CITY OF BEND

RESOLUTION NO. 3460

A RESOLUTION OF THE CITY COUNCIL ADOPTING THE STORMWATER MASTER PLAN

Findings

A. Completion of the Stormwater Master Plan is included as a project in the City Council Work Plan for the 2025-2027 biennium.

B. The City holds two permits from the Oregon Department of Environmental Quality (DEQ) relating to its stormwater system: 1) a Phase II Municipal Separate Storm Sewer System (MS4) permit, administered by the DEQ under the National Pollutant Discharge Elimination System (NPDES) permit program, and; 2) a Water Pollution Control Facilities (WPCF) permit from DEQ to manage and operate public underground injection controls (UICs) in ways that are protective of water resources.

C. In 2024, the City of Bend retained Otak to prepare an updated Stormwater Master Plan and Goal 11 Public Facility Plan for the City's stormwater infrastructure. The 2025 Stormwater Public Facility Plan (PFP) will replace the Stormwater Master Plan and Public Facility Plan adopted in 2014.

D. Pursuant to the 2014 Stormwater Master Plan and PFP and the City's stormwater permits, the City primarily relies on a dispersed drainage system which infiltrates and injects stormwater close to the source of runoff. The City's dispersed stormwater system is composed of approximately 6,000 drywells and 1,000 drillholes (both types of UICs). Additionally, the City's stormwater system includes approximately 80 miles of storm pipe. In the central portion of Bend, the City-owned and maintained MS4 is a piped system of approximately 7 miles of pipe that carries stormwater to 36 outfalls on the Deschutes River.

E. The 2025 Bend Stormwater Master Plan builds on and expands the 2014 Stormwater Master Plan and provides a plan to guide the implementation of stormwater projects and policies for the next 20 years, including capital improvement needs such as drainage, water quality, and system condition. The Stormwater Master Plan also includes policies seeking efficient and effective processes for stormwater management to serve development, setting level of service expectations and tracking measures, and preparing for future changes to the City's density and precipitation patterns, which are concurrently being adopted into the Bend Comprehensive Plan along with a Stormwater Public Facility Plan.

F. The Stormwater Master Plan provides a baseline inventory of facilities, provides geotechnical and drainage basin guidance, sets high level strategies and goals for addressing stormwater quantity and quality, and provides an implementable infrastructure improvement approach.

G. Between 2024 and 2025, the City worked with Otak and the Water Services Department's Water Advisory Group (WAG, formerly the Utilities Public Advisory Group), to review work products and provide feedback to the project team that informed development of a final 2025 Stormwater Master Plan. Members of the WAG and others who provided input on the Stormwater Master Plan and PFP included Bend Park and Recreation District (BPRD), Central Oregon Builders Association (COBA), the City of Redmond, local engineering firms, individuals with experience or expertise in areas that relate to the protection and management of water resources including landscape design and construction, property development and consulting engineers, members of the environmental community, other community members and representatives of neighborhood organizations, and the Bend Chamber of Commerce and representatives from Bend businesses and the City of Bend Environment and Climate Committee.

H. To address growing stormwater program demands, the Stormwater Master Plan outlines strategic priorities that reflect City Council's goals and incorporates input from stakeholders gathered during the plan's development. The Implementation Plan, Section 8 of the Stormwater Master Plan, serves as a guiding framework for implementing these priorities and adapting to changing conditions and changing funding over time.

I. The 2025 City of Bend Stormwater Master Plan provides an appropriate approach to planning for stormwater facilities.

Now, therefore, based on these findings, THE CITY COUNCIL OF THE CITY OF BEND RESOLVES AS FOLLOWS:

1. The 2025 City of Bend Stormwater Master Plan, attached as Exhibit A, is adopted.
2. The 2014 City of Bend Stormwater Master Plan, adopted by Resolution No. 2957, is rescinded.
3. This resolution takes effect when the ordinance approved by Council on January 7, 2026, adopting changes to the Bend Comprehensive Plan and the 2025 Stormwater Public Facility Plan becomes effective, including the resolution of all appeals, if any.

Adopted by the Bend City Council on January 7, 2026.

YES: Kebler, Franzosa, Méndez, Norris, Perkins, Platt, Riley

NO:

Melanie Kebler, Mayor

Attest:

Ashley Bontje

Ashley Bontje, City Recorder

Approved as to form:

Ian Leitheiser, City Attorney

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Stormwater Master Plan

2025

CITY OF BEND

Acknowledgments

Submitted to:	Prepared by:
City of Bend Department of Public Works 575 NE 15th St. Bend, Oregon 97703	Otak, Inc. 808 SW Third Avenue Suite 800 Portland, OR 97204
December 2025	Project No. 20359

Project Development Team, City of Bend:

Project Manager	Austin Somhegyi, PE
Environmental Resources Manager	Lori Faha, PE
Stormwater Program Manager	Elisabeth O’Keefe
Principal Engineer	Brittany Barker, PE
Engineering Associate	Madeline Allen-Sandoz
Stormwater Utility Worker Lead	Travis Somers
Stormwater Utility Worker	Brian Sievers
Stormwater Compliance Technician	Billy Johnson
Stormwater Compliance Technician	Sam Rossi

Project Development Team, Otak, Inc.:

Project Manager	Trista Kobluskie, Senior Stormwater Planner
Project Engineer	Karina Nordahl, PE
Project Engineer	Phillip Kenyon, PE
Project Engineer	Amy Murdick, PE
Engineering Designer	McKenzie Baldner, PE
Engineering Designer	Jordan Jimmie
Stormwater Planner	Tim Seed
Senior GIS Specialist	John Rogers
Senior QC Reviewer	Jonathan Archibald, PE

Subconsultants:

Haley & Aldrich

GSI Water Solutions, Inc.

FM Civic

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Abbreviations and Acronyms

ADT	Average Daily Trips
BDC	Bend Development Code
BMC	Bend Municipal Code
BMPs	Best Management Practices
BNSF	Burlington Northern Santa Fe
BPRD	Bend Park and Recreation District
CFA	Climate Friendly Area
CFEC	Climate Friendly and Equitable Communities
CIP	Capital Improvement Program
COBA	Central Oregon Business Association
COIC	Central Oregon Intergovernmental Council
COSM	Central Oregon Stormwater Manual
CWA	Clean Water Act
DEQ	Oregon Department of Environmental Quality
DLCD	Department of Land Conservation and Development
EPA	U.S. Environmental Protection Agency
FTE	Full-Time Equivalent
FY	Fiscal Year
GIS	Geographic Information Systems
ISMP	Integrated Stormwater Management Plan
LID	Low Impact Design
LOS	Level of Service
MS4	Municipal Separate Storm Sewer System

Abbreviations and Acronyms

NPDES	National Pollutant Discharge Elimination System
ODOT	Oregon Department of Transportation
ROW	Right-of-Way
SDWA	Safe Drinking Water Act
SMP	Stormwater Master Plan
TMDL	Total Maximum Daily Load
UIC	Underground Injection Control
UGB	Urban Growth Boundary
UPAG	Utilities Public Advisory Group
WAG	Water Advisory Group
WOZ	Waterway Overlay Zone

Executive Summary

The Bend Stormwater Master Plan (SMP) builds on and expands the 2014 SMP. It also acknowledges and builds on the City's work to manage stormwater in compliance with two permits from the Oregon Department of Environmental Quality (DEQ) which regulate stormwater discharges to groundwater and surface water. Since publication of the 2014 SMP, the City has grown dramatically, and new stormwater regulations and issues have arisen. The City has taken action to address these emerging priorities and seeks a plan to guide the implementation of stormwater projects and policies for the next 20 years. The SMP collects and assesses the current suite of stormwater issues and concerns. These include capital improvement needs such as drainage, water quality, and system condition. They also include policies seeking efficient and effective processes for stormwater management to serve development, setting level of service expectations and tracking measures, and preparing for future changes to the City's density and precipitation patterns.

The SMP proposes a balance between addressing immediate concerns and preparing for the future. This executive summary and implementation plan will help the City sequence its efforts over the next 20 years and adapt to changing circumstances and priorities.

Stormwater Program Goals

Completion of infrastructure master plans, including this update to the SMP, is a stated goal of City Council for 2025 to 2027. Implementation of the SMP will help Bend address public concerns with drainage, stakeholder priorities for public safety and environmental stewardship, and City Council's goals.

Public Drainage Concerns

Several intense rainstorms with severe localized flooding have occurred in the last decade, drawing increasing public attention to private property damage and traffic safety resulting from lack of collection and/or conveyance capacity in the City's storm systems. These intense storms include, but are not limited to, two storms over Pilot Butte in August 2025 as this plan was reaching its conclusion. Addressing severe localized flooding is a priority for staff and affected members of the public and could serve to reduce the City's liability.

