form partnerships
- Develop interagency agreements for implementation and maintenance

## Ongoing Program Implementation Components

The ongoing program implementation planning level cost estimate for the Roadway Stormwater Treatment Program includes direct labor and overhead and material costs for staff to:

- Continue to identify and prioritize best retrofit opportunities
- Coordinate with cities and WSDOT
- Continue to develop interagency agreements for implementation and maintenance

## SUSTAIN Lifecycle Cost Elements

The following lifecycle cost elements have already been developed as part of the SUSTAIN modeling:

- Design capital improvement projects
- Construct capital improvement projects
- Maintain capital improvement projects
- Replace capital improvement projects

## Program Size

For the planning level cost evaluation, our team evaluated two program sizes for the Roadway Stormwater Treatment Program:

- **Small:** $200M Package from SUSTAIN results reflecting 30-year life cycle costs

- **Large:** $731M Package representing the "knee" of the cost-effectiveness curve from SUSTAIN results reflecting 30-year life cycle costs

## Applicable Program Delivery Models

The following program delivery models were selected for evaluation for the Roadway Stormwater Treatment Program:

### Model 1: Capital Program

- Model 1.1: County led
- Model 1.2: County led with consultant support

Table 3 provides a summary of the Roadway Stormwater Treatment Program description, the numbers and types of Actions included in the small and large scale programs, and the planning level cost estimates for different Program delivery models.

**Table 3. Roadway Stormwater Treatment Program.**

| Program Description and Cost Components | Short Program Description | Program Cost Components: Program Development | Program Cost Components: Ongoing Program Implementation | SUSTAIN Lifecycle Cost Components: Ongoing BMP Implementation | Combined Program and SUSTAIN Lifecycle Cost Components |
|---|---|---|---|---|---|
|  | The Roadway Stormwater Treatment Program would fund, plan, and implement capital improvement projects to construct treatment practices (Actions) to treat runoff from roads and highways in King County.<br>The Program would be administered by King County in partnership with cities and the Washington State Department of Transportation (WSDOT). | Direct labor and overhead and material costs for staff to:<br>• Implement a County-wide planning effort to identify and prioritize best retrofit opportunities<br>• Conduct outreach to cities and WSDOT to form partnerships<br>• Develop interagency agreements for implementation and maintenance | Direct labor and overhead and material costs for staff to:<br>• Continue to identify and prioritize best retrofit opportunities<br>• Coordinate with cities and WSDOT<br>• Continue to develop interagency agreements for implementation and maintenance | Direct labor and overhead and material costs for staff to:<br>• Design capital improvement projects<br>• Construct capital improvement projects<br>• Maintain capital improvement projects<br>• Replace capital improvement projects | Includes Program Development, Ongoing Program Implementation, and Ongoing BMP Implementation |

**Program Delivery Model and Planning Level Program Implementation Costs**

| | | | | Program Development | | | Ongoing Program Implementation | | | Ongoing BMP Implementation | | Program + SUSTAIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scale | Description of Actions Included[a] | Model | Applicable Program Delivery Models | Initial Cost (including staff)[b] | County Staff | Approx. Annual Cost (including staff)[c] | Approx. Program Cost per BMP | Total 30-Year Cost (including staff)[d] | County Staff | Approximate Annual Cost[c] | Total 30-Year Lifecycle Cost[e] | Total 30-Year Lifecycle Cost[d] |
| Small | 795 media filter drains<br>411 bioretention units<br>248 high-rate underground filters<br>34 high-rate filter deep UIC wells<br>17 biofiltration swales | 1. Capital Program | *1.1:* County led | $300,000 | 2 FTE | $150,000 | $2,990 | $3M | 1 FTE | $6.6M | $200M | $203M |
| | | | *1.2:* County led with consultant support (25%) | $308,000 | 1.5 FTE | $154,500 | $3,080 | $3M | 0.8 FTE | | | $203M |
| Large | 2,993 bioretention units<br>2,331 media filter drains<br>469 high-rate underground filters<br>282 bioretention planters<br>34 high-rate filter deep UIC wells | 1. Capital Program | *1.1:* County led | $600,000 | 4 FTE | $300,000 | $2,888 | $6M | 2 FTE | $24M | $731M | $737M |
| | | | *1.2:* County led with consultant support (75%) | $644,000 | 1 FTE | $322,000 | $3,100 | $7M | 0.5 FTE | | | $738M |

[a] The following BMPs were removed from the SUSTAIN results to simplify implementation of the Small Program: 2 bioretention planters
The following BMPs were removed from the SUSTAIN results to simplify implementation of the Large Program: 1 biofiltration swale

[b] Initial cost is based on 2023 dollars.

[c] The 30-year lifecycle cost was divided evenly among 30 years. Actual costs may be higher or lower each year than what is presented here for the initial planning level cost estimates.

[d] Total 30-year cost is based on 2023 dollars. A 3% labor cost escalation and 5.25% discount rate was incorporated into these initial planning level cost estimates.

[e] Small Program was defined as the SUSTAIN 30-year lifecycle cost for a GSI realistic, sediment optimization, Lake Washington $200M Package.
Large Program was defined as the SUSTAIN 30-year lifecycle cost for a GSI realistic, sediment optimization, Lake Washington Package selected to represent the "knee" of the cost-effectiveness curve ($731M).

BMP = best management practice

FTE = full-time equivalent

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# Regional Stormwater Treatment Program

The Regional Stormwater Treatment Program would fund, plan, and implement capital improvement projects to construct regional stormwater treatment facilities for treating stormwater runoff from large drainage areas that may include multiple types of land uses. The Program would be administered by King County in partnership with cities.

## Program Development Components

The program development planning level cost estimate for the Regional Stormwater Treatment Program includes direct labor and overhead and material costs for staff to:

- Implement a County-wide planning effort to identify and prioritize best retrofit opportunities
- Conduct outreach to cities and WSDOT to form partnerships
- Develop interagency agreements for implementation and maintenance
- Develop outreach materials for private parcel owners

## Ongoing Program Implementation Components

The ongoing program implementation planning level cost estimate for the Regional Stormwater Treatment Program includes direct labor and overhead and material costs for staff to:

- Continue to identify and prioritize best regional stormwater treatment opportunities
- Coordinate with cities and WSDOT
- Continue to develop interagency agreements for implementation and maintenance
- Conduct outreach to private parcel owners

## SUSTAIN Lifecycle Cost Elements

The following lifecycle cost elements have already been developed as part of the SUSTAIN modeling:

- Design capital improvement projects
- Construct capital improvement projects
- Maintain capital improvement projects
- Replace capital improvement projects
- Acquire privately-owned parcels

## Program Size

For the planning level cost evaluation, our team evaluated two program sizes for the Regional Stormwater Treatment Program:

- **Small:** $200M Package from SUSTAIN results reflecting 30-year life cycle costs
- **Large:** $1.8B Package representing the “knee” of the cost-effectiveness curve from SUSTAIN results reflecting 30-year life cycle costs

## Applicable Program Delivery Models

The following program delivery models were selected for evaluation for the Roadway Stormwater Treatment Program:

### Model 1: Capital Program

- Model 1.1: County led
- Model 1.2: County led with consultant support

### Model 3: Public-Private Partnership

- Model 3.1: County led; design-build by landowner (medium-large scale; often multiple project sites)
- Model 3.2: Community Based Public-Private Partnership (CBP3)

Table 4 provides a summary of the Regional Stormwater Treatment Program description, the numbers and types of Actions included in the small and large scale programs, and the planning level cost estimates for different Program delivery models.

