Town of Lyons Stormwater Masterplan

ICON Engineering, Inc.

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Contents

1.0 Introduction

1.1 Authorization

This study was authorized by the Town of Lyons, under contract with ICON dated xxxx.

1.2 Purpose and Scope

The purpose of this study is to develop a comprehensive stormwater master plan for the Town of Lyons. The focus of the study is to:

- Quantify stormwater runoff and quantity
- Identify potential flood hazards and problem areas for subbasins tributary to North St. Vrain Creek, South St. Vrain Creek, and St. Vrain Creek, as they flow through the Town
- Identify and prioritize capital improvement projects to reduce flood frequency and flood risk
- Recommended improvement to enhance water quality and meet other sustainable objectives
- Provide a guide for redevelopment within the Town of Lyons.

The original drainage master plan for the Town of Lyons was completed by BRW, Inc. in 1998. This study will provide and update to the 1998 plan.

The following is a summary of the scope of work completed for the Town of Lyons Storm Drainage Master Planning study:

- Data Collection and Review
- Field inventory of existing stormwater features
- Baseline Hydrology and Hydraulics
  - Document rainfall using NOAA Atlas 14
  - Develop a basin-wide two-dimensional hydrodynamic model to estimate general flow paths within the watershed.
  - Define individual subwatershed boundaries
  - Develop hydrologic models for the 2-, 5-, 10-, 50-, and 100-year return period storms subject to the following guidelines:
    * Use the Colorado Urban Hydrograph Procedure (CUHP) to generate basin runoff hydrographs

    * Use the Environment Protection Agency Storm Water Management Model (EPA SWMM) to route the individual hydrographs
    * Evaluate the performance of existing storm drain infrastructure 24 inches or greater in size
  - Identify residual flood potential within the basin using a two-dimensional hydrodynamic model, such as FLO-2D

- Alternatives Analysis
  - Identify existing and future potential drainage and water quality problems along tributary paths to North St. Vrain Creek, South St. Vrain Creek, and St. Vrain Creek, as they flow through the Town
  - Document existing wetland and riparian zones along the outfall paths
  - Develop and evaluate alternative plans on an outfall-by-outfall basis to reduce flooding potential on insurable structures and to provide water quality treatment
  - Estimate benefits of flood reduction

- Conceptual Design
  - Development of a selected plan, refined to an approximate 20% design level
  - Identify a Phasing and Prioritization Plan for improvements

1.3 Mapping and Survey

One foot interval contours were generated from LiDAR project mapping. Project mapping was based on Federal Emergency Management Agency (FEMA) 2013 Post-flood LiDAR mapping with the following attributes and is equivalent to 1-foot contour interval topographic mapping:

Name: 2013 South Platte River Flood Area 1
Collection Date: Fall 2013 - Spring 2014
Vertical Accuracy: 9.25 cm RMSE
Point Spacing: 0.7 m
Vertical Datum: NAVD88
Horizontal Datum: NAD83

Survey data at existing storm drains and sewers were collected by ICON Engineering and associated sub-consultants as part of this contract. All survey was also gathered on NAD83 horizontal datum and the NAVD88 vertical datum.

1.4 Data Collection

A summary of reports reviewed alongside the preparation of this report are presented below:

Table 1-1: Data Collected

Document Title	Date	Author
Town of Lyons, Boulder County, Colorado, Drainage Master Plan Final Report	April 1998	BRW, Inc.
Zoning District Map of the Town of Lyons, Colorado	January 2009	King Surveyors, Inc.
2010 Lyons Planning Area Map	2010	Civil Resources
Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual		UDFCD

2.0 Study Area Description

2.1 Project Area

The project area includes the subbasins tributary to the North Saint Vrain Creek, South Saint Vrain Creek, Red Hill Gulch, and Stone Canyon within the Town of Lyons. The total drainage area studied is approximately 8.6 square miles.

Existing drainage in the Town reflects open channel drainageways in combination with storm sewer conveyance for more urbanized areas. Most of the Town's existing drainage infrastructure is undersized due to the increase in development within the Town during the 1990s. The existing conveyance system has the capacity to convey nuisance flows, but it does not have the capacity to convey even the minor (5-year) storm events.