Staff and Stakeholder Goals

Both City staff and stakeholders have emphasized public safety as a priority that can be served by attending equally to both drainage problems that impact pedestrians or traffic safety or private property and to water quality protection. Stakeholders have emphasized environmental stewardship and projects that serve multiple purposes. Compliance with the City's two stormwater permits is a priority for staff and stakeholders and is the driver of several of the recommendations.

City Council Goals

The following elements of the 2025-2027 City Council Work Plan are pertinent to the SMP:

- Prioritizing policies that support affordable, attainable housing, and livability contribute to Council's "Safety + Belonging" principle.
- Prioritizing environmental resilience to ensure a thriving and livable Bend contributes to Council's "Environment and Climate" guiding principle and honors the original stewards of the land.
- Adopting development code and entitlement process improvements that remove barriers and speed up missing middle-income, affordable housing, and infill development serve Council's Housing objectives.

- Several objectives of the Transportation & Infrastructure goal are pertinent:
    - Enhancing safety for all modes of travel.
    - Developing projects and funding solutions to improve safety, reliability, maintenance, and capital needs, aligning revenue options with planning and performance metrics and goals.
    - Ensuring stormwater systems are aligned with the needs of a growing city and understanding capacity for growth.
    - Finishing the Stormwater Master Plan, prioritizing infill development.
- Leveraging public-private partnerships that catalyze investment in the Bend Central District.
- Improving permitting processes and reducing review times to support housing and economic development.

The SMP addresses each of these principles or goals through capital improvements and policy recommendations.

Stormwater Issues and Solutions

Context

Bend's topography and soils, along with its high desert landscape and climate, create variable conditions for drainage and stormwater management over the City's 35 square miles.

Although there is relatively little annual rainfall, it often comes in short, intense bursts, particularly in the spring and fall, causing considerable localized flooding throughout the City. During the winter months, when drainage systems are sometimes blocked by snow and ice, rapid snowmelt and rain-on-snow events exacerbate flooding.

Bend's volcanic geology created a landscape with many ridges, drops, sinks, and hills. Volcanic rock is at or near the surface throughout the City, and its permeability and topography vary greatly, with three primary types of permeability present. Soils close to or within the Deschutes River channel are primarily river deposits composed of gravels, sand, and silt, and they have variable permeability. Portions of the City are underlain by basalt that is relatively fractured with a sufficiently high permeability to allow for high rates of stormwater infiltration. Some areas of the City are underlain by consolidated basalt or tuff, which is highly impermeable and does not provide acceptable conditions for the use of shallow infiltration techniques, including drywells.

Within this context, Bend's system of public stormwater infrastructure relies on large number of drywells (6,083) and drillholes (933), which are known as underground injection controls (UICs), to dispose of stormwater directly into the ground. Each UIC is the terminus of an individual small stormwater system that is not connected to other City stormwater systems. As Bend began to regulate stormwater systems on private property during development, and to require that most rainfall be kept on each site, many private UICs were also installed where soil conditions are favorable to infiltration. In addition to UICs, the City also has 36 public stormwater outfalls to the Deschutes River, draining approximately 2.2 square miles through small to medium-sized connected pipe systems.

Issues

This stormwater system serves a growing population. City planning staff are relying on growth projections that estimate the City population will increase from approximately 104,000 today to more than 130,000 by

2035. The urban growth boundary (UGB) was expanded in 2016 and has been expanded two additional times since then, and the City is pursuing a UGB amendment to add 100 more acres in 2025 or 2026.

As the population has grown, Bend has become denser. Managing stormwater on individual lots by relying on areas of superior infiltration has become increasingly difficult as lots sizes decrease and/or lot coverage increases. The need to provide stormwater facilities that also protect water quality can increase the footprint of the required systems, exacerbating the rising competition for space on lots and in the City's rights-of-way (ROW). Also related to rapid development, the total number of Bend's stormwater system assets has increased. For example, the inventories of catch basins and UICs have been growing at an annual average rate of 1.9% and 1.5%, respectively, since 2015.

With urbanization comes a decrease in undeveloped land, which is generally pervious, does not produce much runoff, and may often act as an unofficial stormwater management facility for adjacent roads and lots. As these more pervious areas disappear, adjacent existing stormwater systems may be overwhelmed by new flows they were not designed to handle. New localized flooding has occurred on streets, bike lanes, sidewalks, and property.

Intense storms, which produce significant rainfall in a short period of time, may stress or overwhelm stormwater systems that are otherwise adequate to handle the same amount of rainfall over a longer period of time. A literature review provided for the SMP indicates that the rainfall data used to determine design capacity of Bend's stormwater conveyance and management facilities is outdated by several decades and may underrepresent both the intensity and the overall precipitation depths in storms over Bend. The national dataset used also may not address how Bend's topography, with its steep buttes, can create a significant increase in storm intensity over a tiny area. Public awareness and complaints about flooding resulting from intense storms appears to be rising. The cost of providing additional storm system capacity, which may be needed only infrequently, must be balanced against the risks to public safety and to property from storm system flooding.

In addition to localized flooding, water quality is a concern. Historically, Bend's stormwater system did not mitigate or prevent impacts to the quality of groundwater or the river. In recent years, reducing pollutants in stormwater runoff to protect water quality has become increasingly important because of both regulation and public sentiment.

The SMP identifies a total of 103 stormwater issues related to Bend's drainage systems. Each issue is categorized into one of the following primary concerns: drainage, condition, maintainability, erosion, groundwater quality, or surface water quality. Table E-1 shows the number of issues that fall into each category.

Table E-1 Count of Stormwater Known Issues by Type

Type	Count	Category Description
Drainage	57	Drainage issues include ponding and flooding on streets and private properties where the drainage system is inadequate, damaged, or is not present
Water Quality – Groundwater	26	Groundwater quality issues are identified where underground injection controls such as drillholes and drywells may pose a contamination risk to groundwater because they are located near drinking water wells or do not have a spill control structure
Water Quality – Surface Water	7	Surface water quality issues are identified by analyzing the pollutant-causing characteristics of Bend's outfall basins and then prioritizing those outfalls that may discharge the most pollutants to the Deschutes River.

Table E-1 Count of Stormwater Known Issues by Type

Type	Count	Category Description
Condition	6	Condition issues are identified when the drainage system or stormwater facility is damaged
Maintainability	5	Maintainability issues are identified where the drainage system or stormwater facilities are difficult or dangerous for City staff to maintain due to location, design, or condition
Erosion	2	Erosion issues are identified where stormwater flows over denuded or sparsely vegetated landscaped or natural areas and deposits eroded soils into streets, catch basins, UICs, or other elements of the drainage system
Total	103	

In addition, the SMP also identifies policies related to drainage and density, level of service for the stormwater utility, and climate change as issues to be explored.

Recommended Solutions and Costs

The SMP recommends implementation of stormwater capital improvements that have been planned, designed, or started construction since the 2014 SMP. Most of these projects address drainage issues. It recommends planning for 11 new stormwater capital improvement program (CIP) projects to address larger-scale drainage and water quality issues and three programmatic solutions to systematically address smaller-scale water quality and storm system condition issues over time (Figure E-1, on page E-6).

Recommended capital improvements are estimated to cost more than $76 million in 2025 dollars. Planning-level estimates include the full cost of implementing capital improvements, from design through construction. Maintenance costs are not included.

The 20-year cost table (Table E-2, on page E-7) spreads the recommended capital investments over a 20-year horizon in phases correlating to the City's capital planning cycle: years one through five, years six through ten, and the remaining years 11 through 20. The table also includes stormwater CIPs that were in progress or planned for implementation prior to the completion of the SMP and that appear in the capital improvement budget or planning documents such as the Midtown Crossings Stormwater Report.

The SMP recommends policy initiatives. To address drainage and density, the SMP explores how the City could enforce stormwater standards more rigorously while allowing greater flexibility for centralizing stormwater management facilities. To address the pressures on available staffing and equipment resources resulting from growing storm system inventory and increasing regulation, the SMP recommends establishing and communicating about levels of service for the various stormwater services provided by the City and recommends more uniform and rigorous tracking of service metrics. Over time, these service expectations and metrics will assist in evaluating the costs and benefits of different levels of staffing and revenues. Finally, the SMP recommends the City take a watchful waiting stance to address the uncertainties of climate change, while pursuing an update to the outdated national precipitation data used to size stormwater facilities.

Funding and Implementation

The stormwater utility receives its funding from the Stormwater Fund, which collects revenue from the stormwater utility fee paid by property owners. The stormwater utility issued long-term debt for the first time in FY 2021 for capital projects. The SMP recommends capital investment of more than $76 million over the next 20 years to address drainage issues, protect groundwater and surface water quality, and meet permit requirements for operating storm sewers and UICs. The costs of day-to-day stormwater operations and regulation of stormwater systems on private property have not been estimated in this plan; however, budgets for system operations, maintenance, and regulation can be expected to grow with increasing inventory of storm system assets, increasing growth in private development, and increasing regulation of the City.

