Watershed Nature-Based and Green Infrastructure Activities Avoiding Emissions from Water Management Gray Infrastructure Construction and Operations Methodology v1.0

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1. Methodology Overview

This *Methodology* can be used by *Project Proponents* to generate carbon credits by reducing nonpoint source contamination of watersheds, thereby avoiding the increased greenhouse gas emissions from the status-quo infrastructure construction and electricity use associated with industrial drinking water, wastewater, and stormwater management and treatment.

This methodology creates a standardized approach to quantify and verify the emission reduction benefits of green infrastructure projects that improve water quality. Project Proponents using this methodology will quantify the reduction in GHG emissions associated with avoided energy and material use from the upgrading or new construction of water quality treatment facilities.

Calculation of GHG reductions and issuance of credits

The primary credit-generating activity under this methodology is the selection and implementation of green infrastructure by a water treatment facility, which then avoids decades of GHG emissions related to an upgrade which has been rendered unnecessary by the implementation of the green infrastructure solution. The credits generated after this decision are therefore 'ex-post' at this stage, given that the credit-generating decision has been made and attested to. However a more conservative approach to credit issuance is taken here that requires monitoring and verification that the green infrastructure has been implemented and water quality benefits are on the anticipated trajectory.

This Methodology assumes that the full lifetime avoided emissions are achieved as of the approval and establishment of the green alternative, and not annually. At the same time, many geographies, including many states in the United States, are in an energy transition toward renewable energy sources. As such, it is clear that in many cases a new gray infrastructure installation will have varying and decreasing emissions over time. This Methodology is designed to conservatively account for this, by requiring best-in-class and best-available energy transition forecasts (for example in the United States, the NREL Cambium 2022 mid-scenario) in the GHG life cycle analysis.

The carbon credits generated under this methodology are associated with replacing industrial emissions required to treat water with the lower (or negative) emissions from green infrastructure alternatives. While the green infrastructure alternative is intended to meet water quality obligations, carbon credits are not directly associated with the success or failure of this alternative. Instead, the green infrastructure program becomes a management obligation of the water treatment facility.

In the United States, watershed conservation or restoration in lieu of gray infrastructure has been formally used since the 1980s, and there are no known instances of a regulatorily-approved green infrastructure project failing to the point where the regulator has required a reversion to a new gray infrastructure installation. In fact, regulators typically provide for 20 years or more for utilities to demonstrate green infrastructure function, followed by what is typically at least a decade of additional deliberation. As such, the 30-year lifetime emissions calculated under this Methodology and then issued as carbon credits upon deployment of the alternative are both robust and permanent.

Geographic Scope

This *Methodology* and associated *Credit Class* is designed to be applicable globally, where nature-based alternatives are a potential, but not widespread, alternative to centralized water and wastewater treatment. In this methodology we provide references to primarily US-based data sources and precedents. A Project Developer and third party validator must apply their own judgment in establishing the most appropriate data sources and standards internationally. There are many examples of international watershed programs including in Canada, Australia, New Zealand, the United Kingdom, the Netherlands, Honduras, India, China, and Kenya.

Background on Water Quality Trading in the United States

This *Methodology* and associated *Credit Class* are in part designed to support the generation of carbon credit incentives to support and scale 'water quality trading,' whereby a wastewater discharger gains compliance via credits generated by watershed restoration projects. While this is not the only project type eligible (for example, the New York Watershed Program is one of many examples globally of a drinking water facility choosing to actively protect its watershed), additional context on water quality trading may be helpful for some stakeholders.

Roughly half of America's rivers are impaired. Degradation primarily stems from land-use change, agricultural and forestry practices, soil erosion, and urbanization as well as large-scale, short-and-medium term shocks associated with climate-related extremes such as floods and wildfires. Socially and economically marginalized communities are often the most negatively impacted by poor watershed health. 'Point source' (piped) river discharges are regulated by the Environmental Protection Agency (EPA) and state agencies under the Clean Water Act, while 'nonpoint' (diffuse) sources are largely unregulated.

These environmental and regulatory realities are subsequently putting increasing pressure on water and wastewater utilities to address riverine water quality. Historically, water and wastewater utilities have met these regulatory obligations by constructing "gray infrastructure," requiring significant energy demand and in turn large amounts of carbon emissions annually. In many cases, gray infrastructure could be substituted with green infrastructure, including riparian, floodplain, and wetlands restoration; regenerative agricultural practices; improved forestry management; and other efforts to reduce nonpoint source contamination.

Formal 'water quality trading' programs have long been established by the EPA and by state agencies , but have not achieved significant national scale, despite typically being much more cost effective, primarily because of systemic bias, risk aversion, sectoral inertia and questions about the effectiveness and measurability of nature-based alternatives. The EPA has recently revitalized their commitment to market-based water quality trading, emphasizing the role of the private sector in enabling improved river water quality in the United States, and encouraging regulators to embrace these opportunities and methodologies.

Monitoring Requirements

An existing barrier to scale for water quality trading programs is the ability to directly measure the performance of the alternative compliance mechanism - the green infrastructure. To-date, most programs have relied on modeling of environmental benefits. Consistent with the imperative to improve and maintain the quality of carbon credits, while recognizing existing technological and scientific limitations, this Methodology required direct in-stream measurements of water quality.

Additionality

Green infrastructure programs designed to meet water quality obligations or goals, and thereby offsetting emissions associated with gray infrastructure, have variable and evolving effectiveness, costs, risks, and uncertainties. Further, the carbon credit revenue anticipated under this methodology is in most or all cases anticipated to be only a fractional contribution toward the project cost.