**Table 4. Regional Stormwater Treatment Program.**

| Program Description and Cost Components | Short Program Description | Program Cost Components: Program Development | Program Cost Components: Ongoing Program Implementation | SUSTAIN Lifecycle Cost Components: Ongoing BMP Implementation | Combined Program and SUSTAIN Lifecycle Cost Components |
|---|---|---|---|---|---|
|  | The Regional Stormwater Treatment Program would fund, plan, and implement capital improvement projects to construct regional stormwater treatment facilities to treat stormwater runoff from large subbasins.<br>The Program would be administered by King County in partnership with cities and the Washington State Department of Transportation (WSDOT). | Direct labor and overhead and material costs for staff to:<br>● Implement a County-wide planning effort to identify and prioritize best retrofit opportunities<br>● Conduct outreach to cities and WSDOT to form partnerships<br>● Develop interagency agreements for implementation and maintenance<br>● Develop outreach materials for private parcel owners | Direct labor and overhead and material costs for staff to:<br>● Continue to identify and prioritize best retrofit opportunities<br>● Coordinate with cities and WSDOT<br>● Continue to develop interagency agreements for implementation and maintenance<br>● Conduct outreach to private parcel owners | Direct labor and overhead and material costs for staff to:<br>● Design capital improvement projects<br>● Construct capital improvement projects<br>● Maintain capital improvement projects<br>● Replace capital improvement projects<br>● Acquire privately-owned parcels | Includes Program Development, Ongoing Program Implementation, and Ongoing BMP Implementation |

| Program Delivery Model and Planning Level Program Implementation Costs | Scale | Description of Actions Included | Model | Applicable Program Delivery Models | Program Development: Initial Cost (including staff)[a] | Program Development: County Staff | Ongoing Program Implementation: Initial Cost (including staff)[a] | Ongoing Program Implementation: County Staff | Ongoing Program Implementation: Initial Cost (including staff)[a] | Ongoing Program Implementation: County Staff | Ongoing BMP Implementation: Approximate Annual Cost[b] | Ongoing BMP Implementation: Total 30-Year Lifecycle Cost[d] | Program + SUSTAIN: Total 30-Year Lifecycle Cost[c] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Small | 26 regional facilities:<br>3.05 acres of private regional<br>0.238 acres of small public regional<br>0.232 acres of private regional draining to small public regional | 1. Capital Program | *1.1:* County led | $300,000 | 2 FTE | $160,000 | $184,615 | $3M | 1 FTE | $6.7M | $200M | $203M |
| | | | | *1.2:* County led with consultant support (25%) | $308,000 | 1.5 FTE | $164,500 | $189,808 | $3M | 0.8 FTE | | | $203M |
| | Large | 238 regional facilities:<br>25.68 acres of private regional<br>2.88 acres of large public regional<br>2.33 acres of small public regional<br>1.53 acres of private regional draining to small public regional | 1. Capital Program | *1.1:* County led | $450,000 | 3 FTE | $320,000 | $40,336 | $7M | 2 FTE | $59.8M | $1.8B | $1.9B |
| | | | | *1.2:* County led with consultant support (75%) | $461,500 | 2.3 FTE | $328,000 | $41,345 | $7M | 1.5 FTE | | | $1.9B |
| | | | 3. Public-Private Partnership | 3.1: County led, design-build by landowner | $450,000 | 3 FTE | $210,000 | $26,471 | $4M | 0.5 FTE | | | $1.8B |
| | | | | 3.2: Community Based Public-Private Partnership (CBP3) | $450,000 | 3 FTE | $187,500 | $23,634 | $4M | 0.5 FTE | | | $1.8B |

[a] Initial cost is based on 2023 dollars.

[b] The 30-year lifecycle cost was divided evenly among 30 years. Actual costs may be higher or lower each year than what is presented here for the initial planning level cost estimates.

[c] Total 30-year cost is based on 2023 dollars. A 3% labor cost escalation and 5.25% discount rate was incorporated into these initial planning level cost estimates.

[d] Small Program was defined as the SUSTAIN 30-year lifecycle cost for a GSI realistic, sediment optimization, Lake Washington $200M Package.
Large Program was defined as the SUSTAIN 30-year lifecycle cost for a GSI realistic, sediment optimization, Lake Washington Package selected to represent the "knee" of the cost-effectiveness curve ($1.8B).

BMP = best management practice

CBP3 = Community Based Public-Private Partnership

FTE = full-time equivalent

UIC = underground injection control

WSDOT = Washington State Department of Transportation

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# Summary

This document provides example Program implementation assumptions and planning level costs for three Programs modeled with the WQBE Toolkit. The examples provided assume a program length of 30 years and that the costs are evenly distributed over the 30-year period. When implementing a Program, there may be higher costs initially to get the program started that taper to a lower amount as program maintenance. It should also be noted the 30-year lifecycle costs from SUSTAIN for the Regional Stormwater Treatment Program might be lower than estimated due to expected efficiencies from the Public-Private Partnership implementation model for facility construction and long-term operations and maintenance. These efficiencies should be further explored once information is available from regional implementation of this model (e.g.., Seattle's RainCity Partnership Program and Washington Department of Ecology's Stormwater Community-Based Public-Private Partnership Program). Attachment A summarizes the QAQC completed for the estimated costs.

# References

Herrera. 2022. Water Quality Benefits Evaluation – Phase 2 Action and Program Factsheet Development (431-TM1). Prepared for King County Water and Land Resources Division by Herrera Environmental Consultants. May 2.

Paradigm and Herrera. 2022. Water Quality Benefits Evaluation – Phase 2 SUSTAIN Model Development (821-TM1). Prepared for King County Water and Land Resources Division by Paradigm Environmental and Herrera Environmental Consultants. December 22.

# Attachment A

## QAQC Form

HERRERA
Science + Planning + Design

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# FORM WQBE QC-1: TECHNICAL REVIEW COMMENTS

| PROJECT INFORMATION | |
|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation (WQBE) |
| **Project #:** | 1136613 |
| **Subtask:** | Subtask 439 - Flow Control Action and Program Development |
| **Contact:** | Carly Greyell (carly.greyell@kingcounty.gov) |

| Comment Type Category: |
|---|
| G - General |
| T - Technical |
| E - Editorial |
| C - Coordination |

| DOCUMENT INFORMATION | |
|---|---|
| **Title:** | WQBE_Program_Costs_DRAFT_v3_20240119 |
| **Created by:** | Herrera |
| **Contact:** | Rebecca Dugopolski (rdugopolski@herrerainc.com) |
| **Type:** | Spreadsheet |
| **Date:** | 2/16/2024 |
| **Purpose:** | Estimate total agency costs to launch and administer a GSI Incentive Program at different scales (small, medium, large), including agency time, potential state/federal grant funding, consultant time, and dollars allocated for project implementation. The point of comparison for the WQBE GSI Incentive Program was the SFPUC GI Grant Program, which was launched in 2018 with first awards (max $2M/project) in 2019. |

| RESPONDER | |
|---|---|
| **Name:** | Olivia Wright |
| **Company/Agency:** | Herrera |
| **Title:** | Senior Engineer |
| **Response Date:** | 6/7/2024 |
| **Email:** | owright@herrerainc.com |

| Response Code: |
|---|
| 1 - Accepted - Will comply |
| 2 - Accepted - Action completed |
| 3 - Discussion or clarification required |
| 4 - Unacceptable for reasons given |

| REVIEWERS | Reviewer #1 | Reviewer #2 |
|---|---|---|
| **Name:** | Robert Dusenbury (RD) | |
| **Company:** | Lotus Water | |
| **Title:** | Senior QA/QC Reviewer | |
| **Review Date:** | 2/2/2024 | |
| **Email:** | rdusenbury@lotuswater.com | |

| Comment Status Code: |
|---|
| 1 - Resolved |
| 2 - Resolution pending |
| 3 - Unresolved |
| 4 - Rolled over to next submittal |

| Comment No. | Reviewer | Comment Type | Review Comment | Responder | Response Code | Response Comment | Verifier | Comment Status Code |
|---|---|---|---|---|---|---|---|---|
| 1 | RD | G | Agency costs are in the same ballpark as those seen by SFPUC for their GI Grant Program, although WQBE estimates are a bit higher nominally. This is mainly because PUC has seen a ramp-up period over the first 5 years where the # of active projects takes some time to reach its plateau. SFPUC costs are estimated as a step function with ~$100K/yr to run the program + $20K/project for technical assistance. | OW | 1 | Noted with no action required. | JL | 1 |