Using cost inputs from the SMP, the City will study the cost of providing stormwater capital improvements and ongoing stormwater services to the community and assess how to align stormwater utility fees with City costs.

To address growing stormwater program demands, the SMP outlines strategic priorities that reflect City Council's goals and incorporate input from stakeholders gathered during the plan's development. The Implementation Plan, Section 8, serves as a guiding framework for implementing these priorities and adapting to changing conditions and changing funding over time.

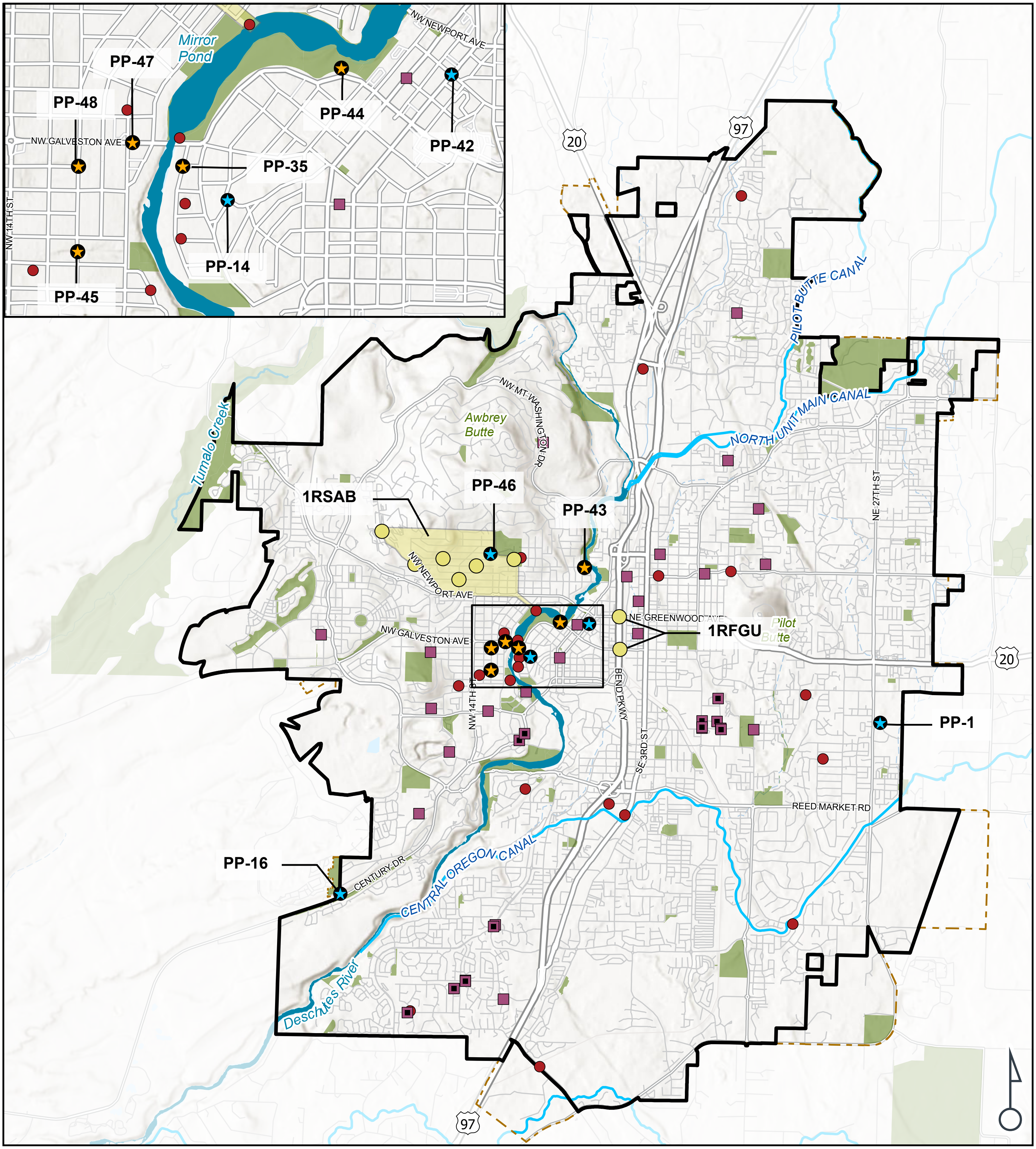

FIGURE E-1

STORMWATER MASTER PLAN PROJECTS & PROGRAMS

BEND STORMWATER MASTER PLAN

BEND, OREGON

Data Sources: City of Bend, Deschutes County, USGS, Google Maps.
Date: 10/28/2025
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

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LEGEND

- ▭ Bend City Limits
- ⬚ Urban Growth Boundary
- — Streams
- — Canals
- ★ CIP - Drainage
- ★ CIP - Outfall Retrofit
- ● CIP In Progress
- ● Major Maintenance Program
- ▣ Drillhole Water Quality Retrofit Program
- ■ Failing UIC Drainage Improvements Program

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CITY OF BEND

Otak

Table E-2 Recommended Stormwater Capital Improvements 20-Year Costs and Prioritization

Rank	ID	Project Name	Total Cost*	Information Source	Notes	Years 1-5†	Years 6-10	Years 11-20
Existing CIPs – Individual Projects								
1A‡	1SSW3	SW Sewer Basin Improvements Phase 3	$400,000	2025-27 Proposed Biennial Budget	Costs included in this table begin in 2026-27. Estimated completion in 2026-27.	$500,000		
1A	1RSAB	South Awbrey Butte Drainage Improvements	$12,500,000	2025-27 Proposed Biennial Budget	Costs included in this table begin in 2026-27. PP-2, PP-3, PP-4, PP-5, PP-6, PP-7 are all part of the drainage improvements; Estimated completion date of 2029	$15,450,000		
1A	1RFGU	Franklin Stormwater Improvements, Phase 1	$620,000	Midtown Crossing Stormwater Report	PP-51; Estimated completion date of 2026; Franklin is included in the budget with Greenwood, though they are separate project locations	$1,216,000		
1A	1RFGU	Greenwood Stormwater Improvements, Phase 1	$1,000,000	Midtown Crossing Stormwater Report	PP-39; Greenwood is included in the budget with Franklin, though they are separate project locations; Estimated completion date of 2026	$1,824,000		
					Existing CIPs Subtotal	*$18,990,000*	*$0*	*$0*
Planned CIPs – Individual Projects								
1B‡	1RFGU, Ph 2	Franklin Stormwater Improvements, Phase 2	$850,000	Midtown Crossing Stormwater Report	Date of Implementation TBD; Franklin is included in the budget with Greenwood, though they are separate project locations		§	
1B	1RFGU, Ph 2	Greenwood Stormwater Improvements, Phase 2	$3,800,000	Midtown Crossing Stormwater Report	Date of Implementation TBD; Greenwood is included in the budget with Franklin, though they are separate project locations		§	
1	PP-35	Riverfront Street Stormwater Improvements	$880,000	CIP Fact Sheet	Date of implementation TBD. Note that the 2025-27 Proposed Biennial Budget has a placeholder for Outfall Improvements (1ROTI) with expenditures beginning in 2028-29.		$880,000	
2	PP-42	Downtown Pedestrian Safety Drainage Improvements	$770,000	CIP Fact Sheet	Date of implementation TBD.		$385,000	$385,000
3	PP-44	Drake Park Stormwater Quality Improvements	$4,140,000	CIP Fact Sheet	Date of implementation TBD. Note that the 2025-27 Proposed Biennial Budget has a placeholder for Outfall Improvements (1ROTI) with expenditures beginning in 2028-29.		$2,070,000	$2,070,000
4	PP-14	Congress Street Drainage Improvements	$1,320,000	CIP Fact Sheet	Date of implementation TBD.			$1,320,000
5	PP-46	Vicksburg Avenue Drainage Improvements	$490,000	CIP Fact Sheet	Date of implementation TBD.		$490,000	
6	PP-47	Galveston Avenue Stormwater Quality Improvements	$5,820,000	CIP Fact Sheet	Date of implementation TBD. Note that the 2025-27 Proposed Biennial Budget has a placeholder for Outfall Improvements (1ROTI) with expenditures beginning in 2028-29.		$5,820,000	
7	PP-48	Fresno Avenue Stormwater Improvements	$4,230,000	CIP Fact Sheet	Date of implementation TBD. Note that the 2025-27 Proposed Biennial Budget has a placeholder for Outfall Improvements (1ROTI) with expenditures beginning in 2028-29.			$4,230,000
8	PP-45	12th Street Stormwater Quality Improvements	$1,040,000	CIP Fact Sheet	Date of implementation TBD. Note that the 2025-27 Proposed Biennial Budget has a placeholder for Outfall Improvements (1ROTI) with expenditures beginning in 2028-29.			$1,040,000
9	PP-1	Dove Lane Drainage Improvements	$390,000	CIP Fact Sheet	Date of implementation TBD.			$390,000
10	PP-43	Saginaw Avenue Stormwater Quality Improvements	$2,620,000	CIP Fact Sheet	Date of implementation TBD. Note that the 2025-27 Proposed Biennial Budget has a placeholder for Outfall Improvements (1ROTI) with expenditures beginning in 2028-29.			$2,620,000
11	PP-16	Campbell Rd Drainage Improvements	$130,000	CIP Fact Sheet	Date of implementation TBD.			$130,000
					Planned CIPs Subtotal	*$0*	*$9,645,000*	*$12,185,000*
					Individual CIPs Total	**$18,990,000**	**$9,645,000**	**$12,185,000**