While green infrastructure is often projected to be more affordable than gray infrastructure, it is presently the preferred solution by most global water facilities because decision-makers work within a system that is heavily biased towards the certainty provided by technological upgrades and processes. In developed and highly regulated water management systems, distributed, nature-based solutions cannot 'guarantee' performance the same way established hardware technologies can.

Therefore, under this methodology additionality is sufficiently established as follows:

a.) The Project Proponent and/or Project Owner conducts an analysis consistent with the UNFCCC CDM "Tool for the demonstration and assessment of additionality". For avoidance of doubt, it is anticipated that proposed green infrastructure projects would usually be more financially attractive than gray infrastructure. Instead, the Project will likely establish additionality through the Barrier Analysis followed by the Common Practice Analysis.

AND:

b.) The water treatment facility (which may or may not also be the Project Owner and/or Project Developer) attests in writing that the anticipated carbon revenue enables green infrastructure water quality solutions that: 1) enable pre-permit action, and/or, 2) provides a necessary performance risk-reduction incentive, and/or c) in the case of projects already deployed at least in part, that the additional monitoring and verification requirements of this methodology strengthen the program performance and accountability.

Project Developer / Owner Obligations

This Methodology is necessarily broad in order to allow use across diverse program types, geographies, and regulations. As such, there is considerable responsibility devolved to the Project Plan Document produced by Project Developers and Owners, to translate the guidance provided into actionable, and verifiable, projects.

An outline of the methodology structure is shown in the following figure.

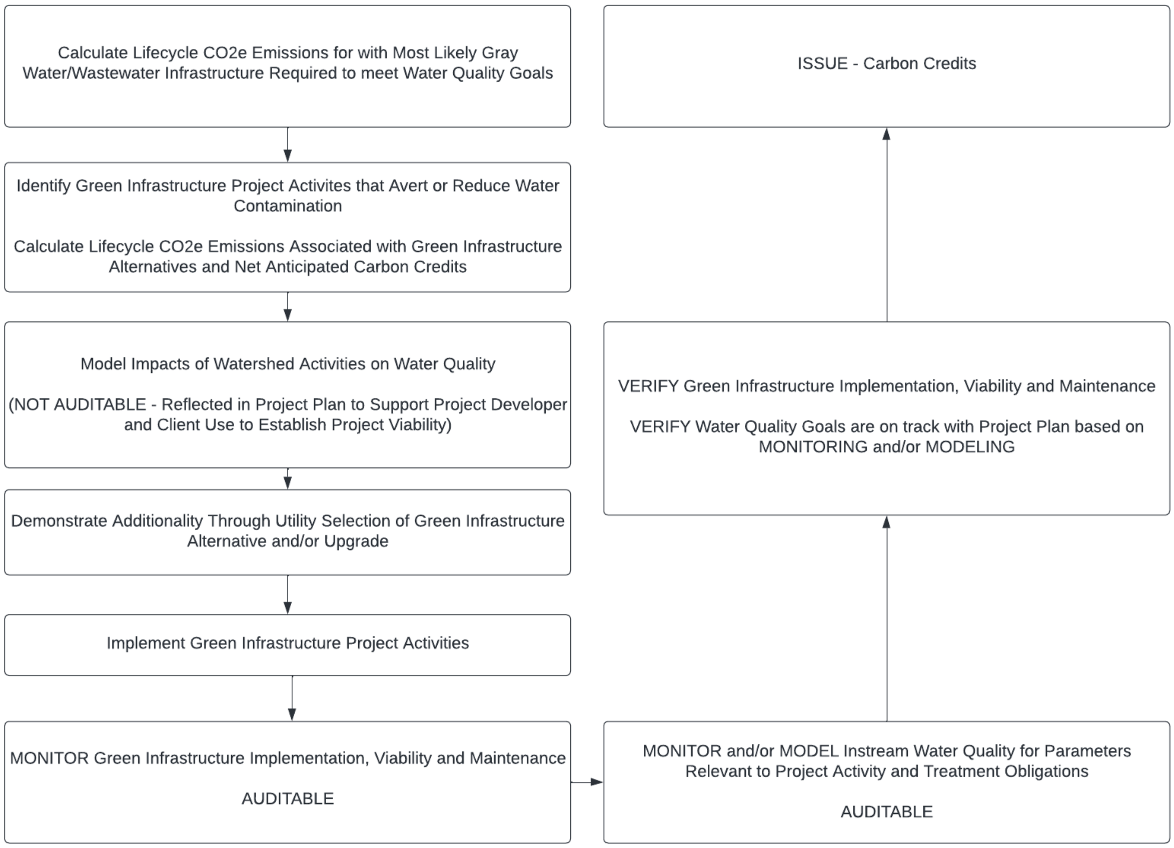

Figure 1: Methodology Overview

1.1. Scope

The methodology directs Project Proponents through the calculation of the GHG emissions avoided through the implementation of a green infrastructure program in a watershed, including the estimation of avoided energy and material use from the upgrading of water quality treatment facilities. The methodology also provides guidance on green infrastructure projects implemented in a watershed that improve water quality. The methodology includes a detailed description of the project activities, including the selection criteria for project sites, the design and implementation of projects, and the maintenance and monitoring of projects over time.

1.2. Normative References

The methodology refers to the latest approved versions of the following tools as guides. Project Developers will identify the most appropriate tools for their projects:

A. e-grid: The Emissions & Generation Resource Integrated Database (eGRID) is a comprehensive source of data from EPA's Clean Air Markets Division on the environmental characteristics of almost all electric power generated in the United States. This data set has the current grid emissions from teh differnt US regions.