# FORM WQBE QC-1: TECHNICAL REVIEW COMMENTS

| PROJECT INFORMATION | |
|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation (WQBE) |
| **Project #:** | 1136613 |
| **Subtask:** | Subtask 439 - Flow Control Action and Program Development |
| **Contact:** | Carly Greyell (carly.greyell@kingcounty.gov) |

| Comment Type Category: |
|---|
| G - General |
| T - Technical |
| E - Editorial |
| C - Coordination |

| DOCUMENT INFORMATION | |
|---|---|
| **Title:** | WQBE_Program_Costs_DRAFT_v3_20240119 |
| **Created by:** | Herrera |
| **Contact:** | Rebecca Dugopolski (rdugopolski@herrerainc.com) |
| **Type:** | Spreadsheet |
| **Date:** | 2/16/2024 |
| **Purpose:** | Estimate total agency costs to launch and administer a GSI Incentive Program at different scales (small, medium, large), including agency time, potential state/federal grant funding, consultant time, and dollars allocated for project implementation. The point of comparison for the WQBE GSI Incentive Program was the SFPUC GI Grant Program, which was launched in 2018 with first awards (max $2M/project) in 2019. |

| RESPONDER | |
|---|---|
| **Name:** | Olivia Wright |
| **Company/Agency:** | Herrera |
| **Title:** | Senior Engineer |
| **Response Date:** | 6/7/2024 |
| **Email:** | owright@herrerainc.com |

| Response Code: |
|---|
| 1 - Accepted - Will comply |
| 2 - Accepted - Action completed |
| 3 - Discussion or clarification required |
| 4 - Unacceptable for reasons given |

| REVIEWERS | Reviewer #1 | Reviewer #2 |
|---|---|---|
| **Name:** | Robert Dusenbury (RD) | |
| **Company:** | Lotus Water | |
| **Title:** | Senior QA/QC Reviewer | |
| **Review Date:** | 2/2/2024 | |
| **Email:** | rdusenbury@lotuswater.com | |

| Comment Status Code: |
|---|
| 1 - Resolved |
| 2 - Resolution pending |
| 3 - Unresolved |
| 4 - Rolled over to next submittal |

| Comment No. | Reviewer | Comment Type | Review Comment | Responder | Response Code | Response Comment | Verifier | Comment Status Code |
|---|---|---|---|---|---|---|---|---|
| 2 | RD | G | SFPUC's LOE to develop and launch their program was closer to 1 annual FTE (I don't think they captured legal costs). Ongoing costs to manage the program have been ~1 FTE, plus a consultant for technical program support. Consultant support appears to be leveling around 1 FTE as the program matures and more projects are active. Contactor training for GSI was done separately. So, a total of 2 FTE for small program seems right. | OW | 1 | Noted with no action required. | JL | 1 |
| 3 | RD | G | Over the past 4 years, SFPUC's total implementation costs have been 15% of total program cost (~$250/yr), but that percentage has been dropping and is targeted for ~half of that (~7.5% right there with WQBE projections) as more projects become eligible for reimbursement of construction costs (i.e., payments to grantees go up a lot while internal costs increase marginally). | OW | 1 | Noted with no action required. | JL | 1 |

# FORM WQBE QC-1: TECHNICAL REVIEW COMMENTS

| PROJECT INFORMATION | |
|---|---|
| **Project Name:** | King County Water Quality Benefits Evaluation (WQBE) |
| **Project #:** | 1136613 |
| **Subtask:** | Subtask 439 - Flow Control Action and Program Development |
| **Contact:** | Carly Greyell (carly.greyell@kingcounty.gov) |

| Comment Type Category: |
|---|
| G - General |
| T - Technical |
| E - Editorial |
| C - Coordination |

| DOCUMENT INFORMATION | |
|---|---|
| **Title:** | WQBE_Program_Costs_DRAFT_v3_20240119 |
| **Created by:** | Herrera |
| **Contact:** | Rebecca Dugopolski (rdugopolski@herrerainc.com) |
| **Type:** | Spreadsheet |
| **Date:** | 2/16/2024 |
| **Purpose:** | Estimate total agency costs to launch and administer a GSI Incentive Program at different scales (small, medium, large), including agency time, potential state/federal grant funding, consultant time, and dollars allocated for project implementation. The point of comparison for the WQBE GSI Incentive Program was the SFPUC GI Grant Program, which was launched in 2018 with first awards (max $2M/project) in 2019. |

| RESPONDER | |
|---|---|
| **Name:** | Olivia Wright |
| **Company/Agency:** | Herrera |
| **Title:** | Senior Engineer |
| **Response Date:** | 6/7/2024 |
| **Email:** | owright@herrerainc.com |

| Response Code: |
|---|
| 1 - Accepted - Will comply |
| 2 - Accepted - Action completed |
| 3 - Discussion or clarification required |
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| REVIEWERS | Reviewer #1 | Reviewer #2 |
|---|---|---|
| **Name:** | Robert Dusenbury (RD) | |
| **Company:** | Lotus Water | |
| **Title:** | Senior QA/QC Reviewer | |
| **Review Date:** | 2/2/2024 | |
| **Email:** | rdusenbury@lotuswater.com | |

| Comment Status Code: |
|---|
| 1 - Resolved |
| 2 - Resolution pending |
| 3 - Unresolved |
| 4 - Rolled over to next submittal |

| Comment No. | Reviewer | Comment Type | Review Comment | Responder | Response Code | Response Comment | Verifier | Comment Status Code |
|---|---|---|---|---|---|---|---|---|
| 4 | RD | G | Agency costs vary depending on how they roll out their programs (e.g., how much technical support they offer, # of facility inspections). | OW | 1 | Noted with no action required. | JL | 1 |
| 5 | RD | G | Recommend accounting for a 5-yr horizon from launch to maturity. During this time, agency costs may rise incrementally with the # of active projects, but the $$ given to projects may increase several fold. | OW | 4 | Costs are planning level estimates and reflect an initial Program development cost followed by annual ongoing Program implementation costs. It is recommended that the County consider reviewer comment when developing Programs in the future. | JL | 1 |
| 6 | RD | G | Recommend lowering Implementation costs for the Large program to ~6.5% of overall program costs. The only real oddity I see in the spreadsheet is in comparing implementation costs as a % of overall program costs across the 3 scales. You would expect that to drop from Small to Medium to Large. It does drop from Small to Medium, but then increases from Medium to Large. | OW | 1 | The large program (package with max reduction) was removed from the analysis based on input from County. The medium program is renamed to the large program. | JL | 1 |

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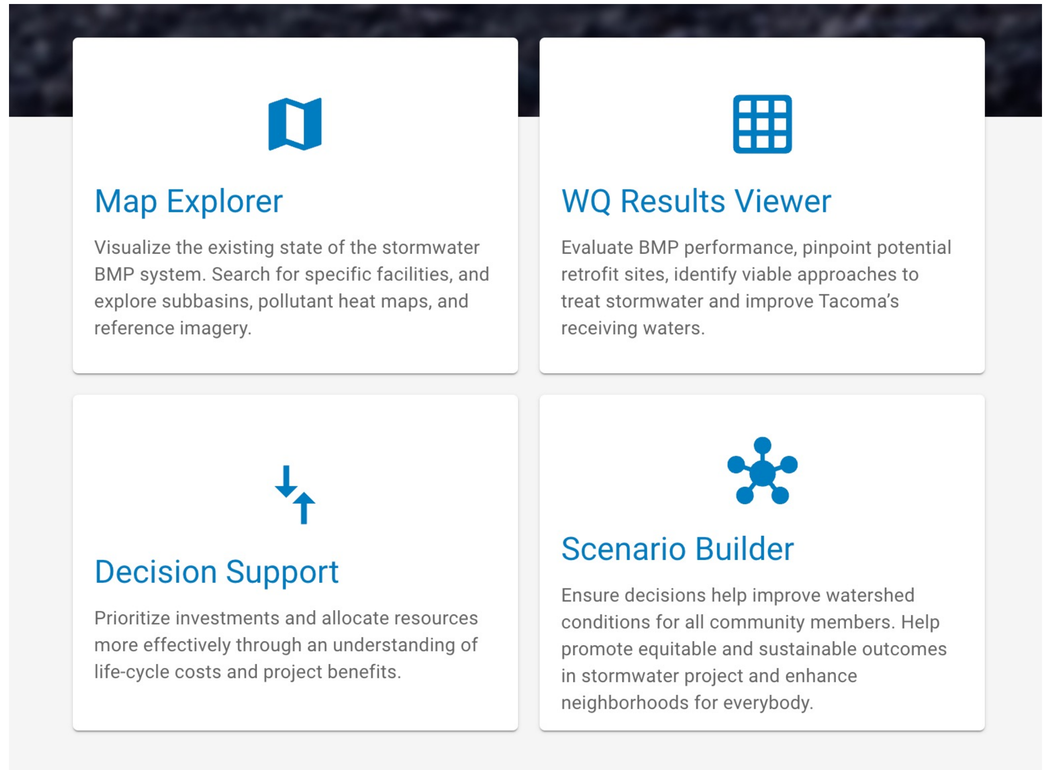
# 13 Appendix C - Workshop Slides