2.2 Land use

The study area watershed is comprised of a combination of Hydrologic Soil Group (HSG) A, B, C, and D soils as classified by the Natural Resources Conservation Service (NRCS). These soil types are very intermixed with HSG A soils (i.e. soils with increased hydrologic conductivity) covering areas such as downtown locations, and north-south along the eastern basin limits. HSG B soils cover the least area in the watershed, with locations predominately along Saint Vrain Creek, and north and south branches. HSG C soils are represented along a north-south plane, along the easternmost portions of the watershed. Finally, HSG D soils (i.e. soils with the least potential for hydrologic conductivity) represent the greatest are of the watershed and are predominately located towards the northern and western watershed limits, covering rock outcrops and other less permeable sources. A soil map of the watershed can be found in *Appendix B.*

It should be noted that for the study area, the HSG A soils are colluvial land type soil. According to the colluvial land soil description, the depth to restrictive feature is 2 to 60 inches to lithic bedrock. Because of the underlying bedrock, it was assumed that the HSG A soils would have the drainage characteristics of HSG B soils.

This is a sample picture

Land use was determined by compiling information from the 2009 Zoning District Map, 2010 Lyons Planning Area Map, and by ground-truthing the land cover based on an October 2015 aerial image of the watershed. Each land use category was assigned a percent imperviousness with guidance from Chapter 6 - Runoff of the UDFCD Urban Storm Drainage Criteria Manual. Table 2-1 outlines the land use categories and the corresponding percent imperviousness. In addition to the land use categories found in Table 2-1, Boulder County Open Space land use represented a significant portion of the watershed. Table 2-2 displays the soil types used to calculate imperviousness for the Boulder County Open Space land use category.

Table 2-1: Land Use Description

Land Use Category	UDFCD Equivalent	Imperviousness
Agriculture	Undeveloped: Greenbelts, agricultural	2%
Business	Business: Downtown areas	95%
Park	Parks, cemeteries	10%
Municipal Facilities	Business: Suburban areas	75%
Estate Residential1	Residential: Single Family: 2.5 acres or larger	35%
Low Density Residential1	Residential: Single Family: 0.25-0.75 acres	75%
Medium Density Residential1	Residential: Single Family: 0.75-2.5 acres	85%
Commercial	Business: Downtown areas	95%
Employment Area	Business: Downtown areas	95%
Commercial Entertainment	Business: Downtown areas	95%
Light Industrial	Industrial: Light areas	80%
General Industrial	Industrial: Heavy areas	90%

Table 2-2: Soil Types Found in Boulder County Open Space Land Use Category

Soil Unit	HSG	Soil Type	Drainage Class	Runoff Class	Rock Outcrop	Imperviousness
MdB	A	sandy loam	well	very low		2%
Nh	B	loam	poorly	very low		2%
Cu	A	gravelly sandy loam	excessively	low		5%
NnB	C	sandy clay loam	well	medium		8%
SmF	C	stony loam	well	high	10%	10%
BaF	D	very stony sandy loam	well	very high	10%	10%
PrF	D	very stony loamy fine sand	well	very high	35%	35%
Ro	D	unweathered bedrock	N/A	very high	100%	100%

It should be noted that land use category corresponds to the 2010 Lyons Planning Area Map. However, in some cases, the planning description and corresponding lot size were not representative of what is observed through aerial imagery and field reconnaissance. In these cases, the imperviousness percentages were revised to be more representative of what was observed.

Future imperviousness was determined by comparing the land use in the 2010 Lyons Planning Area Map to current aerial imagery, and noting which areas of the Town could be further developed based on the planning guidance.

2.3 Outfall Descriptions

Outfalls within the watershed were categorized based on their spatial location whether the outfall discharges into the Greeley No. 3 Canal or to the Cache La Poudre River.

An inventory of all major storm drainage structures can be found in *Table 4-1* and *Table 4-2*.

An outfall map can be found in *Figure 2-2* and on the interactive map in *Appendix B*.

3.0 Hydrologic Analysis

3.1 Overview

For this study, a new hydrologic model was prepared for the Town of Lyons. This purpose of this model was to develop updated hydrology for the 2-, 5-, 10-, 50-, and 100-year storm frequencies for both existing and future imperviousness. Similar to the 1998 BRW study, the UDFCD's Colorado Urban Hydrograph Procedure (CUHP) was used to develop runoff hydrographs for each sub-basin in the study. However, with the recent release of CUHP v2.0 by the UDFCD, and that Lyons is located outside of the UDFCD boundary, further investigations were made to confirm the applicability of the new CUHP software in comparison to other hydrologic methods. The selection of the hydrologic model is discussed below.