Table E-2 continues on next page

Table E-2 Recommended Stormwater Capital Improvements 20-Year Costs and Prioritization

Rank	ID	Project Name	Total Cost*	Information Source	Notes	Years 1-5†	Years 6-10	Years 11-20
Programmatic Solutions								
n/a	1RDHD	Drillhole Water Quality Retrofit Program	$5,700,000	Program Fact Sheet and 2025-27 Biennial Budget	Total costs include the priority locations documented in the fact sheet for a five-year implementation schedule and subsequent lower-priority projects implemented at a slower pace in future years.	$750,000	$3,375,000	$ 1,575,000
n/a	TBD	Failing UIC Drainage Improvement Program	$5,340,000	Program Fact Sheet	10-year implementation schedule to begin after completion of the high priority projects in the 1RDHD program. This program will be rolled into Stormwater Major Maintenance after the priority issues completed.		$2,670,000	$2,670,000
n/a	1RCAP	Stormwater Major Maintenance Program	Annual allocation	Annual allocation	Currently "Stormwater Capital Repair and Replacement" (1RCAP) in 2025-27 Proposed Biennial Budget. Assume continuation of this program at a set annual level of $1.5 million from years 6 to 20.	$6,620,000	$4,830,000	$13,155,000
					Programmatic Solutions Total	**$7,370,000**	**$10,875,000**	**$17,400,000**
					Total by Planning Horizon	**$26,360,000**	**$20,520,000**	**$29,585,000**
					Grand Total		**$76,465,000**	

** All costs are in 2025 dollars*
† Year 1 is the fiscal year 2025-2026
‡ Ranks 1A and 1B are given to projects that were not ranked by the SMP project team but are considered high-priority because they are either ongoing or budgeted capital improvements (1A) or contained in an existing master plan or infrastructure improvement plan that is being implemented by the City (1B)
§ City of Bend is determining if this work will be addressed through a City-funded CIP or through private development

Section 1. Introduction

The City of Bend has experienced rapid growth over the past 20 years, resulting in increased impervious area and more stormwater runoff. Historically, due to the City's semi-arid climate and well-draining soils, stormwater management was not a major priority. Bend's early development was close to the Deschutes River, and piped systems conveyed stormwater to the river. As the City expanded, drillholes became the primary method of stormwater management, followed by drywells. Drywells have been predominantly used for many years to manage the City's stormwater because they are relatively low-cost, easy to install, and generally effective at dissipating runoff flows without needing to be connected to a City conveyance system. However, they have also been used in areas with natural impermeable layers which impede their intended function, and near drinking water wells, which have raised concerns about pollutants in stormwater interacting with water supply sources.

Drywells and drillholes require regular maintenance. Road cinders (used to improve traction for the motoring public during icy weather), eroded soils, and debris accumulate in structures, reduce the effectiveness of infiltration if not properly maintained. Failed or failing drillholes and drywells, drywells installed in inappropriate places, and the increase in impervious surface area all contribute to the frequent and widespread nuisance stormwater flooding that now takes place in Bend.

Population growth and the resulting increase in development and density have exacerbated drainage problems by increasing flooding intensity, volume, and timing of peak flows. More intense storms possibly brought about by climate change may also play a role. In some locations, stormwater flooding has become a public safety issue and a threat to private homes and businesses as well as public infrastructure.

Stormwater quality is also a critical topic. The federal Safe Drinking Water Act (SDWA) and the State of Oregon's Underground Injection Control (UIC) rules regulate the City's drywells and drillholes to protect groundwater. The federal and state National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Phase II rules regulate the City's discharges to the Deschutes River. Both regulatory programs require the City to obtain and comply with a permit and to use Best Management Practices (BMPs) to reduce the pollutants discharged to the environment.

1.1. Purpose and Objectives

The primary purpose of the Stormwater Master Plan (SMP) is to identify and prioritize projects, programs, and policies that improve and extend the City of Bend's stormwater infrastructure and management practices over the next 20 years. The community will benefit from the provision of adequate stormwater facilities that reduce current nuisance flooding during frequent storms and protect the quality of groundwater and surface water. In addition, the SMP has two additional goals of reducing disruptions from emergency repairs and supporting redevelopment and development through policy updates.

The City retained Otak, Inc. (Otak) to update and replace the 2014 Stormwater Master Plan (URS, 2014). This SMP includes recommended projects, programs, and policies. The SMP will be implemented primarily by the Engineering Department and Water Services Department

1.2. Organization of the Master Plan

The SMP planning process encompassed several steps with the goal of identifying system improvement priorities and developing programmatic solutions and capital improvement projects (CIPs) to address those priorities.

- **Executive Summary** summarizes the planning context, key issues, and priorities for stormwater planning. It describes the recommended capital plan and policy initiatives. This section can be read alone.
- **1.0 Introduction** introduces the SMP by describing the regulatory background and relationships this plan has with other City plans and programs.
- **2.0 Planning Area** describes the planning area and its characteristics in detail. The planning area for this SMP is the City of Bend with some consideration of the urban growth boundary (UGB).
- **3.0 Planning Process and Analysis** describes the process of identifying and categorizing known issues, then developing solutions and projects to implement those solutions. Known issues were compiled by reviewing project lists, community complaints, work order databases, and drainage problem areas (hotspot) map, as well as interviewing staff from the City of Bend. CIPs and programs of smaller projects were developed to meet the City’s goals.
- **4.0 Stormwater Capital Improvement Projects** presents the CIP selection process and the recommended projects. Eleven projects were selected to develop into CIPs with concept level designs and cost estimates.
- **5.0 Programmatic Solutions** presents recommendations for three programs to systematically improve performance of existing stormwater management infrastructure. Each program groups similar types of projects that would be too small or otherwise ineligible to become a standalone stormwater CIP.
- **6.0 Policy Discussion** explores potential policy initiatives regarding climate change, managing stormwater as the city becomes denser (development and density), and stormwater operations level of service. The full text of two white papers and a presentation on climate change are included in Appendix D.
- **7.0 Public Involvement and Outreach** describes the involvement of the community in the creation of this plan.
- **8.0 Implementation Plan** describes a plan for implementing the recommendations which includes timing considerations, budget, and priorities.

1.3. Regulatory Context and Relationships

Generally, stormwater discharges from developed areas may create adverse impacts on streams, rivers, and lakes in a variety of ways including short-term changes in water quality associated with runoff from storms, long-term changes in water quality resulting from cumulative impacts of pollutant discharges over time from many sources, and habitat-altering physical changes such as erosion, sedimentation, and scour resulting from changes to the volume, frequency, and duration of stream flows (United States Environmental Protection Agency, 1999). Bend’s storm system and stormwater discharges to natural resources are regulated by a variety of federal, state, and local laws, rules, and guidelines designed to mitigate these impacts.

1.3.1. Federal

National Pollutant Discharge Elimination System (NPDES)

The federal Clean Water Act of 1972 (CWA) created the National Pollutant Discharge Elimination System (NPDES) permit program to address sources of pollution in rivers, creeks, and streams. The program requires municipalities of certain sizes to apply for and obtain a municipal NPDES permit for storm systems that discharge to rivers, streams, and other surface water bodies. In Oregon, these permits are administered by the Oregon Department of Environmental Quality (DEQ). These municipal NPDES permits, known as Municipal Separate Storm Sewer System (MS4) permits, are separated into two types based on jurisdictional sizes. Larger jurisdictions are managed under individual Phase I permits, while smaller jurisdictions are managed under general Phase II permits.

Bend obtained an individual MS4 Phase II permit in 2007 and is currently the only individual Phase II permittee in Oregon. The goal of receiving an individual permit was to respond to and manage unique drainage and regulatory conditions. Bend's MS4 Phase II permit was renewed in 2021 with an effective date of January 1, 2022, and will expire in 2026. Permits are issued for five-year periods but may be administratively extended by DEQ. The MS4 permitted area ultimately drains to the Deschutes River.

The MS4 Permit guides many of Bend's stormwater management program's goals, policies, and day-to-day operations. Permit compliance represents a significant investment for Bend.