# Tacoma Watershed Insights

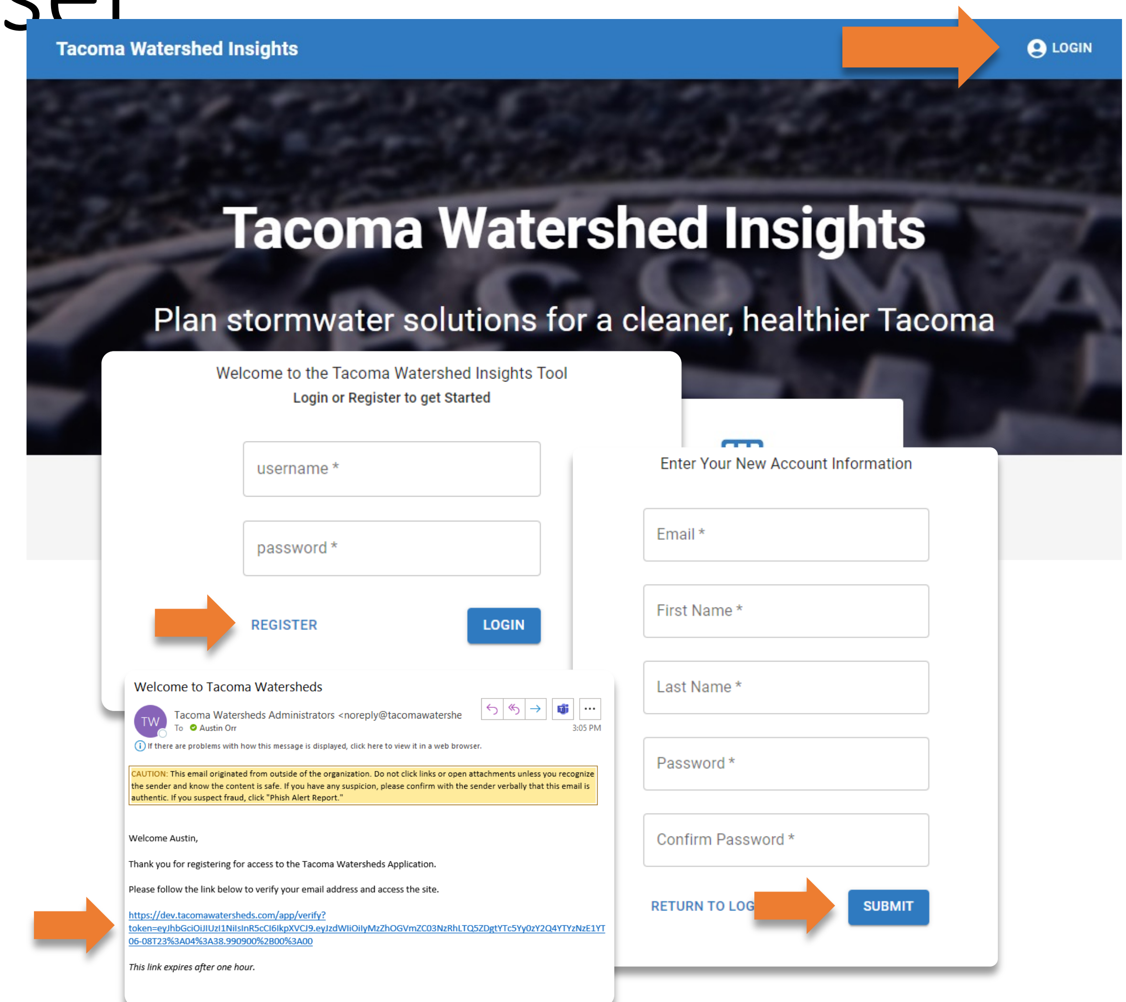
Main Components



# System Administration

# Enroll New User

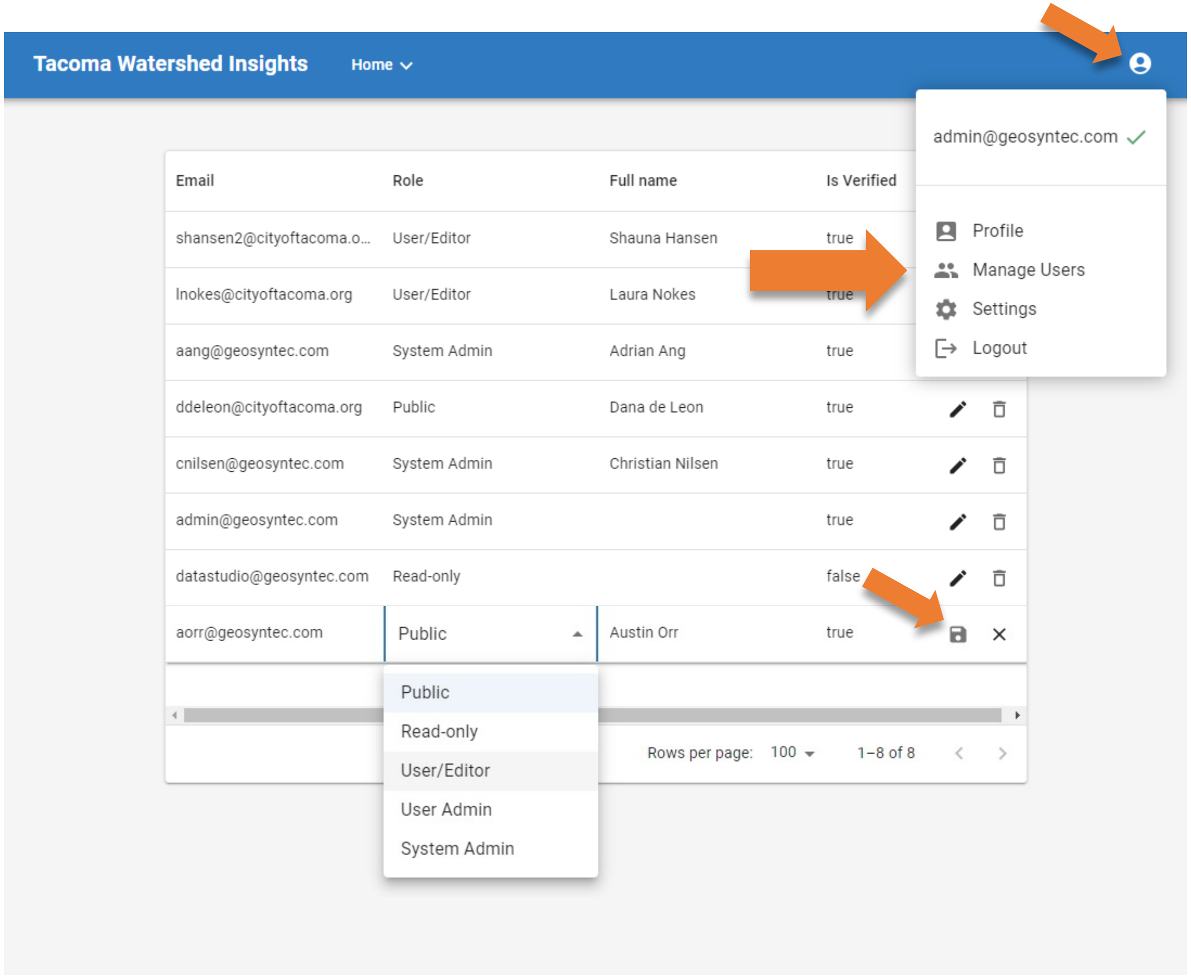
- Navigate to site
- Click Login
- Click Register
- Click Submit
- Check Email & Click through Verification