B. NREL Cambium 2022 mid-scenario: Cambium data sets contain modeled hourly emission, cost, and operational data for a range of possible futures of the U.S. electricity sector through 2050, with metrics designed to be useful for forward-looking analysis and decision support.
C. TRACI 2.1: TRACI is an environmental impact assessment tool. It provides characterization factors for Life Cycle Impact Assessment (LCIA), industrial ecology, and sustainability metrics. Characterization factors quantify the potential impacts that inputs and releases have on specific impact categories in common equivalence units. Impact categories include ozone depletion, climate change, acidification, eutrophication, smog formation, human health impacts, and ecotoxicity.Resource uses of fossil fuels are also characterized.

D. Capdetworks: CapdetWorks is a tool for fast and accurate preliminary design and cost estimation of wastewater treatment plant construction projects. Eliminate cumbersome and time-consuming spreadsheet-based design algorithms.

E. ISO 14040: ISO 14040:2006 describes the principles and framework for life cycle assessment (LCA) including: definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the life cycle analysis phases, and conditions for use of value choices and optional elements.

F. EPA Water Quality Standards Handbook (2017)

G. EPA Water Quality Portal (WQP) - 380 million+ water samples from NWIS, STEWARDS, STORET, BIODATA, and others

H. USGS National Water Dashboard (NWD) - 13,500 observation stations.

I. EPA Surface Water Sampling - general and specific procedures, methods, and considerations to be used and observed when collecting surface water samples for field screening or laboratory analysis.

J. EPA CWA Methods for laboratory analytical methods.

1.3. Definitions

For the purpose of this methodology, the following definitions apply:

1. Additionality: Please refer to the corresponding Credit Class “GHG & Co-Benefits in Watershed Carbon” document for this definition of additionality specific to this Methodology.
2. Best Management Practice (BMP): BMPs include, but are not limited to, nonstructural and structural controls, operation, and maintenance procedures that can be applied before,

during, and after pollution-producing activities to reduce or eliminate the introduction of pollutants into waterways.

3. Baseline: The pollutant-specific discharge limits, BMP installation requirements, or both that must be met prior to generating credits for sale in a trading program.
4. Clean Water Act (CWA): The primary federal law in the United States governing water pollution, codified at 33 U.S.C. §§ 1251–1387.
5. Credit: A measured or estimated unit of pollutant reduction at a specified location, as adjusted by discount factors, trading ratios, reserve requirements and baseline requirements. For this methodology, the word ‘credits’ will be used to describe the units of avoided GHG emissions. The units of environmental improvements in watershed programs will be labeled ‘benefits’, though for many programs there is likely to be terms like ‘water quality credit’ used when describing watershed program transactions.
6. Exceedance: The difference between a regulated facility’s actual discharge and its effluent limit.
7. Load Allocation (LA): The portion of a receiving water's assimilative capacity that is attributed to existing or future nonpoint sources of pollution or to natural background sources by a Total Maximum Daily Load (TMDL).
8. Nonpoint Source: Diffuse sources of water pollution, such as stormwater runoff, that do not originate from a single, discernible source and is largely unregulated by the CWA.
9. Point of Maximum Impact (POMI)/Point of Concern (PoC): The point at which the greatest deviations from a particular water quality standard occurs, as identified by watershed-wide modeling (usually in a TMDL).
10. Point Source: Any discernible, confined and discrete conveyance that discharges pollutants, as defined in 33 U.S.C. § 1362(14). Point sources are subject to federal or state regulation under the CWA.
11. Project Proponent: the project developer or land steward that is applying to register a project on the registry.
12. Project Developer: the individual or organization that is in charge of managing the project and is the main point of contact with Regen Registry. The Project Developer can be the land steward or a third party.
13. Total Maximum Daily Load (TMDL): The maximum amount of a pollutant a waterbody can receive and still meet applicable water quality standards (accounting for seasonal variations and a margin of safety), including an apportionment of the allowable pollutant loadings to point and nonpoint sources.
14. Trading Ratio: A numeric value used to adjust credit values in order to address various forms of risk and uncertainty and to ensure net environmental benefits from credit transactions.
15. Wasteload Allocation (WLA): The portion of a receiving water's loading capacity allocated to existing or future point sources of pollution.
16. Water Quality Standard (WQS): Provisions of state or federal law which comprise a designated use(s) of a waterbody and water quality criteria necessary to achieve and maintain those uses.

17. Life Cycle Assessment (LCA): Methodology used to evaluate the environmental impact of a process or product. The methodology can utilize standard published Life Cycle Inventory (LCI) data. This data quantifies the environmental impact of standard products or processes.

2. Project Boundary

2.1. Spatial Boundaries

To ensure that the green infrastructure program is effective and can be accurately monitored and verified, project proponents must establish a clear project boundary. This boundary defines the area where the green infrastructure projects will be implemented and where environmental benefits will be claimed and monitored.

The project boundary should be defined based on the geographic scope of the green infrastructure program. This may include the entire watershed or specific sub-watersheds, depending on the program's objectives and resources. The project boundary will also include the water entity which may or may not be within a continuous boundary of the green infrastructure program.

3. Calculating Net GHG Reduction

The net GHG reduction is the difference between the emissions of the gray infrastructure (baseline) and the green infrastructure determined through robust, ethical life cycle assessment methodology. The calculator of emissions for gray and green infrastructure will follow standard life cycle assessment methodology and is required to be consistent in terms of functional units and systems boundaries. There are four phases in an LCA study: a) the goal and scope definition phase, b) the inventory analysis phase, c) the impact assessment phase, and d) the interpretation phase. Prior to performing the LCA the technologies to be compared must be defined.