Total Maximum Daily Load (TMDL)

The CWA describes a program of Total Maximum Daily Loads (TMDLs) to protect water quality when other measures have failed to reduce pollutants from stormwater. A TMDL establishes the limit of each pollutant that can be present in a water body for the water body to achieve or maintain water quality standards.

Under the CWA, DEQ is responsible for identifying waters that do not meet water quality standards (known as the 303(d) list). Water quality standards are intended to protect human health, aquatic life, and designated beneficial uses, such as irrigation, recreation, hydropower, or water supply. DEQ is also responsible for calculating the allowable pollutant loads and developing water quality management plans, which allocate pollutant limits among dischargers and describe how a TMDL will be implemented.

As of 2024, there are no EPA approved TMDLs for the Deschutes River. The DEQ listed the Deschutes River as impaired on the 303(d) list but has not yet established TMDLs. The DEQ 2022 Integrated Report listed the following impairments for the Deschutes River near Bend (see Figure 1 at CityofBend_FY2324_MS4_AnnualReport_Final_20241028.pdf_signed_2024.10.29.08.53.25.pdf):

- North Unit Diversion Dam to Whychus Creek – impaired for Year-Round Temperature
- Spring River to North Unit Diversion Dam – impaired for Turbidity, pH, Year-Round Temperature, and Sedimentation

The MS4 Permit requires Bend to evaluate whether stormwater discharges from the MS4 system are likely to either cause or contribute to 303(d) list impairments, whether existing BMPs are effective in addressing those impairments, and if any changes or modifications are required. This evaluation was submitted to DEQ as an attachment with the FY23-24 annual stormwater report in November of 2024. Due to existing pre-treatment for the MS4, best management practices in place, and general nature of stormwater management throughout the City with a focus on infiltration, no modifications were required. Modifications to BMPs are recommended to incorporate new impairment pollutants if any are identified by DEQ in the future.

1.3.2. State

Statewide Planning Goals and Priorities

Oregon Administrative Rules 660 Division 15 establishes several Statewide Land Use Planning Goals. Goal 5 describes the protection of natural resources, including wetlands and riparian corridors. Statewide Planning Goal 6 describes the protection of air, water quality, and land resources quality, and Goal 7 describes protection of areas subject to natural disasters and hazards. Goal 11 describes the steps needed to plan utility infrastructure along with the growth and urbanization (Oregon Department of Land

Conservation and Development, 2019). These goals are addressed through the local jurisdictions' comprehensive plans and Bend's community development rules and standards.

Recent updates to Goal 10, Housing, along with other legislation has increased production goals for all types of housing, including affordable housing, increased the type and variety of housing density possible within urban areas, and is requiring cities to evaluate how and where to increase housing density.

The Oregon legislature adopted climate-related pollution reduction goals in 2007. The Oregon Department of Land Conservation and Development (DLCD) adopted the Climate-Friendly and Equitable Community (CFEC) requirements to reduce climate pollution in 2022 and 2023. The DLCD adopted transportation planning rules that require certain jurisdictions to evaluate and update their standards and codes to create more walkable communities, which should reduce the volume of transportation-related emissions. The CFEC also includes requirements for annual reporting.

WPCF Permit

The federal Safe Drinking Water Act (SDWA) regulates underground discharges in order to protect drinking water resources. These discharges are categorized by type of material being discharged; discharges related to stormwater are classified as Class V Underground Injection Controls (UICs). In Oregon, the DEQ is authorized to regulate Underground Injection Control (UIC) systems through Water Pollution Control Facilities (WPCF) permits to jurisdictions and property owners. Similar to the MS4 Permit, the WPCF Permits require jurisdictions to manage and operate public UICs in ways that are protective of water resources.

The DEQ issued Bend's first WPCF Permit in 2013 and re-issued the WPCF Permit in 2025. WPCF Permits are issued for ten years but may be administratively extended. The WPCF Permit allows the City to discharge stormwater and specific incidental non-stormwater fluids to UICs owned and operated by the City. The permit also requires Bend to identify UICs that may be out of compliance with groundwater quality protection standards and develop a process to bring their performance into compliance. Bend's approximately 7,000 UICs consist of approximately 6,000 drywells/sumps, which were designed to infiltrate stormwater, and approximately 1,000 drillholes, which provide stormwater management. Drillholes are no longer permitted in City standards and specifications for public infrastructure due to maintenance challenges and potential impacts to groundwater quality. Bend's WPCF Permit was reissued in July of 2025 and does not contain major changes to the permit's requirements.

Integrated Stormwater Management Plan

Bend's MS4 and WPCF Permits have similar requirements for managing public stormwater systems, including developing a management plan. Bend submitted its most recent Integrated Stormwater Management Plan (ISMP) to DEQ in 2023 to meet the management plan requirements of both permits. The ISMP includes details on each of the BMPs required by each permit. Many of the BMPs required by each permit are similar, such as conducting public outreach and education, illicit discharge detection and elimination, construction site stormwater activities, post-construction stormwater management for new and re-development, and municipal operations and maintenance.

1.3.3. Local

Bend Municipal Code Title 16

The Bend Community Development Department manages the application, plan review, permit issuance, construction inspection, and acceptance process for private development, including any construction of public improvements required as a condition of development. The Community Development Department reviews proposed projects against adopted standards to support statewide and local goals, such as increasing the rate of completed housing production. The Private Development Engineering Division provides review of privately funded public improvements, such as stormwater infrastructure in the public right of way, and calculation of system development charges.

Title 16 of the Bend Municipal Code includes the adopted requirements for grading, erosion control, stormwater management, illicit discharges, tree protection, and well drilling. This title provides authority for Bend to establish minimum standards for new development and redevelopment on property or in the right of way. Title 16 references and adopts technical standards for stormwater engineering as detailed in the Central Oregon Stormwater Manual.

Central Oregon Stormwater Manual

The Central Oregon Intergovernmental Council (COIC) supported jurisdictions in Central Oregon in collaborating to develop a regional stormwater manual. Bend has adopted the Central Oregon Stormwater Manual (COSM), last updated in 2010, as the design manual for stormwater. The COSM provides minimum standards for stormwater/drainage applicability, plan review, and guidance for stormwater management from design through post-construction. Jurisdictions can choose to adopt the COSM for use within their local development process. The COSM was completed in 2010 and includes guidance for stormwater management systems that discharge stormwater to surface waters or through soil layers to groundwater.

Bend Standards and Specifications, Part II – Design Standards

Bend’s Standards and Specifications is a document that outlines the process for designing, bidding, and constructing City infrastructure for both public and private development. Part II – Design Standards contains the required design constraints, methodologies, features, and practices that must be implemented in all designs of Public Works facilities, which includes stormwater infrastructure. Chapter 6 regulates stormwater and reflects many of the COSM’s technical standards.

Sensitive Areas and Infiltration

The City established a Waterway Overlay Zone (WOZ) in Article V of the Bend Development Code (BDC) Chapter 2.7, Special Planned Districts, Refinement Plans, Areas Plans and Master Plans, to preserve and enhance the Deschutes River and the Tumalo Creek stream corridors within the urban growth boundary.

The City encourages use of infiltration to manage stormwater and provides tools to assist in implementing infiltration facilities on development project sites, including soil maps showing where infiltration may be favorable, maps and guidance for horizontal distance from drinking water wells, and maps of groundwater depths. The SMP will provide recommendations for siting criteria and spill control requirements for deep drywells, an emerging stormwater management technique that uses a structure similar to a typical drywell near the surface paired with a drilled pipe shaft below reaching depths necessary to provide needed discharge of flows, while maintaining minimum separation from groundwater.

Bend Climate Friendly Areas

Bend’s response to CFEC has included changes to local codes and standards, in addition to the required annual reporting. Bend identified 10 potential Climate Friendly Areas (CFAs) where additional public and private investment could result in walkable communities (Bend, 2023). Additional changes to code and standards will likely be necessary after the CFAs are adopted. Creating walkable communities will also help Bend meet housing unit targets and goals. Densities required to meet CFA goals could impact space available for stormwater management on development sites, which is a topic of concern addressed in this SMP.

1.4. City Organization

The City of Bend operates under a Council-Manager form of government. The City Council, composed of six elected councilors and a mayor, serves as the legislative and policy-making body. The mayor, elected at large, presides over Council meetings and serves a ceremonial role but holds no additional legislative authority beyond that of other council members.

The City Manager, appointed by the Council, oversees daily operations, implements Council policies, manages City departments and staff, and prepares the annual budget. City departments carry out essential services under the City Manager's direction. Various Council-appointed advisory boards and commissions provide input on planning, transportation, environmental issues, and budgeting, ensuring community involvement in local governance.