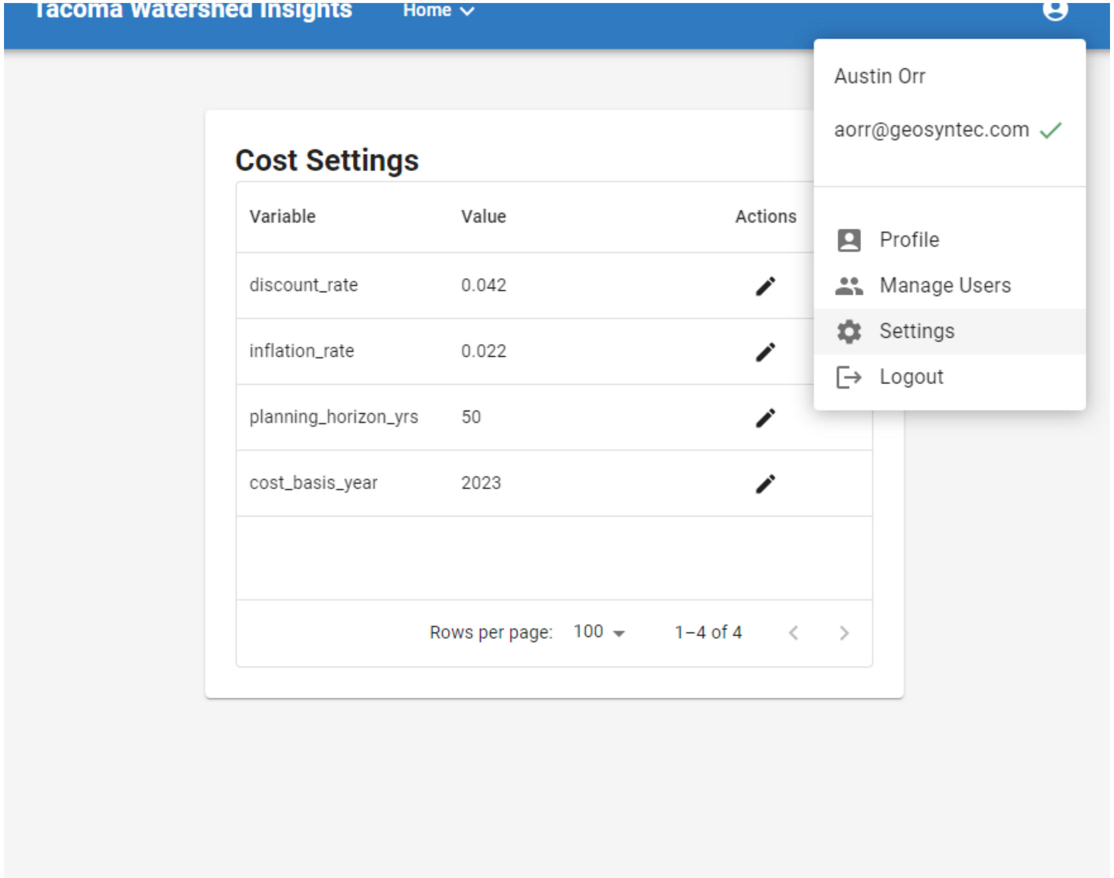
# Modify User Roles

| Role | Permission |
|---|---|
| Public | None |
| Read-only | Read access to data via site and via token |
| User/Editor | All of the above<br>+ access to scenarios and editing data |
| User Admin | All of the above<br>+ access to user manager<br>+ access to application settings |
| System Admin | All of the above<br>+ direct api access |

- Ask a User Admin to change your role
- Click on Profile
- Click Manage Users
- Click the pen to edit
- Select Role
- Save or cancel



# Cost Module Settings

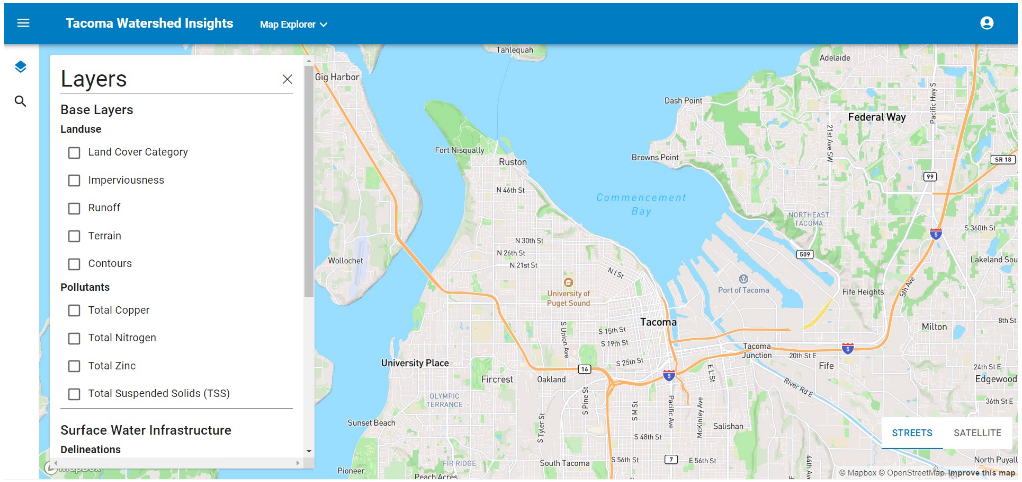



Modify Global Settings

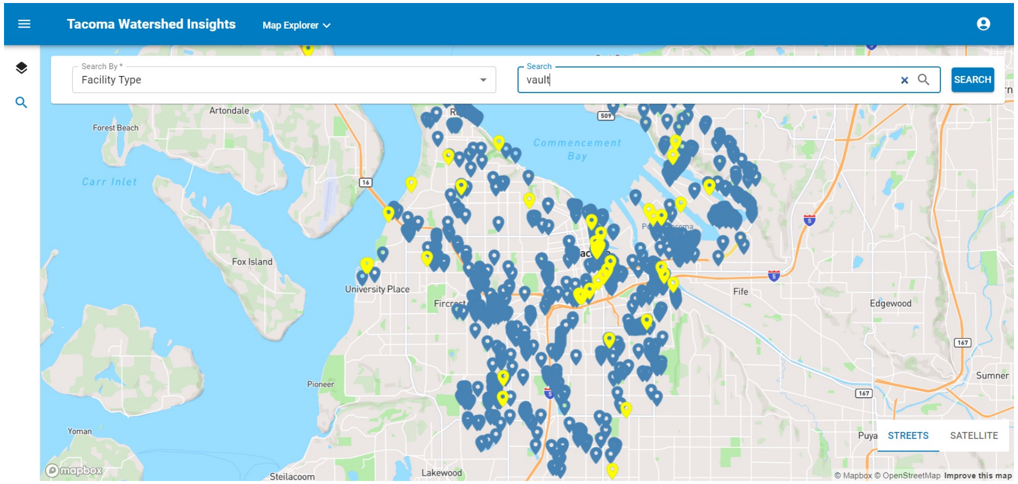
# Map Explorer

# Visualize Existing Infrastructure and Conditions

- Available Layers:
  - Pollutant heat maps
  - Landuse/Terrain
  - Stormwater subbasins
  - Stormwater BMPs
  - Stormwater pipes