3.2 Hydrologic Model

To evaluate the latest version of CUHP (and other hydrologic methods) and to determine the appropriate model inputs, a peak flow sensitivity analysis was conducted for a typical undeveloped sub-basin near the Town, using various hydrologic techniques. The following lists the hydrologic methods that were reviewed in the sensitivity analysis:

- United States Geologic Survey (USGS) Regional Regression Equations.
- Rational Method.
- CUHP 2005 Version 1.4.4 – This is the more recent model used by UDFCD (prior to the recent update) and has been used for over 40 years to estimate peak flows in the Denver metropolitan area and front range.
- CUHP Version 2.0 – Recently the UDFCD has determined that peak flows developed in recent hydrologic studies using CUHP 2005 version 1.4.4 deviated from statistical stream gage analysis across the District and created uncertainty with CUHP model results for some studies. Additionally, CUHP 2005 version 1.4.4 has not been calibrated with gage data since its inception in the 1970s with adjustments made in the 1980s. Therefore, UDFCD has recalibrated CUHP with updated rainfall and runoff with results tested against stream gage frequency analysis. However, it should be noted that during the recalibration of CUHP, there were no watersheds with an imperviousness less than 20 percent. Therefore, for sub-basins with imperviousness below 20 percent, the peak flows are estimated using similar methodology used in CUHP 2005 version 1.4.4.
- HEC-HMS Model - using Curve Number method.
- UDFCD Allowable Release Rates – The UDFCD Urban Storm Drainage Criteria Manual, Volume 2, Storage chapter provides pre-development peak unit discharge rates for watersheds of various slopes and Hydrologic Soil Groups (HSGs) that are utilized to determine the maximum allowable 100-year release rates for a full spectrum detention facility.

Based on the results of the undeveloped sub-basin peak flow sensitivity analysis, CUHP version 2.0 was recommended for the hydrologic modeling for the Lyons storm drainage master plan. The unit rates of runoff from CUHP version 2.0 were generally in the same range as those generated using the Rational Method, in addition to the UDFCD allowable release rates. The unit rates of runoff generated using CUHP 2005 version 1.4.4 were higher than any of the other hydrologic methods which potentially would overestimate the peak flows for the Town. The regional regression equations significantly underestimated the unit rates of runoff when compared to the other hydrologic model methods. Further documentation on the hydrologic model recommendations can be found in Appendix B.

3.3 Design Rainfall

The design rainfall for the project was derived using the one-hour precipitation depths from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14. One-hour point precipitation depths were based on the centroid of the entire project area and were recorded for the 2-, 5-, 10-, 50-, and 100-year recurrence intervals. Point precipitation depths for varying elevation within the project area were identified, but point precipitation depth adjustments due to elevation were not necessary since the difference in the one-hour precipitation depths by elevation was less than 0.1 inches. Using the one-hour precipitation depth, CUHP calculates the incremental depth for each time increment from 5 to 120 minutes. Due to the smaller sizes of sub-basins, precipitation depth-area reduction factors were not utilized. Table 3-1 summarizes the design rainfall depths for various recurrence intervals.

Table 3-1: 1-hr Rainfall Depth

Return Period	1-Hr Rainfall Depth (in)
2-yr	0.77
5-yr	1.05
10-yr	1.33
50-yr	2.23
100-yr	2.71

3.4 Sub-basin Characteristics

Sub-basin characteristics for each basin are further described below and can be found in *Appendix B.*

3.4.1 Sub-basin Delineation Sub-basins were delineated using the 2011 LIDAR and associated 1-ft contours. There is a total of 44 sub-basins within the project area. The undeveloped sub-basins located higher up in the watersheds are larger in size than the sub-basins within the urbanized Town. Sub-basin sizes range from 17 acres to 335 acres. Figure 1 provides an overview of the sub-basins.

3.4.2 Length, Centroid Distance, Slope CUHP parameters such as sub-basin length, distance to centroid, and slopes were derived for each sub-basin using topographic data. Slopes were computed using the length-weighted, corrected average slope from UDFCD's Urban Storm Drainage Criteria Manual (USDCM), including corrections for stream and vegetated channels. Further information on these corrections can be found in *Appendix B.*

3.4.3 Depression Losses The maximum pervious depression storage was set to the recommended value of 0.4 inches for wooded areas and open fields. The maximum impervious depression storage was set to the recommended value of 0.1 inches. No adjustments were made to these recommended values.

3.4.4 Infiltration Soils data was obtained from USDA NRCS Soil Survey Geographic Database for the project area which classified the soils into Hydrologic Soils Groups (HSGs). Additional soils mapping was obtained from the USDA NRCS Web Soil Survey. This information is provided in Appendix B.