Several departments will implement this plan. Design and implementation of larger capital projects will be conducted within the Engineering Department, and the Water Services Department will be responsible for major maintenance, routine maintenance, and stormwater regulatory functions. Some policy and development permitting related recommendations will also involve other departments, including the Community Development Department.

Stormwater functions are carried out primarily within the Water Services Department and are funded by a stormwater utility (Figure 1). Other departments such as Community Development, Engineering, and Transportation and Mobility also interface with the stormwater program or perform essential stormwater functions and activities.

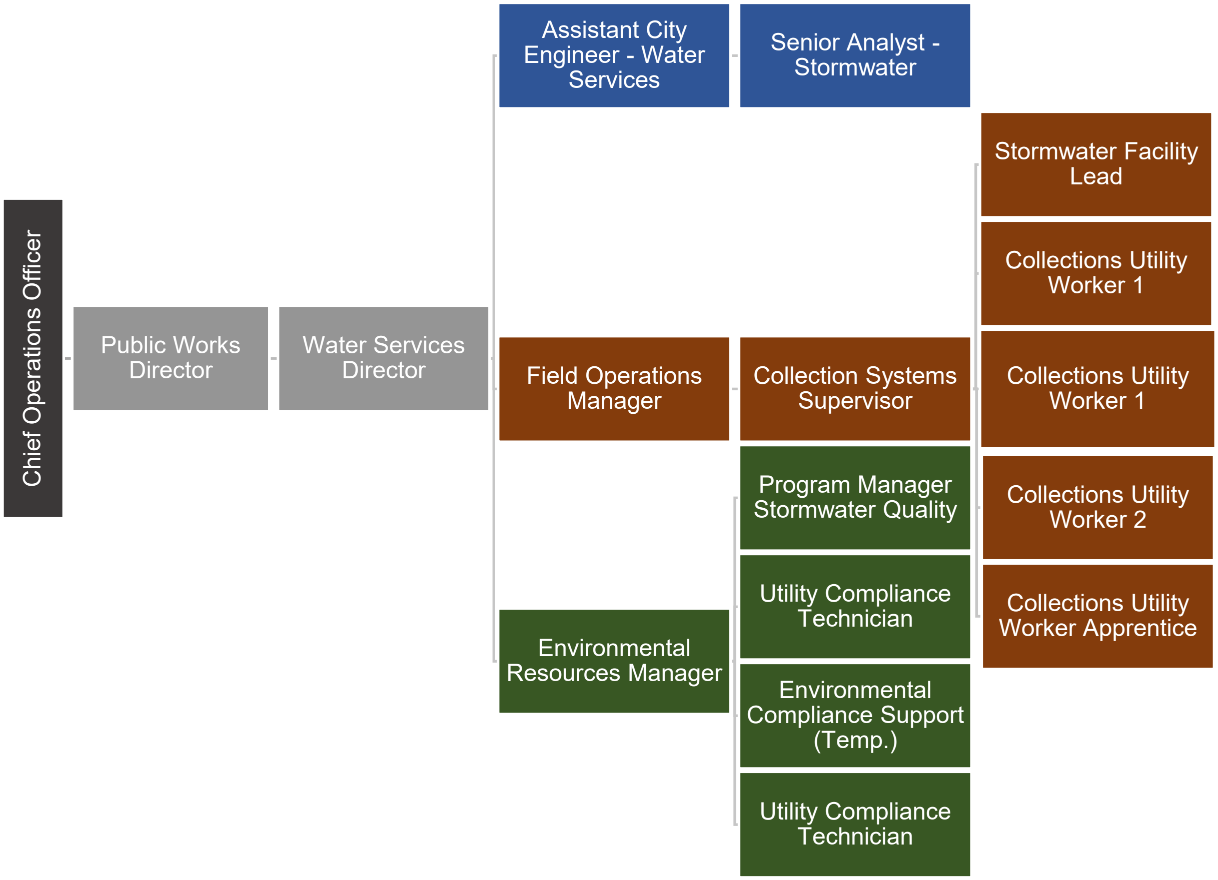

Figure 1 Organization Chart of the Stormwater Utility

1.5. Planning History

The City of Bend began developing its first Stormwater Master Plan in 2006. In 2007, the City started documenting drainage and flooding problems and analyzing hydrologic, hydraulic, and geologic data within the context of stormwater management. As the City grew and increased its impervious surface area, reported drainage and flooding problems increased.

The first formal Stormwater Master Plan (SMP) was developed for the City of Bend in 2008. The purpose of the plan was to evaluate the City's stormwater drainage needs within the 2007 UGB, and to meet increasingly stringent state and federal regulations governing stormwater. To assess the impact of upcoming permit requirements, the draft plan was paused. The document remained a draft while the City implemented several of its recommendations.

In 2013, the City received its WPCF permit governing UICs. The Stormwater Master Plan draft was revisited and completed in 2014. This plan provided an overall strategy for stormwater management, delineated drainage areas and runoff quantities, and outlined programmatic goals for addressing stormwater quantity and quality concerns.

Section 2. Planning Area

The planning area for the SMP encompasses approximately 21,320 acres (35 square miles) in the City of Bend and its urban growth boundary (UGB) as shown in Figure 2, Vicinity Map. All recommended capital improvements are located within Bend's UGB.

2.1. Characteristics

The combination of Bend's environment, natural features, and built infrastructure influences stormwater runoff variables and impacts.

2.1.1. Location

The City of Bend is the county seat of Deschutes County in Central Oregon. On a high plateau in the foothills east of the Cascade Range, the City is about 16 miles south of Redmond and 30 miles north of LaPine. Its clear view of Mt. Bachelor and the Three Sisters, along with a bounty of year-round outdoor recreational activities, make Bend a very desirable place to live. Highways 97, 97 Business, and 20 run through the City. The City Council adopted its current UGB in 2016 and has adopted two additional amendments to the UGB since then.

2.1.2. Climate

Bend has a mild climate, classified as semi-arid or High Desert. With average annual precipitation of only 11.7 inches, the City experiences an average of 300 days of sunshine per year. In addition to rainfall, Bend averages 34 inches of snowfall, most of which occurs between October and May. Bend is to the east of the Cascade Mountains and in their rain shadow and receives a fraction of the precipitation experienced west of the mountains as storms from the Pacific Ocean bring warm moist air inland. Although there is relatively little annual rainfall, it often comes in short, intense bursts, particularly in the spring and fall, causing considerable localized flooding throughout the City. During the winter months, when drainage systems are blocked by snow and ice, rapid snowmelt and rain-on-snow events exacerbate flooding.

The average annual high temperature in Bend is 60 degrees Fahrenheit (°F), with average highs in the summer ranging from 72 to 84°F and average highs in the winter ranging from 39 to 44°F. The average annual low temperature is 33°F, with average lows in the summer ranging from 42 to 47°F and average lows in the winter ranging from 23 to 24°F (US Climate Data, 2025).

Due to its semi-arid climate, irrigation is required for vegetated stormwater facilities and landscaping.