3.1. Gray Infrastructure New Build Upgrade or Green Infrastructure Analysis

Completing a gray infrastructure new build or upgrade options analysis is an important step for project proponents to determine the feasibility of implementing traditional gray infrastructure new build or upgrades as compared to green infrastructure. Here are the steps that a project proponent needs to follow to complete an analysis of all options and determine the net environmental impact for each technology as well as the delta between options:

1. Identify the objectives of the project, including the specific parameters to be addressed, such as water quality, capacity, reliability, or regulatory compliance.
2. Conduct a site analysis to identify the existing conditions of the infrastructure, including age, condition, and capacity and identify gray infrastructure solutions that will meet water quality requirements.
3. Explore potential alternatives to traditional gray infrastructure new build or upgrades, such as green infrastructure, demand management, water reuse, or other innovative solutions.
4. Select a gray technology and a green technology. The two technologies must be comparable in terms of performance (achieve the required performance). It is expected

that the two selected technologies will not meet the exact same performance. Ultimately, the selection of technologies must both meet the same targets in terms of nutrient removal. In the example of water treatment, nitrogen and phosphorus are the targeted contaminants to be removed. It is acceptable for one of the technologies (gray or green) to over perform on the removal of one nutrient as long as it is meeting the same performance as the comparative technologies on the other nutrient. An example is green infrastructure removing “extra” or more nitrogen than a gray technology but the same amount of phosphorus. The selection of comparative technologies must be such that the water quality targets are being met. Additionally, the selection of technologies must be financially prudent.

5. Conduct a life cycle assessment of each alternative to evaluate the greenhouse gas emissions associated with construction, operation, and disposal or decommissioning. The life cycle assessment must use ISO 14040 standards for completing the greenhouse gas accounting with more details presented below. Once completed the difference between the gray and the green infrastructure is determined.

3.1.1. Calculating Environmental Impact of Water Treatment

Calculating the environmental impact through greenhouse gas accounting is an important step in evaluating alternative approaches (green infrastructure) as compared to traditional gray infrastructure new build or upgrades. Here are the steps that a project proponent must follow to calculate the greenhouse gasses of gray infrastructure and green infrastructure:

1. Develop an Engineering process model: Determine the expected energy and material consumption associated with the proposed treatment technology, including the energy and materials required for construction, operation, and maintenance. During this phase of the analysis the practitioner must accurately capture the performance of the technology including all unit process operations. The engineering process model is the foundation of life cycle assessment and must also account for the embodied materials and energy required for the delivery and construction of the facility. Apply the same accounting to all other proposed options including the green infrastructure.
2. Perform the Life Cycle Assessment accounting: Calculate the expected greenhouse gas emissions associated with the energy and material consumption, using appropriate emission factors for the specific energy and materials used based on established life cycle inventory. Detailed description of this process is presented.
3. Compare the life cycle greenhouse gas emissions of the proposed gray infrastructure new build or upgrades to alternative approaches, such as green infrastructure, demand management, water reuse, or other innovative solutions.

By conducting a comparison of gray infrastructure new build or upgrade and green infrastructure analysis and calculating the life cycle emissions of all proposed solutions, project proponents can make more informed decisions about the most effective and sustainable approach to addressing the identified objectives. Importantly, this comparison will enable the practitioner to report the difference in carbon dioxide equivalence for the competing technologies.

3.1.1.1 LCA Goal and Scope Definition

In the context of calculating the environmental impact of gray infrastructure or green infrastructure, the Goal and Scope Definition phase involves the following steps:

1. Defining the Goal: The first step is to clearly define the goal of the life cycle analysis. In this case, the goal is to compare the environmental impact of a gray infrastructure new build or upgrade to the environmental impact of a comparable green infrastructure project in order to make an informed decision on the most sustainable option for improving water quality in the watershed. A critical component here is the two technologies are achieving the same total water quality. Thus the goal is the greenhouse gas compassion of two equivalent technologies. It is acceptable for one technology to over perform on one nutrient as long as it is not underperforming on the other nutrient.
2. Establishing the Scope: The scope of the study should be established to ensure that all relevant processes and impacts are included in the analysis. This would involve identifying the system boundaries, which must include the entire gray infrastructure system, from the water treatment plant to the distribution network, and the associated energy and resource inputs and outputs. The system boundary must be consistent across all compared solutions and should only include the direct impacts and not indirect impacts such as indirect land use.
3. Defining the Functional Unit: The functional unit is a quantifiable measure of the performance of the system being assessed. In this case, the functional unit would be defined as the total amount of nutrient removed while meeting the required water quality requirements. The latter is established through the selection of technologies. The former (total nutrient removed) is the formal functional unit to be used in the LCA. The results should be present on the abyss of total nitrogen removed in the case when this is the limiting nutrient and on the basis of total phosphorus when this is the limiting nutrient.The concept being, the technologies to be compared are expected to perform differently with one over performing on one of the targeted nutrients to be removed. The analysis should thus be compared on the nutrient that is defining the size of the system.
4. Identifying Impact Categories: The impact categories to be assessed should be identified to ensure that all relevant environmental impacts are considered. In this case, the impact category will be global warming potential on the metric of greenhouse gas emissions. The accounting process must include all greenhouse gasses with results presented on a carbon dioxide equivalence with more details presented below.
5. Specifying Data Requirements: The data requirements for the life cycle analysis should be specified to ensure that the study is based on accurate and relevant information. This may include data on energy and resource inputs and outputs, emissions, and waste for both the gray and green infrastructure options. A critical component is defining the evolution of emissions over time from electricity or any other material that is expected to change dramatically in the near future (100 years)..
6. Establishing Assumptions: Finally, any assumptions made during the life cycle analysis study should be documented to ensure that they are transparent and can be verified. This may include assumptions about the expected life cycle of the gray infrastructure new build

or upgrade, the maintenance requirements of the green infrastructure, and the expected energy and resource savings from the green infrastructure option. Assumptions need to be shown to not dramatically impact results.