The initial rate, final rate, and decay coefficient for the Horton's infiltration parameters were based on the recommended values in the USDCM. The Horton's infiltration parameters were weighted based on the percentage of each soil type within each sub-basin. Table 3-2 summarizes the Horton's infiltration parameters utilized in the analysis.

Table 3-2: 1-hr Rainfall Depth

	Infiltration (inches per hour)		
Hydrologic Soil Group	**Initial - fi**	**Final - fo**	**Decay Coefficient**
A/B	4.5	0.6	0.0018
C	3.0	0.5	0.0018
D	3.0	0.5	0.0018

3.4.5 CUHP Output The hydrologic analysis was conducted for both existing conditions and future conditions land use. The 100-year peak discharges from CUHP v2.0 for both conditions are presented in Table 3-3. CUHP output for other recurrence intervals is provided in Appendix B.

Although this hydrologic analysis did not calibrate peak flows to the previous Town of Lyons Drainage Master Plan Final Report prepared by BRW, the CUHP unit rates of runoff were compared with the previous study unit rates of runoff for sub-basins that were similarly delineated. In some cases, the unit rates of runoff are similar, but there are cases where the unit rates of runoff differ. These differences are primarily due to physical differences in input assumptions (imperviousness, HSGs, etc.).

Table 3-3: CUHP Output, 100-Year

Subbasin	Existing Conditions 100-Year Peak Discharge (cfs)	Existing Conditions Unit Rate of Runoff (cfs/ac)	Future Conditions 100-Year Peak Discharge (cfs)	Future Conditions Unit Rate of Runoff (cfs/ac)
1.2	408	2.16	408	2.16
1.3	534	2.21	534	2.21
1.4	403	2.72	403	2.72
1.5	449	2.79	401	2.49
2.1	306	1.65	306	1.65
2.2	97	2.27	97	2.27
2.3	130	1.95	130	1.95
2.4	109	2.57	109	2.57
2.5	102	2.89	102	2.89
3.1	142	1.83	167	2.15
3.2	111	2.55	111	2.55
3.3	114	2.16	114	2.16
3.4	51	3.04	51	3.04
4.1	102	2.66	128	3.33
4.1	183	1.38	183	1.38
4.2	113	1.68	114	1.70
4.3	387	1.27	387	1.27
4.4	128	1.33	128	1.33
4.5	117	1.52	117	1.52
4.6	526	1.57	526	1.57
4.7	70	1.47	70	1.47
4.8	227	1.49	227	1.49
4.9	575	1.94	575	1.94
5.1	375	2.32	386	2.39
6.1	367	1.62	373	1.65
6.2	187	2.18	187	2.19
6.3	370	1.37	370	1.37
6.4	186	1.19	186	1.19
6.5	213	1.68	213	1.68
6.6	233	1.00	233	1.00
6.7	176	2.21	176	2.21
6.8	252	1.35	252	1.35
6.9	216	1.69	216	1.69
7.1	531	2.52	599	2.84
7.2	65	1.92	65	1.92
7.3	73	3.35	73	3.35
7.4	68	2.37	68	2.37
7.5	33	1.43	33	1.43
7.6	134	2.25	134	2.25
7.7	360	1.87	360	1.87
7.8	143	1.96	145	1.98
8.1	313	1.49	313	1.49
8.2	93	1.13	93	1.13
8.3	75	1.07	75	1.07