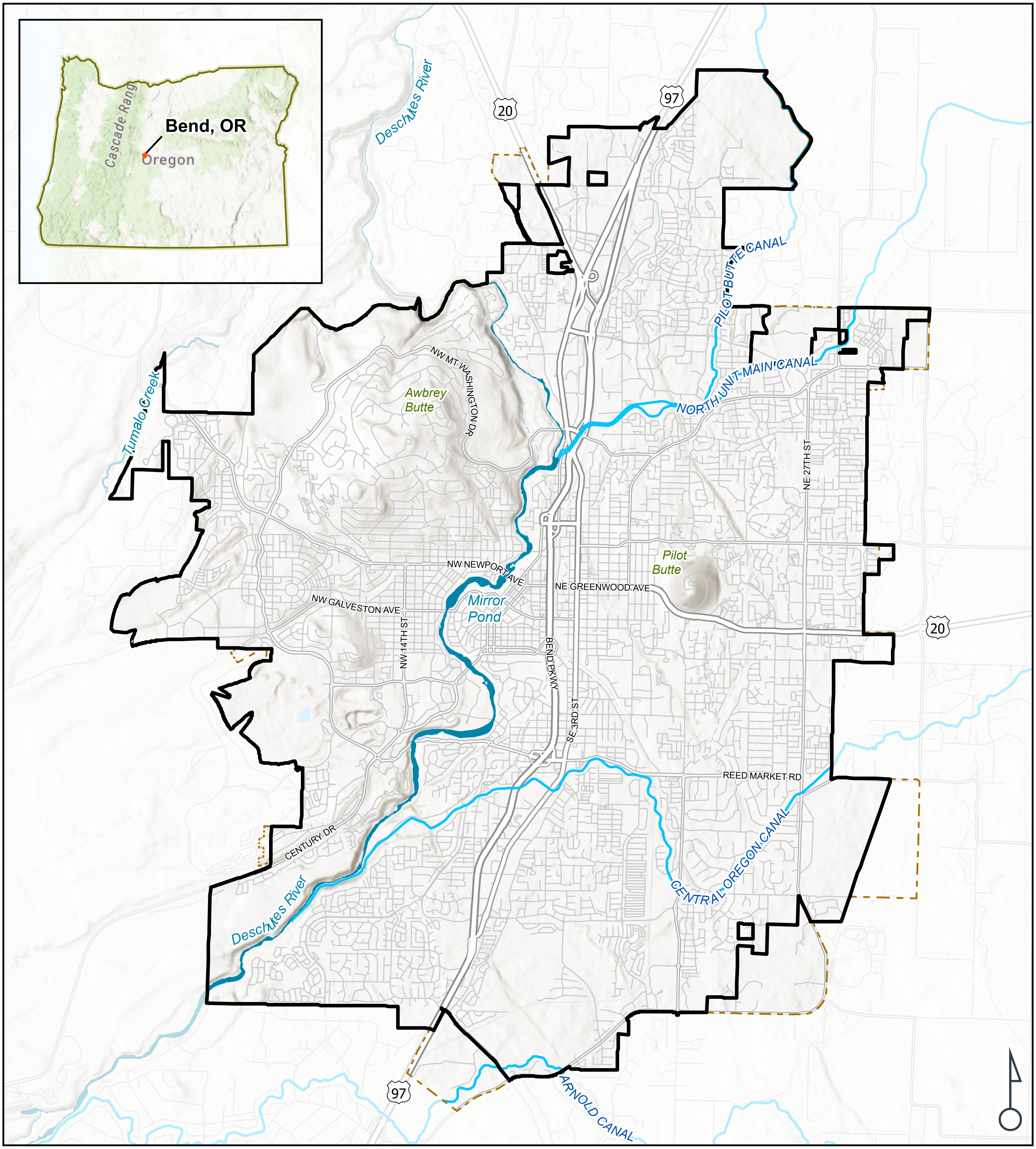

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FIGURE 2
VICINITY MAP
BEND STORMWATER MASTER PLAN
BEND, OREGON

LEGEND

- ▭ Bend City Limits
- ┅ Urban Growth Boundary
- — Streams
- — Canals

Data Sources: City of Bend, USGS, Google Maps.
Date: 10/28/2025
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

CITY OF BEND

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2.1.3. Vegetation

Except where it is irrigated, vegetation is limited to drought-tolerant species in the arid, high desert climate of Bend. Several deciduous and evergreen trees and shrubs are drought tolerant; these include plants native to Central Oregon (Native Plants of Oregon, 2008) such as juniper (*Juniperus occidentalis*) and ponderosa pine (*Pinus ponderosa*). Deciduous trees growing in Bend include alder (*Alnus sp.*), ash (*Fraxinus latifolia*), aspen (*Populus tremuloides*), larch (*Larix occidentalis*), and maple (*Acer macrophyllum*). Chokecherry (*Prunus virginiana*), elderberry (*Sambucus racemosa* or *Sambucus nigra ssp. cerulea*), rabbitbrush (*Chrysothamnus sp.*), and snowberry (*Symphoricarpos albus*) are a few of the local shrubs. Sagebrush and bunch grasses thrive in the area. Xeriscaping, landscaping with vegetation that requires minimal amounts of water, is widely practiced.

Invasive species create problems for wildlife by removing habitat, increasing soil erosion, and outcompeting native vegetation. Concern over the spread of invasive weeds is being addressed through a public information program, including the creation and distribution of pamphlets describing how to identify and eradicate problem vegetation. Some of the major invasive weeds of concern are cheatgrass, Canadian thistle, Scotch thistle, poison hemlock, whitetop, perennial pepperweed, spotted knapweed, diffused knapweed, Dalmatian toadflax, and purple loosestrife.

2.1.4. Wetlands

Wetlands within Bend were inventoried and evaluated by the City in 2000, as shown on Figure 3, Natural Resources. The Comprehensive Plan lists and maps wetlands that are significant State Planning Goal 5 resources to be protected through the City’s riparian corridor standards. These wetlands may not have been field verified, and evaluation by a wetland scientist to verify their protection status under state or federal rules may be appropriate before any activity that could affect them is undertaken. Many of the City’s significant wetlands are adjacent to the Deschutes River and are within the WOZ, which intends to conserve wetlands as a natural resource and requires additional processes for proposed changes to the land.

2.1.5. Topography

Central Oregon’s topography ranges from relatively flat to hilly, with two distinctive buttes in the vicinity of Bend. Awbrey Butte is the highest point in the City, at an elevation of 4,214 feet, and Pilot Butte is nearly as high at 4,138 feet (Figure 4). The volcanic geology created a landscape with many ridges, drops, sinks, and hills. Anecdotally, this topography creates a variety of precipitation patterns and microclimates which may cause some areas of the City to experience storm events in greater severity than other areas. Drainage patterns and directions vary throughout the City, although both surface and subsurface flows are generally northward. The Deschutes River divides the City into eastern and western drainage basins while roughly dividing the City in half. Tumalo Creek influences the drainage patterns in the northwestern area of the City. There are no other creeks or significant drainage ways in the City. East of the river the ground slopes in a northeasterly direction, directing stormwater away from the river.

Mirror Pond, an icon in the heart of the City, was created by the construction of a hydroelectric dam in 1905. This dam is privately owned by PacifiCorp. The pond is in an approximately one-mile-long stretch of the Deschutes River, bordered roughly by the Galveston Bridge to the south and Newport Bridge to the north. The dam is a few hundred feet downstream from Newport Bridge.

Several large irrigation canals run through the City, conveying water from the Deschutes River to serve agricultural areas as far away as Madras, approximately 50 miles to the north. These canals and laterals still have a large influence on drainage patterns within the City. Discharge of stormwater to an irrigation canal requires approval from the relevant irrigation district and therefore is typically avoided.

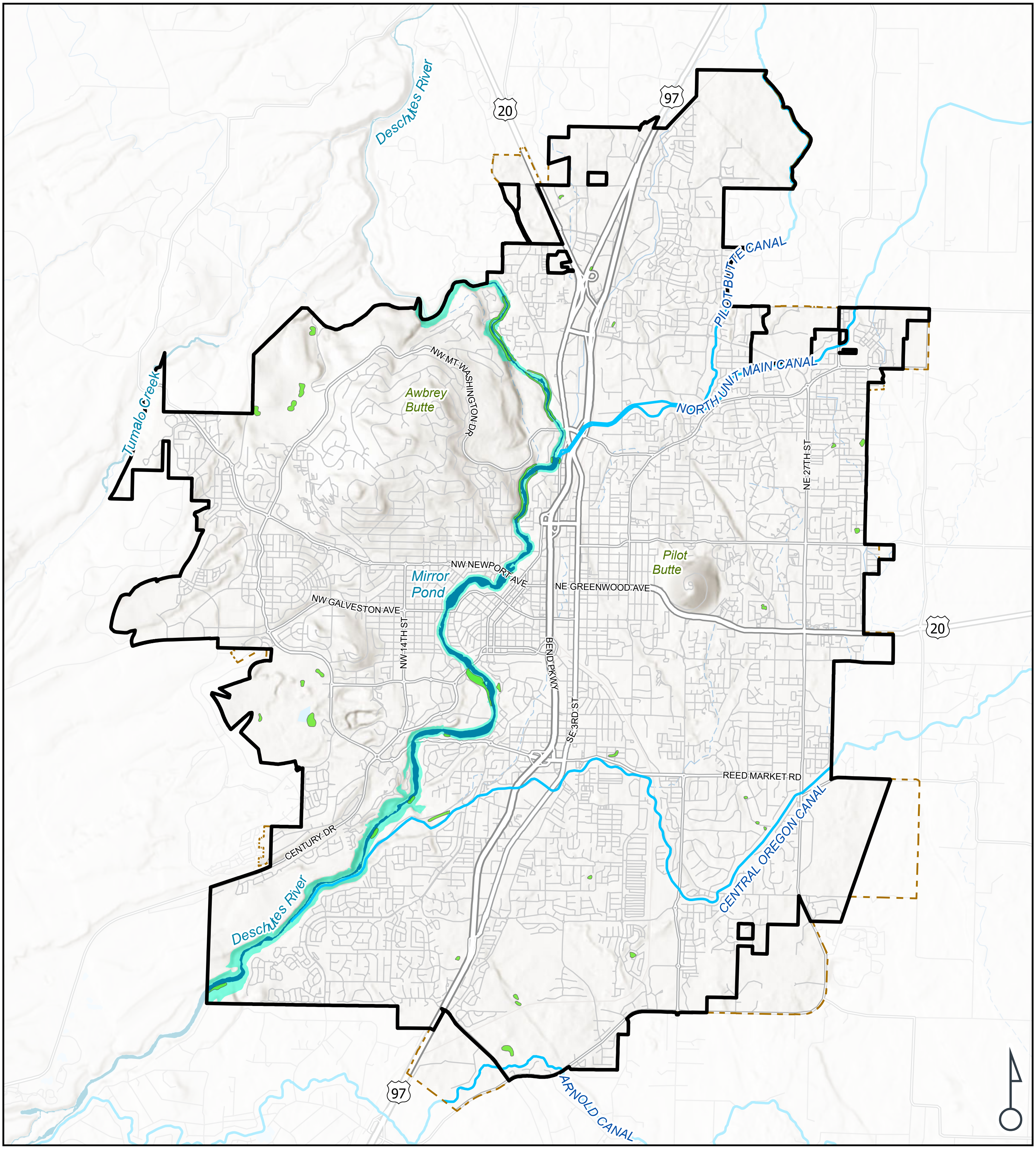

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FIGURE 3
NATURAL RESOURCES
BEND STORMWATER MASTER PLAN
BEND, OREGON

LEGEND

▭ Bend City Limits	🟩 Local Wetlands Inventory
▭ Urban Growth Boundary	— Streams
🟦 Waterway Overlay Zone	— Canals