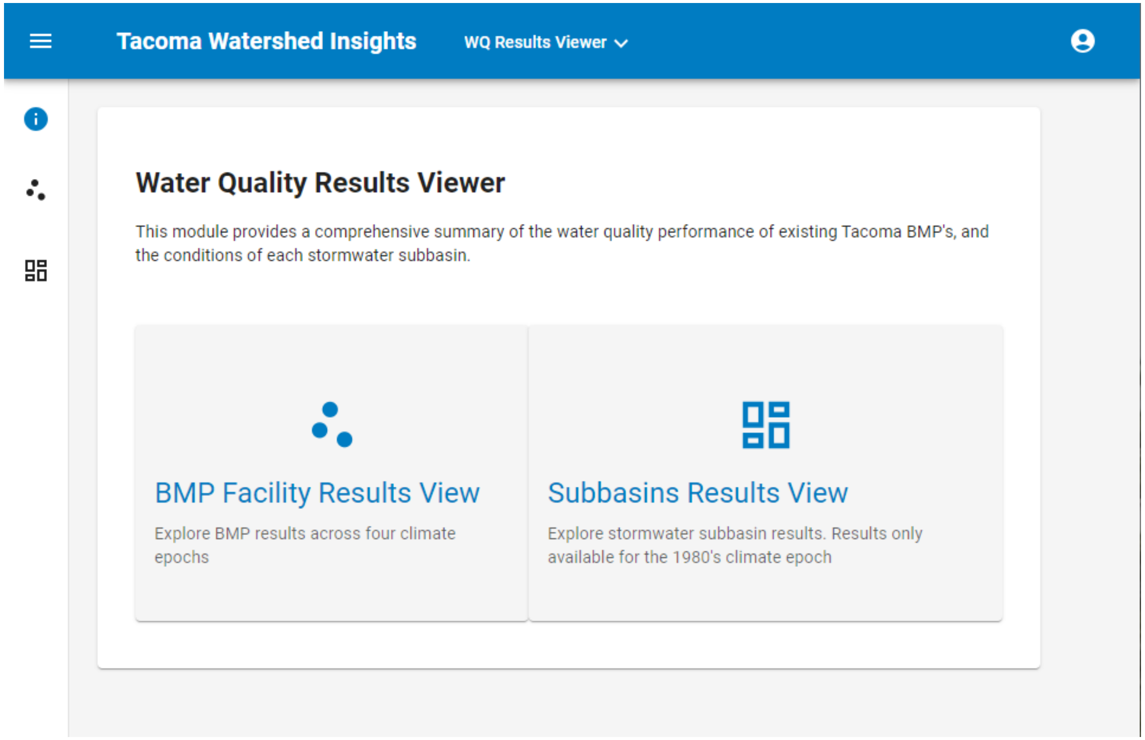


# Search by Facility Type



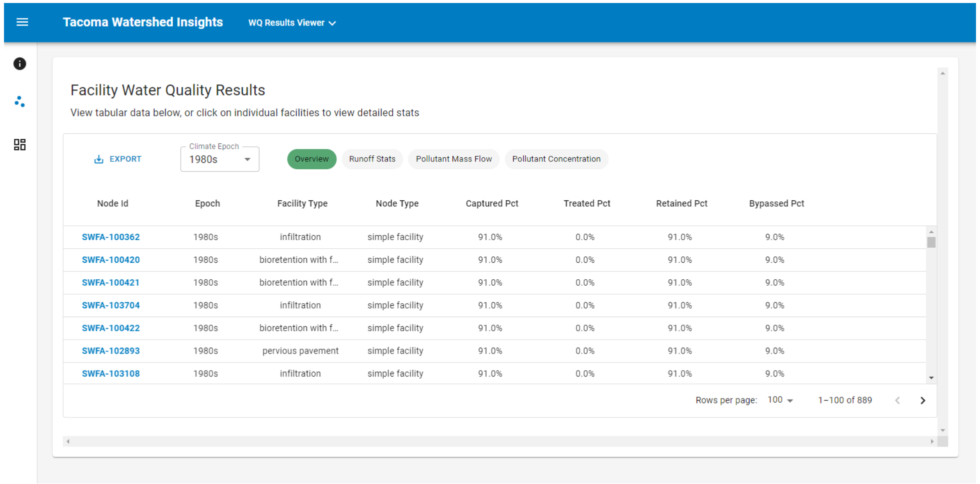
# Results Reviewer

# Explore WQ Performance at Facilities and Subbasins

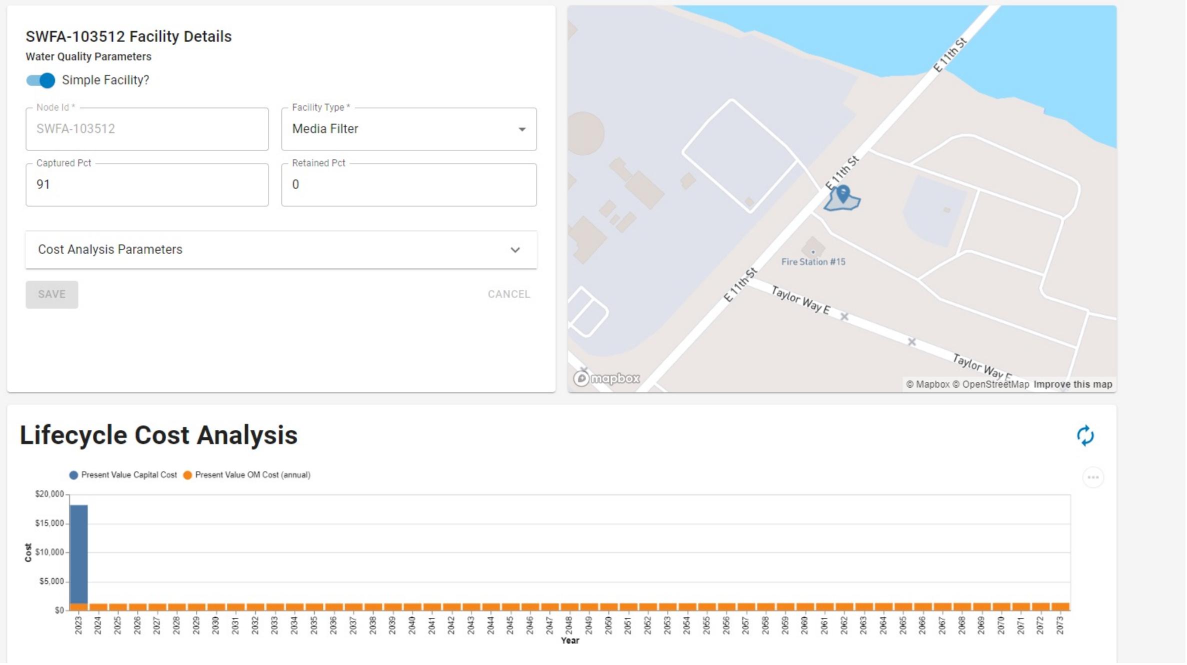


# Explore BMP Attributes

- Link to individual facility details
- View stats by climate epoch and type

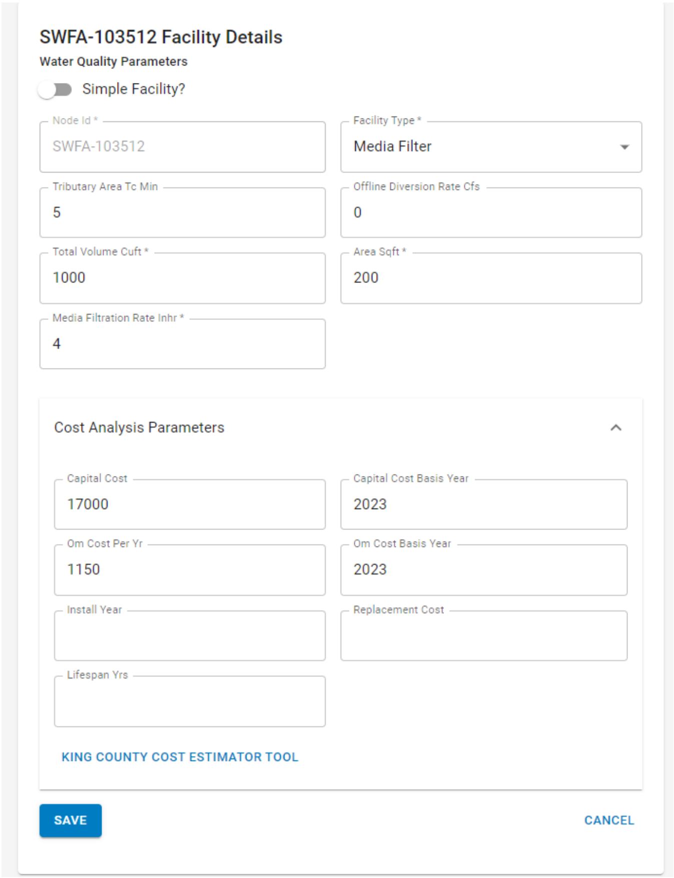


# Drill down to individual BMPs



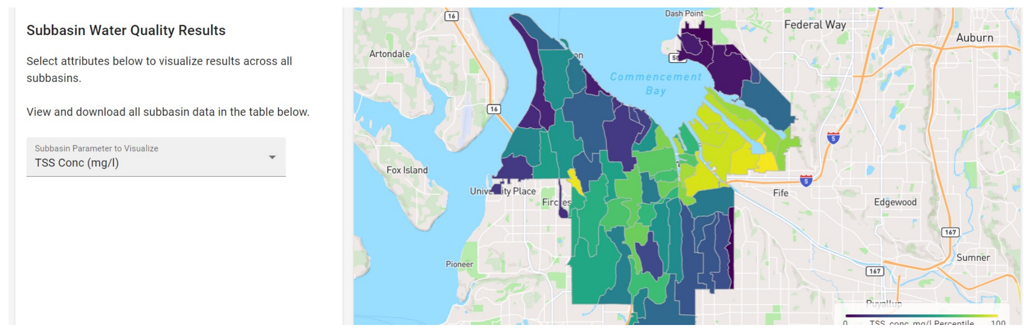
# Create BMPs with Detailed Performance and Cost Attributes

- Toggle between 'simple' facilities driven by percentage based capture and treatment stats to ones based on physical attributes
- Add cost data that allows for capital and O&M costs to be amortized over the lifespan of the facility



# Visualize Subbasin Attributes

- Available Parameters:
- -Land Use/Cover
- -Runoff
- -Treatment Facility Summary
- -Pollutant Concentrations/Reductions



# Visualize Subbasin Attributes

- View and download tabular results

EXPORT | Land Use Breakdown | Land Cover Breakdown | Runoff | Treatment Facility Summary | Average Pollutant Washoff Concentration | Annual Load Reductions