By following these steps, the Goal and Scope Definition phase of the life cycle analysis study can ensure that the analysis is comprehensive, transparent, and scientifically rigorous, providing a solid foundation for the subsequent phases of the study.

3.1.1.2 Selection of the functional unit and system boundaries

The functional unit for an analysis of water treatment is defined here as the total amount of nutrients removed from the water. This functional unit will be used to normalize data in the life cycle inventory (LCI) phase. The service performance of water and wastewater treatment plants is associated with the pollutant load removed, which is often legislated. While a volumetric-based functional unit is the most common, it ignores differences in water quality and potential dilution effects. Adopting a functional unit that reflects influent or effluent pollutant loads and operation targets in terms of water quality is to specific for the methodology. For the gray infrastructure, the system designed is required to hit a specific discharge concentration. For the green infrastructure system, the discharge quality is not prescribed but rather a total nutrient removal. For the comparison of these two technologies the functional unit is total mass of nutrient removed. In treatment systems, typically nitrogen and phosphorus are the targeted pollutant. The performance of the two systems in terms of total nitrogen and phosphorus removed is expected to be different. Thus the functional unit should be the nutrient that is the limiting factor.

System boundaries must be appropriately chosen to ensure comparable results. All unit process operations required for water treatment must be included, and all inputs and outputs relevant to the purpose of the study must be considered. For gray water and green infrastructure this includes all capital infrastructure, operational energy, materials required, and end of life energy and material disposal for treatment. Inclusion of capital infrastructure emissions and end of life emissions is required.

3.1.1.3 Life cycle inventory analysis (LCI) phase

The inventory phase of the process-based life cycle analysis approach involves collecting data on inputs (e.g. materials, energy, resources) and outputs (e.g. emissions to air, water, and soil) of the system, including construction, operation, and end-of-life. End of life refers to the final stage of the system's life cycle. It encompasses activities such as disposal, recycling, or other forms of waste management that occur after the useful life of the system.

- The first step for performing the life cycle assessment is creating a process flow diagram that accurately represents the modeled process, detailing all energy and mass inputs and outputs. This is fully defined above (engineering process modeling).
- The next step is collecting emissions intensity data, which can be sourced from various databases providing life cycle inventory data.
    - Emissions data may come from eGRID, or other transparent and verifiable databases, some recommendations of which are given later and include the

modeling of the evolution of the grid based on NREL estimates with additional references suggested to support.
  - Ecoinvent is a widely used database for life cycle assessment (LCA) data. It provides detailed information on the environmental impacts and resource use associated with various products and processes.

These two sources are suggestions. The highest quality LCI data should be used when doing analysis. It is essential to disclose energy and mass balances as well as life cycle inventory data for verification.

3.1.1.4 Life cycle assessment (LCA) phase

The focus of this methodology is the calculation of the greenhouse gas emissions associated with gray and green infrastructure. In this step the life cycle inventory data is combined to assess the greenhouse gas emissions of the systems. This methodology requires the inclusion of all greenhouse gas emissions combined into a carbon dioxide equivalence unit. The equivalence factors for all greenhouse gasses must be the most recent from the IPCC . An example of this is the use of 1, 29, and 273 based on AR6 as equivalence factors for CO2, Ch4, and N2O, respectively.

Co-product credit methodology: Some systems will generate co-products in the form of products or energy. An example of this is the treatment of water with the production of energy and concentrated nutrients from the anaerobic digestion of sludge with methane generated and used onsite for the production of electricity through a combined heat and power system and concentrated nutrients land applied. In this example situation where there is a co-product, the displacement method should be used to determine the credit associated with the co-product. Specifically, the produced product is assumed to displace a current product. In the example of electricity production from a system, the produced electricity is assumed to displace the local average grid electricity. The land applied sludge is assumed to replace traditional fertilizer. In greenhouse gas accounting the system is given as a greenhouse gas credit for the production of electricity and fertilizer that would not need to happen traditionally.

Geospatial considerations: Local life cycle inventory data should be used whenever possible. Electricity is a good example. EIA or EPA data for localized GHG emissions should be used. (It is important to note that the electrical grid is expected to continue to become cleaner over time. This methodology does require the inclusion of grid evolution due to uncertainty in the future grid (details below) with results revised every 5 years with models updated.) During life cycle assessment work evolution of grid emissions needs to be considered with practitioners encouraged to have multiple sources/predictions.

3.1.1.5 Life cycle interpretation phase

This includes the critical evaluation of results including a direct comparison to existing literature. The ISO 14040 standard includes three steps in support of this effort. First is considering the results in terms of the impact of relative contributions of the life cycle stages. Second, evaluation is performed, including completeness, sensitivity, and consistency checks. Lastly, conclusions and recommendations are documented. During this phase, results that are dramatically different than those reported in the literature the work needs to be re-evaluated and verified for accuracy.

3.1.1.6 Grid Energy Mix GHG Updates

It is important to note, the electrical grid is evolving with more and more renewable energy being integrated and fossil fuels being eliminated. This dramatically changes the greenhouse gas intensity of the grid. This methodology requires using the current projections of the grid emissions based on NREL Cambium 2022 mid-case which can be accessed here for all US based analysis: https://scenarioviewer.nrel.gov/.

Some locations might have other models and better predictions for grid emissions. =The suggested Cambuim dataset represents a suggestion with the practitioner encouraged to use the most appropriate dataset for future grid emissions.