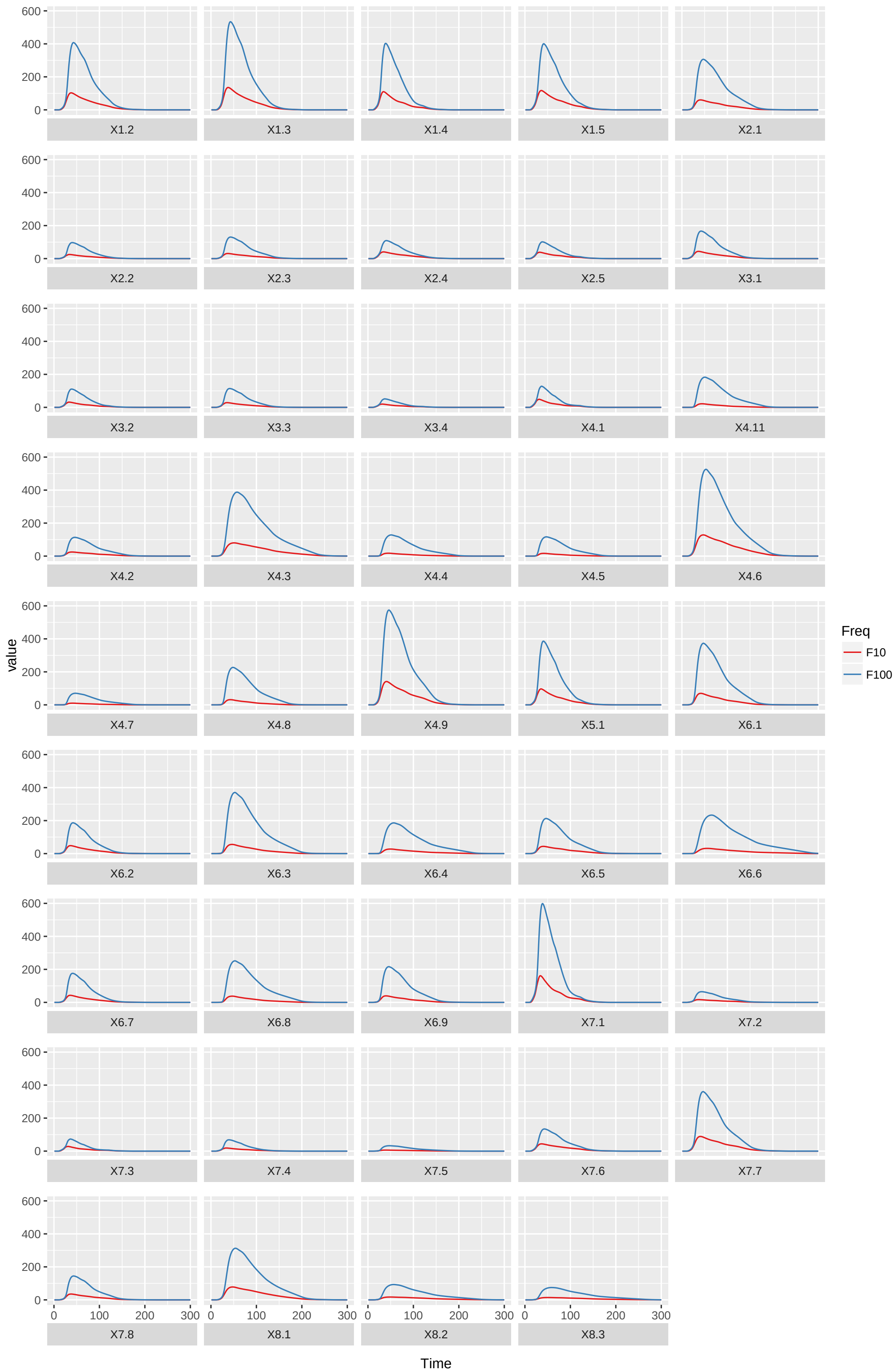
3.5 Hydrograph Routing

A hydrograph routing network was developed based on field reconnaissance, survey of the existing storm sewer network within Town, and the BRW, Inc. drainage master plan using EPA SWMM. The routing network in EPA SWMM includes: nodes (junctions and dividers), conduits (including overflow or diverted links), storage units, storage outlets, and outfalls. The model input parameters for nodes include: node identifier, invert elevation, maximum node depth, and overflow or diverted link identifier. Input parameters for conduits include: conduit identifier, upstream and downstream node identifiers, shape (e.g. trapezoidal, circular, rectangular, etc.), length, bottom width, side slopes, roughness coefficient, number of barrels, and inlet/outlet offset depths. Input parameters for storage units include: storage unit identifier, invert elevation, maximum depth, and a stage-area relationship. Input parameters for storage outlets include: outlet identifier, upstream and downstream node identifiers, and a stage-discharge relationship. Input parameters for outfalls include the outfall identifier and invert elevation. Input parameters for the SWMM model are provided in Appendix B.

3.5.1 SWMM Node Input Parameters Node identifiers in SWMM are synonymous with the sub-basin IDs. Invert elevations were determined using the 2011 LIDAR data. In some instances, a divider was used to allow the flow to be routed through the existing storm sewer system but when the capacity of the storm sewer is exceeded, the water overflows into the street (along 2nd Avenue south of E. Main Street and near the intersection of Main Street and E. Main Street).

3.5.2 SWMM Conduit Input Parameters For the drainage basins located outside of Town, transects of the drainage channels were generated using the 2011 LIDAR and a representative channel cross-section was input into the SWMM model. The manning's roughness coefficient for these undeveloped drainage basins was estimated to be 0.035 to represent channels with some weeds and stones.