| Basinname | Subbasin | DEHP Conc (mg/l) | PHE Conc (mg/l) | PYR Conc (mg/l) | TCu Conc (mg/l) | TN Conc (mg/l) | TP Conc (mg/l) | TSS Conc (mg/l) |
|---|---|---|---|---|---|---|---|---|
| FLETT CREEK | FL_07 | 0.000476 | 0.00000583 | 0.00000886 | 0.0121 | 1.28 | 0.161 | 16.8 |
| FLETT CREEK | FL_08 | 0.00041 | 0.00000502 | 0.00000763 | 0.0114 | 1.37 | 0.147 | 14.5 |
| FLETT CREEK | FL_09 | 0.00038 | 0.00000466 | 0.00000708 | 0.012 | 1.05 | 0.0832 | 13.4 |
| FLETT CREEK | FL_10 | 0.000445 | 0.00000545 | 0.00000829 | 0.0117 | 1.37 | 0.177 | 15.7 |
| FOSS WATERWAY | FS_01 | 0.000445 | 0.00000545 | 0.00000829 | 0.015 | 1.18 | 0.137 | 15.7 |
| FOSS WATERWAY | FS_02 | 0.000486 | 0.00000595 | 0.00000905 | 0.0136 | 1.42 | 0.233 | 17.1 |

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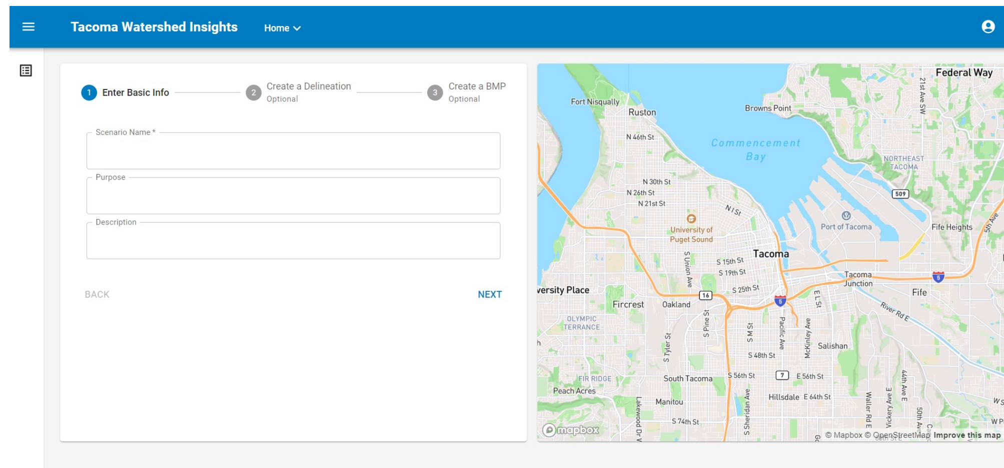
# Scenario Builder

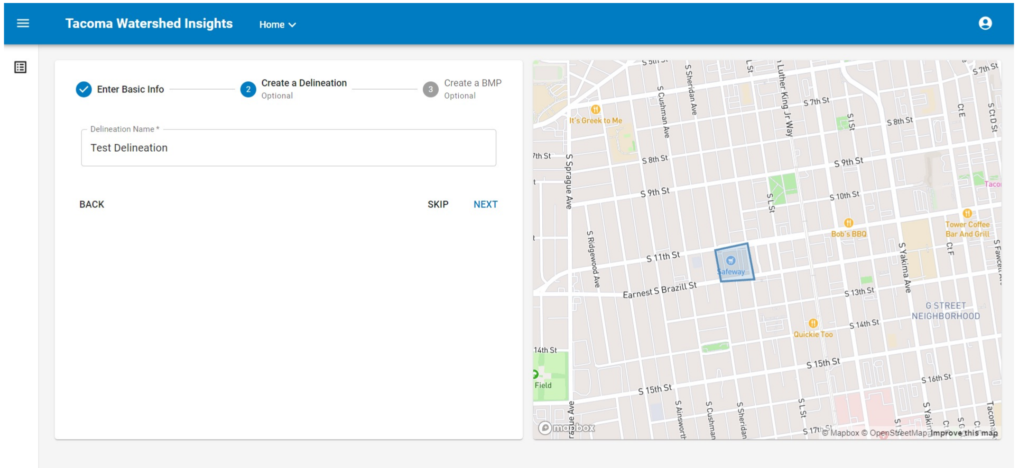
# Purpose and Process

- Allows users to model a proposed single BMP facility with an upstream delineation
- Scenarios can be designed incrementally (facility/delineation can be added after creation)
- WQ results can be generated after scenario creation and future edits