3.1.1.7 Credit Calculations

The carbon credit is the difference in emissions between the two water quality management approaches. It is expected the gray infrastructure system will be a net greenhouse gas emitter. In some cases the green infrastructure system has the potential to be a net negative carbon system. The credit calculation will be done through taking the total emissions determined for the gray infrastructure minus the green infrastructure emissions. In the case when the green infrastructure is negative then the total greenhouse gas savings will be the gray greenhouse gas emissions plus the greenhouse gas emissions savings for the deployment of green infrastructure.

3.1.1.8 Reporting and critical review of the LCA

Transparency in life cycle analysis is critical and is foundational in life cycle analysis reporting. The reporting of results needs to include all foundational assumptions including implemented methodology. The reporting should be sufficient to where the work can be regenerated by a seasoned life cycle analysis practitioner. The reporting must include functional units, system boundary, detailed process flow diagrams of the treatment process evaluated, and references to all data. The work developed will support the evaluation of the greenhouse gas emissions reductions from green infrastructure which will simply be the delta between gray infrastructure and green infrastructure. The reporting must include sufficient information to support reproducible science. Specifically, the life cycle analysis reporting section will include complete methods sufficient for the regeneration of results with the publishing of foundational models encouraged.

3.1.1.9 Data Sources

The following data sources are recommended for the LCA:

- Grid Emissions: NREL Cambium 2022 mid scenario
- CO2-eq factors: EPA's Tool for Reduction and Assessment of Chemicals and Other Environmental Impacts (TRACI).
- Energy data: The U.S. Energy Information Administration (EIA) provides various kinds of energy data that may be useful for the LCA.
- The Ecoinvent Database is a Life Cycle Inventory (LCI) database that supports various types of sustainability assessments.

- U.S. Life Cycle Inventory (USLCI) Database, published through the National Renewable Energy Laboratory.

3.2. Temporal Resolution

The current temporal resolution of the analysis is defined as 30 years. This is a standard timeline of analysis in the field of sustainability. It is acknowledged that a deployed green technology would be in play for longer than 30 years and there is the ability to reissue credits at the end of current evaluation period (30 years). It is expected that the grid will be cleaner by this point but not carbon zero. The proposed methodology would apply to a reissuance of carbon credits at 30 years.

4.0 Green Infrastructure Project Activity Design

Green infrastructure projects are highly variable in concept and design. Example project types are provided in the corresponding Credit Class for this Methodology. Some project types and/or geographies may have established methods and legal requirements. Other project types and/or geographies may require custom or novel designs.

This Methodology is designed to calculate GHG emission reductions based on the avoided use of grid electricity and gray infrastructure, in favor of alternative, low- or no- emitting green infrastructure to meet water quality goals.

Project Proponents are required to apply the life cycle analysis described in the previous section to account for and subtract GHG emissions associated with the green infrastructure.

If the green infrastructure solution includes any carbon sequestration benefit (i.e., biomass or soil carbon sequestration), Project Proponents may separately account for and seek issuance of associated potential carbon credits.

Because both the green infrastructure projects are highly variable, and because carbon credits are calculated only on the avoided gray infrastructure emissions, it is outside the scope of this Methodology or associated Credit Class to prescribe the design approach for the green infrastructure.

Instead, Project Proponents are obligated to demonstrate that the gray infrastructure was avoided in favor of the green infrastructure alternative, and that water quality goals are met.

Therefore, the balance of Section 5 of this methodology is provided as advisory guidance for project proponents and is not auditable by third-party verifiers.

The first step in this phase is to assess the current water quality conditions in the watershed and identify areas that require improvement. This involves analyzing data on pollutant loads and sources, identifying impaired waterbodies, and assessing the potential impacts of climate change on water quality. Once areas for improvement have been identified, the next step is to evaluate potential green infrastructure projects that could be implemented to address these issues. Criteria for evaluating and selecting green infrastructure projects may include factors such as cost-effectiveness, environmental benefits, feasibility, and community support.

The project proponent may collect baseline data on the current water quality conditions in the watershed before the project activity begins. This data will be used to establish a baseline against which the impacts of the proposed project activity can be compared. The proponent may then use watershed models to simulate the impacts of the proposed project activity on water quality.

The project proponent may use an appropriate watershed model that is widely accepted within the scientific community and that is relevant to the specific watershed. The model may be used to simulate the impacts of the proposed project activity on water quality for a range of possible scenarios, such as varying levels of precipitation or different land use patterns.

The project proponent may also conduct a sensitivity analysis to identify the key inputs and assumptions that are driving the model results. This will help to identify the areas of greatest uncertainty in the modeling results and inform any necessary adjustments to the project design or monitoring plan.

Finally, the project proponent may compare the modeled impacts of the proposed project activity to the baseline water quality conditions in the watershed. This comparison should conservatively demonstrate that the proposed project activity will maintain or improve water quality in the watershed. The methodology should provide clear and transparent documentation of the modeling methods, assumptions, and results, including any limitations or uncertainties associated with the modeling.

5.0 Implementing the Watershed Program

The project proponent and key project stakeholders (water treatment facility staff, regulatory agency staff) must agree to the site selection priorities, and proponent must obtain appropriate approvals from landowners and any necessary authorities.

Site preparation is an important step in implementing a green infrastructure project, and it involves preparing the land for the installation of the green infrastructure. This can involve activities such as removing vegetation, grading the land, and installing erosion control measures. Any site preparation activities must not have a long term negative impact on water quality or ecosystem function. The Project Proponent should denote which local, state or federal best management practices they are using to guide implementation of site preparation and project activities. Examples of local/state/federal BMP definitions for riparian restoration are: the

Johnson Creek Watershed Council, South Carolina Department of Natural Resources (), and US EPA.