Within the developed areas, characteristics of the drainage facilities were based on survey of the existing storm sewer system, field reconnaissance, and sizing the channels so that the flow could adequately be conveyed to the outfall. Between 5th Avenue and 4th Avenue, there is an existing drainage ditch that varies in width and depth but is enclosed downstream to accommodate development over the ditch. For the purposes of the SWMM model, it was assumed to have a uniform width and depth. There is a small roadside swale with intermittent driveway and roadway culverts along the west side of 3rd Avenue.


value
Time
Freq
F10
F100
X1.2 X1.3 X1.4 X1.5 X2.1
X2.2 X2.3 X2.4 X2.5 X3.1
X3.2 X3.3 X3.4 X4.1 X4.11
X4.2 X4.3 X4.4 X4.5 X4.6
X4.7 X4.8 X4.9 X5.1 X6.1
X6.2 X6.3 X6.4 X6.5 X6.6
X6.7 X6.8 X6.9 X7.1 X7.2
X7.3 X7.4 X7.5 X7.6 X7.7
X7.8 X8.1 X8.2 X8.3
0 200 400 600
0 100 200 300

However, the swale and culverts have such limited capacity and during large storm events, the water would flow down 3rd Avenue. At 3rd Avenue and Main Street there is a 30″ reinforced concrete pipe that diverts flow from 3rd Avenue to the southeast along E. Main Street. During large storm events, the flow continues down within E. Main Street, which was modeled as an open channel, until it discharges into the St. Vrain Creek. South of E. Main Street along 2nd Avenue there is a storm sewer system consisting of 18-inch, 12-inch, and 15-inch corrugated metal pipe which discharges into the St. Vrain Creek. This storm sewer system was modeled as a 12-inch pipe in the SWMM model.

There are many sub-basins which are direct flow areas into the North St. Vrain Creek, South St. Vrain Creek, or St. Vrain Creek. Therefore, the conduits for these sub-basins were modeled as ''dummy'' conduits.

3.5.3 SWMM Storage Input Parameters An existing detention pond is located within Sub-basin 1.5. The stage-area relationship was taken directly from the BRW, Inc. drainage master plan, as well as the stage-discharge relationship for the outlet. No additional detention ponds were modeled for the existing conditions, although inadvertent storage and/or privately owned detention may elsewhere within the project area.

3.5.4 SWMM Output The SWMM routing was conducted for both existing conditions and future conditions. The 100-year peak discharges at all of the outfalls from the SWMM model for both conditions are presented in Table 3-4. SWMM output for other recurrence intervals is provided in *Appendix B*.

Table 3-4: SWMM Output, 100-Year

SWMM Outfall Name	Routed Subbasins	Receiving Water	Existing Conditions 100-Year Peak Discharge (cfs)	Future Conditions 100-Year Peak Discharge (cfs)
StoneCanyonSt.VrainOUT	4.9, 4.11, 4.6, 4.8, 4.7, 4.3, 4.5, 4.4, 4.1, 4.2	St. Vrain Creek	2357	2361
EagleCanyonN.St.VrainOUT	1.4, 1.3, 1.2, 1.5	North St. Vrain Creek	1362	1362
RedHillGulchS.St.VrainOUT	6.8, 6.9, 6.6, 6.7, 6.4, 6.5, 6.2, 6.3, 6.1	South St. Vrain Creek	2357	2361
Sub2.4N.St.VrainOUT	2.1, 2.2, 7.4, 2.3, 2.4	North St. Vrain Creek	695	695
Sub7.2St.VrainOUT	3.1, 3.2, 2.5, 3.4, 3.3, 7.2	St. Vrain Creek	577	610
Sub7.3St.VrainOUT	7.3	St. Vrain Creek	73	73
Sub7.7N.St.VrainOUT	7.7	North St. Vrain Creek	360	360
Sub7.8S.St.VrainOUT	7.8	South St.Vrain Creek	143	145
Sub5.1N.St.VrainOUT	5.1	North St. Vrain Creek	375	386
Sub7.5N.St.VrainOUT	7.5	North St. Vrain Creek	33	33
Sub8.2St.VrainOUT	8.2	St. Vrain Creek	93	93
Sub8.3St.VrainOUT	8.3	St. Vrain Creek	75	75
Sub7.1St.VrainOUT	7.1	St. Vrain Creek	531	599
Sub7.6N.St.VrainOUT	7.6	North St. Vrain Creek	134	134

References