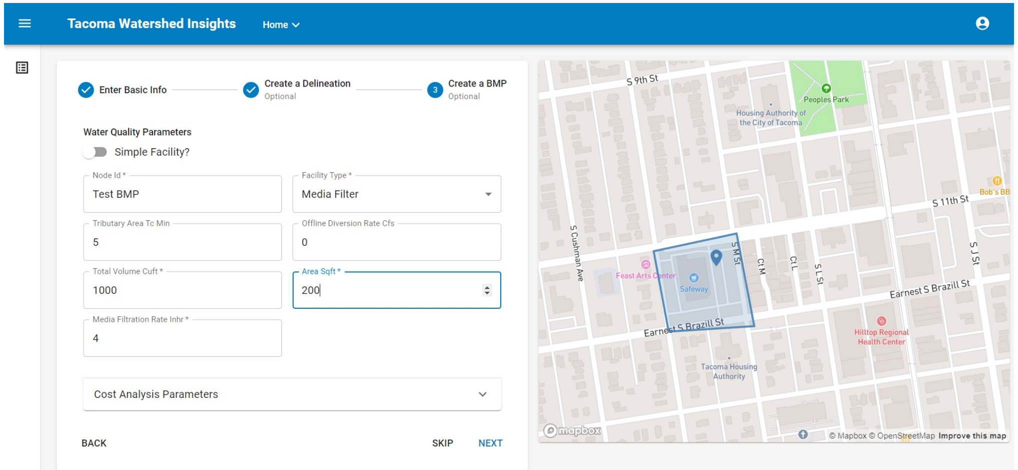
# Scenario Design Process



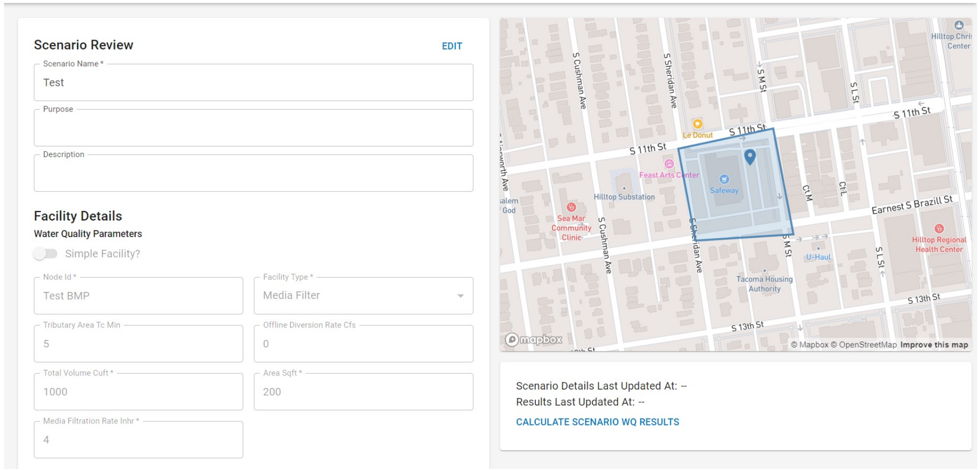
# Scenario Design Process



# Scenario
# Design Process



# Scenario Design Process




Make edits and calculate results

# Purpose and Process

Allows users to prioritize subbasins for stormwater improvements based on a number of goals and subgoals:

- Clean Water Goal
- Resilient Community Goal
- Healthy Ecosystem Goal
- Equity Goal

Subbasins are ranked using a pairwise algorithm - visual/tabular results are produced

Criteria and subbasin ranks can be downloaded for future use

## About Subbasin Prioritization

Use this tool to identify regions of the City of Tacoma Watershed that are most in need of stormwater retrofit or preservation projects

### Set a project type

Are you prioritizing preservation projects or retrofit projects?

Retrofit

### Set Priority Weights

Goal 1: Improve water quality outcomes (Clean Water Goal)

1.1: Prioritize areas based on pollutant concentrations

1

1.2: Improve infrastructure in areas with inadequate stormwater management

0

Goal 2: Increase resilience to climate change impacts (Resilient Community Goal)

2.1: Target areas most vulnerable to and at risk for climate change impacts

0

Goal 3: Preserve and restore critical and sensitive habitat (Healthy Ecosystems)

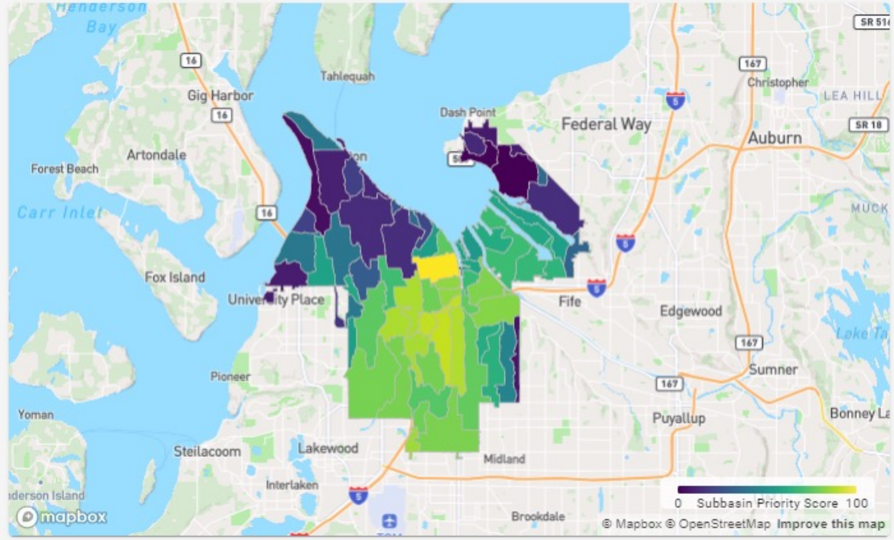
3.1 Preserve and improve Natural Spaces

0

Goal 4: Implement Equity and Social Justice (Healthy neighborhoods; Equity)

4.1: Prioritize areas of overlapping equity needs as identified by other Tacoma programs

2




### Subbasin Prioritization Results

Higher priority scores indicate subbasins more favorable for new projects

To view the specific subbasin attributes that determine scores, export the results below

EXPORT

| Subbasin ID | Priority Score ↓ |
|---|---|
| FS_05 | 100 |
| FS_09 | 91.153 |
| FS_08 | 90.349 |
| FS_10 | 88.204 |
| FS_02 | 87.668 |
| FS_03 | 87.668 |
| FL_05 | 86.863 |

After submitting priorities, subbasins are scored, and results can be visualized and downloaded

Tacoma GIS (refreshed each morning)

- BMP Facilities
- BMP Facility Delineations
- Subbasins (and static subbasin metrics forthcoming)

TNC in Washington Stormwater Heatmap

- POC concentration
- runoff depth (4 climate epochs)

## Changeable data

- BMP Facility modeling attributes (e.g. % capture performance, size)
- BMP Facility cost attributes (e.g., capital cost)
- Scenarios
  - Delineations, facility attributes
- Users & Permissions
- Cost Settings (e.g,. Inflation rate)

## Calculated data

- BMP Facility volume and load reductions
- BMP Facility cost metrics
- Delineation and Subbasin loading
- Upstream and Downstream source control measures (sweeping and drain line cleaning for Foss Watershed)
- Scenarios
  - Delineations, BMP Facility WQ, BMP Facility Cost

# Access via api with token

- TMNT Facilities: https://dev.tacomawatersheds.com/api/rest/tmnt_facility/token/<token>?f=geojson

**Data Integration** Via User Profile

https://dev.tacomawatersheds.com/api/rest/tmnt_facility/token/9ddba26a-79a8-412f-b06f-4eebd2405457?f=json&limit=1000000&offset=0

Get attributes or geojson for all tmnt facilities.
f: str (optional, default=json, [json, geojson]) Format of response data
limit: int (optional, default=1e6) Number of records to return
offset: int (optional, default=0) Start from index

https://dev.tacomawatersheds.com/api/rest/tmnt_facility/{altid}/token/9ddba26a-79a8-412f-b06f-4eebd2405457

Get attributes for tmnt facility with given altid.

https://dev.tacomawatersheds.com/api/rest/tmnt_delineation/token/9ddba26a-79a8-412f-b06f-4eebd2405457?f=json&limit=1000000&offset=0

Get attributes for all delineations.
f: str (optional, default=json, [json, geojson]) Format of response data
limit: int (optional, default=1e6) Number of records to return

# Data Integration GIS