After site preparation is complete, the Project Proponent can proceed with installing the green infrastructure based on design plans. The Project Proponent should ensure that all installations are conducted in accordance with best management practices and that all necessary permits and approvals are obtained.

The Project Proponent must develop a long-term maintenance plan that includes periodic maintenance activities, such as bi-annual or annual inspections performed by Project Proponent or local contractors, and identifies the party responsible for carrying out the maintenance activities. This plan should also include a budget for maintenance activities, as well as a plan for monitoring and reporting the performance of the green infrastructure over time and making adjustments as needed.

6.0 Water Quality Monitoring, Reporting, Verification

This section outlines the procedures and protocols for monitoring and reporting on water quality impacts resulting from the implementation of the program, consistent with the Credit Verification and Release Schedule in the associated Credit Class document for this methodology.

A variety of monitoring approaches can be used to monitor changes or maintenance of in-stream water quality. In-situ sensors can measure water quality parameters such as Dissolved Organic Matter (DOM), pH, temperature, and dissolved oxygen in real-time, providing detailed data on changes in water quality. Remote sensing technologies can be used to monitor changes in land use and vegetation cover, which impact water quality. Observational sample collection and laboratory analysis can provide a point-in-time estimate of water quality and validate other approaches. Mechanistic and statistical models can be used to simulate the effects of watershed protection activities on water quality. Together, these tools can quantify the impacts of watershed protection activities on water quality and the environment.

6.1 Parameters

Parameters for this methodology are often set by regional regulations, or in their absence, state regulations, or in their absence, national standards.

Specific parameters used in existing watershed solutions and supported by this methodology are:

- **Temperature** - see example Temperature Standard IMD from the Department of Environmental Quality, Oregon USA.
- **Phosphorus** - see example Lake Winnipeg trading system architecture, Manitoba Canada.

- **Nitrogen** - see proposed nitrogen trading application in Suffolk, England, the Taupo Nitrogen Market in New Zealand, or the Nitrogen Control Program for the Long Island Sound in New York, USA.
- **Five-Day Carbonaceous Biochemical Oxygen Demand (CBOD5)** - see example Rahr Malting trading program in Minnesota, USA.
- **Total Suspended Solids** - see example Adaptive Management webpage from the Department of Natural Resources, Wisconsin USA.
- **Selenium** - see example Grasslands Bypass Project in the Central Valley of California, USA.
- **Salinity** - see example Hunter River Salinity Trading Scheme in New South Wales, Australia
- **Quantity** - see example JAWRA article on water transactions in Western USA.
- **Mercury** - see example Mercury Offset Program evaluated by Regional San of Sacramento, USA.
- Other parameters such as Dissolved Oxygen, Acid, Metals, and Ammonia have been studied and modeled by regulatory agencies and regulated entities in the USA and elsewhere.

Generally the parameters that a project manager should consider are clearly defined by national, regional, state or water-body quality standards. The following references are provided as guidance only - project proponents must select water quality standards appropriate to the specific context of the project activity. Local standards are more restrictive than national, and where they exist must be the focal point for this methodology.

1. State-specific water quality standards effective under the CWA
    a. E.g. Colorado Regulation No. 31 (Tables I-III, p. 54); Oregon Water Quality Standards (Table 40, p. 107)
    b. E.g. Colorado Regulation No. 38:
2. Water quality criteria tables - dependent on designated uses (aquatic health, recreation, domestic water supply, and agricultural, industrial, navigational and other)
    a. E.g. Human Health Criteria Table includes 125 contaminants

6.2 Setting Water Quality Targets

Water Quality targets are established by the Project Proponent and the Client Facility, and other stakeholders. These Targets are based on achieving the Client Facility water quality obligation (i.e., a temperature or nutrient reduction), through water quality trading approach. The Project Proponent must describe in the Project Plan the relevant water quality targets.

6.3 Estimating Water Quality Benefits

In order to determine the effect of an upstream or upland best management practice (BMP) on a downstream point of concern for each water quality parameter, it may be necessary to use multiple models.

These models often consist of combinations of other models representing different processes, such as water balance, crop growth, and soil erosion, and can be composed of both empirical and mechanistic models.

To quantify the water quality benefits of a green infrastructure project, the project proponent should take the following steps:

1. Identify Relevant Methods and Select a Model: Project proponents should select the most applicable existing water quality model from those developed by federal or state agencies to quantify the water quality benefits of their project. They should review the model's documentation to ensure that it is capable of simulating the necessary processes, and that it can be applied to their specific project site.
2. Adapt to Local Conditions (Set-Up and Refine): Once a model has been selected, it must be adapted to the local conditions of the project site. This may include the input of site-specific data, such as soil characteristics, land use, and climate data, and calibration of the model to local conditions through comparison of model predictions to measured data.
3. Technical Review: The model should be reviewed by technical experts in the field of water quality modeling to ensure that the model is applied correctly and that the results are valid.
4. Direct Monitoring: Direct monitoring of water quality should be conducted to validate the model's predictions and confirm the water quality benefits of the green infrastructure project.

In the Project Plan the Project developer must include a map and a justification for the selection of the locations, based on the consideration of the above factors, proving locations are appropriate/ best located within the possibilities and the local experts knowledge to be representative.

6.4 Setting Water Quality Baseline

The setting of a water quality baseline is an important step in the project development process. It establishes a starting point for measuring water quality improvements resulting from the project activity. Instructions for setting a water quality baseline:

1. Identify the location and boundaries of the project site, including the watershed that it is located within.
2. Determine the parameters that will be used to measure water quality. Common parameters include dissolved oxygen, pH, temperature, total suspended solids, turbidity, and specific pollutants such as nitrogen and phosphorus compounds.
3. Identify the existing water quality conditions in the project area. This may involve collecting and analyzing water samples from streams, rivers, and other water bodies in the watershed.
4. Establish a baseline water quality for each parameter. This baseline should reflect the average water quality conditions over a sufficient period of time (e.g. several years) to capture seasonal and annual variations in water quality.
5. Consider any relevant regulatory requirements or water quality standards when establishing the baseline. For example, if there are established Total Maximum Daily Loads (TMDLs) for a particular pollutant in the watershed, the baseline should reflect compliance with those TMDLs.

6. Document the baseline conditions in a clear and transparent manner. This documentation should include a summary of the water quality parameters, the methodology used to collect and analyze data, and the resulting baseline values.
7. Once the baseline has been established, it can be used as a reference point to measure water quality improvements resulting from the project activity.

6.5 Data Sources

Project proponents may directly measure water quality, or provide data collected through existing monitoring programs including public data sources.

Project proponents must provide water quality data with at least as much frequency as required by relevant regulatory authorities, for each parameter of interest, but in no case less frequently than three times per year.

6.6 Monitoring Locations

The project proponent must actively measure water quality within the project boundary to demonstrate either improvement or maintenance of relevant water quality parameters compared to the Baseline and Targets.

The monitoring locations are the specific points within the watershed where water quality samples will be collected and analyzed to evaluate the effectiveness of the green infrastructure projects and reduced treatment demand at the facility. The selection of monitoring locations is critical for the success of the monitoring program, as they must be representative of the impacts of the projects on water quality in the watershed.

At minimum:

- The project proponent must collect data from at least one control site, i.e., a location within the river that is upstream of the target contamination and green infrastructure remediation project boundary.
- The project proponent must collect data in proximity to the water treatment facility supply discharge.
- The project proponent must collect data in proximity to the green infrastructure activity.
- The project proponent may collect data in proximity to the POMI.
- All water quality collect locations must be well-mixed, i.e., not stagnant or contained water.

Further, when selecting monitoring locations, the following factors should be considered:

1. Proximity: Monitoring locations should be in close proximity to the green infrastructure project and to sites in the watershed that are strategic to the facility to capture the effects of the project on water quality.
2. Diversity of land use: Monitoring locations should be representative of the different land uses within the watershed, such as residential, agricultural, and industrial, to capture the variability in water quality within the watershed.

3. Hydrological connectivity: Monitoring locations should be located on the same stream or water body as the green infrastructure project to capture the effects of the project on downstream water quality.
4. Accessibility: Monitoring locations should be accessible to field crews for routine water quality sampling.
5. Historical data: Existing water quality data should be used to help guide the selection of monitoring locations to ensure continuity with previous monitoring efforts.

Overall, the selection of monitoring locations should be based on a combination of scientific principles and practical considerations to ensure the accuracy and relevance of the water quality data collected.

6.7 Data Accuracy

To ensure the accuracy of the calculations, all data collected must be reliable and consistent. The following guidelines should be followed:

1. Standardized methods and protocols should be used for sampling and analysis.
2. Quality control measures should be put in place to identify and address any errors or inconsistencies in the data.
3. Regular calibration of monitoring equipment is necessary to ensure accuracy and consistency of measurements.
4. All calculations must be reviewed and verified by qualified professionals to ensure accuracy and consistency.

6.8 Technology

Monitoring of water quality can be accomplished through a variety of techniques, ranging from traditional grab sampling to advanced sensor technologies. A inclusive but not exhaustive list of technology options is presented as guidance below:

Grab Sampling: Grab sampling is a method of collecting water samples that involves physically obtaining a water sample at a specific location and time. Grab samples are typically collected using a sample bottle or container that is designed for water sampling. To ensure that the sample collected is of high quality and suitable for analysis, several procedures and standards must be followed. The container used for sampling must be made of an appropriate material such as borosilicate glass or high-density polyethylene (HDPE) and must be thoroughly disinfected and rinsed with the sample water before use. The sample must be collected at the right depth, ensuring that the sampling location is representative of the water quality at that location. The sample should be stored in a cooler or icebox at the correct temperature and transported to the laboratory for analysis as soon as possible after collection.

Laboratories performing water quality analysis must adhere to a variety of standards and certifications to ensure the accuracy and precision of their results. In the United States, the Environmental Protection Agency (EPA) has established a series of standards and methods for water quality analysis. Laboratories performing water quality analysis should follow the EPA's guidelines for quality assurance and quality control. Additionally, laboratories should be certified by a recognized accrediting body such as the National Environmental Laboratory Accreditation Program (NELAP) or the American Association for Laboratory Accreditation (A2LA).

Sensors: Advanced sensor technologies can provide continuous and real-time water quality monitoring data. These sensors can be placed in a water body and remotely transmit data to a central database for analysis. Sensors can measure a wide range of parameters such as dissolved oxygen, pH, temperature, turbidity, and conductivity. The use of sensors can reduce the need for manual sampling and provide more accurate and frequent data. However, it is important to note that sensors may require regular maintenance and calibration to ensure accuracy.

Further, sensor data may be combined with other data sources and statistical and mechanistic models capable of yielding quantified or semi-quantified results. These technology combinations are acceptable if demonstrated to be at least 75% accurate and if the conservative bound of the 80% confidence interval is reported.

6.9 General References

These sources can be used as a guide for project proponents to deepen their understanding of specific aspects of the program, as well as to provide a basis for further research and exploration. The references cover a wide range of topics, from best management practices to technical standards, and are intended to be a comprehensive resource for anyone involved in the implementation of a watershed green infrastructure program.