Data Sources: City of Bend, USGS, Google Maps.
Date: 10/28/2025
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

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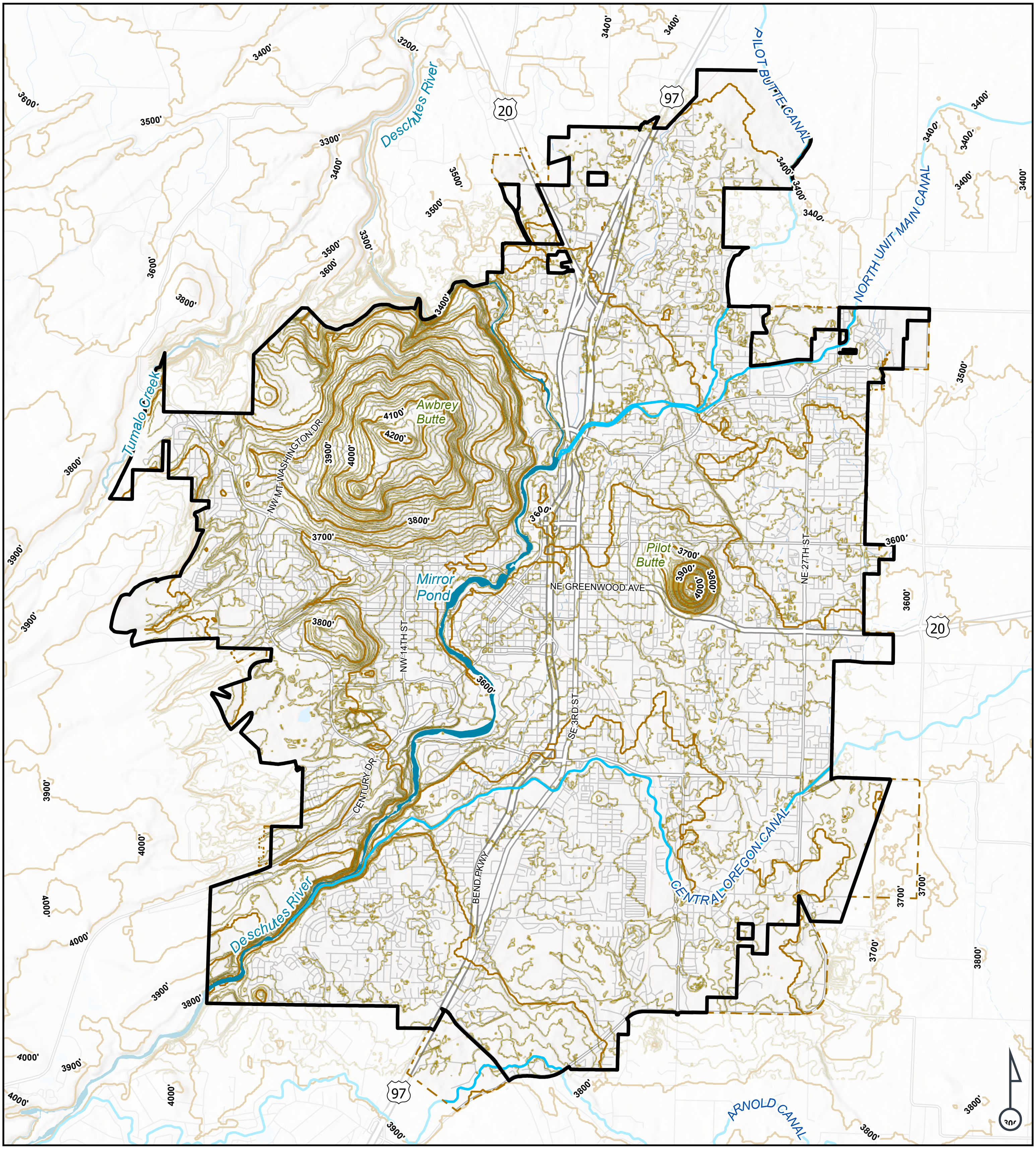

FIGURE 4

TOPOGRAPHY

BEND STORMWATER MASTER PLAN

BEND, OREGON

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LEGEND

▭	Bend City Limits
⬚	Urban Growth Boundary
—	Contour (100')
—	Contours (20')
—	Streams
—	Canals

Data Sources: City of Bend, USGS, Google Maps.
Date: 10/28/2025
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

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2.1.6. Geologic and Hydrogeologic Conditions

The following summary of geologic and hydrogeologic conditions within the City of Bend and surrounding area is based on the more technical and comprehensive text provided in GeoEngineers' 2007 report and GSI's 2020 update. This report is a geologic and geotechnical study based on existing documentation and provides general guidance on the effectiveness of drywells and drillholes in various areas of Bend.

Regional geologic features are largely the result of volcanic activity and subsequent weathering along the Cascade Range. These processes have resulted in the relatively recent deposition of a thick sequence of volcanic and volcanically derived sedimentary rocks (GeoEngineers, 2007). For example, Awbrey Butte, in the northwestern part of town, is a volcanic vent composed of basalt. Volcanic rock is at or near the surface throughout the City, and its permeability and topography vary, creating many areas where stormwater infiltration is very slow with a high risk of localized flooding.

As the volcanic and sedimentary rocks weather, they create a thin soil layer that ranges in depth from 0 to 60 inches or more. In some areas, the soil layer is too thin to allow for deeply rooted vegetation. Soil within the City tends to drain well, with some exceptions, such as Tumalo and Plainview sandy loams. Soil close to or within the Deschutes River channel is primarily river deposits composed of gravels, sand, and silt. The soil layers adjacent to the river have variable permeability (GeoEngineers, 2007).

Portions of the City are underlain by basalt that is relatively fractured with a sufficiently high permeability to allow for infiltration of stormwater at relatively high rates, particularly given the relatively low annual rainfall experienced in Central Oregon. Before the City was developed, the permeability of this basalt was generally high enough to allow infiltration of large quantities of stormwater runoff, even for large storm events. Drywells for disposal of stormwater runoff performed reasonably well when Bend was a smaller town with a smaller impervious area. However, when stormwater runoff is concentrated to a higher volume and increased rate of runoff because of the increase in impervious area, the permeability of the basalt does not always allow the increased stormwater runoff to infiltrate quickly enough, and flooding occurs.

Some areas of the City are underlain by consolidated basalt or tuff, which is highly impermeable and does not provide acceptable geotechnical conditions for the use of drywells or drillholes that are not deep enough to penetrate through it. Many of these areas can be identified by the presence of drillholes, installed to allow stormwater to be disposed of below near-surface low-permeability layers. Drillholes are generally about 6 inches in diameter with casing in the top several feet.

With Bend's rapid growth in the past 30 years, the number of UIC systems in the public right-of-way has increased to over 7,000. Many private properties also have UICs which are required to be registered through DEQ and are not part of the City's system. Construction of piped drainage is expensive in Bend due to the rocky geology and has been avoided in most areas of the City. The City has not had the time or resources to develop adequate drainage infrastructure to keep up with the growth in population and the resulting increase in impervious areas. Many of the existing UICs no longer handle the design volume and rate of stormwater runoff for reasons such as improper installation, inappropriate geotechnical conditions, plugging by sediment and/or road traction cinders, and having been constructed according to standards and specifications that are now outdated.

In their 2007 report, GeoEngineers identified three major drainage areas. These areas were refined in a 2020 *Stormwater Infiltration Evaluation Update*. This report updated drainage area maps and characteristics (see Figure 5, Drainage Areas), UIC ageing, water well locations, and mapped potential perched groundwater.

Drainage Area A, located east of the Deschutes River, is composed of fractured basalt and generally provides the best geotechnical conditions for the use of drywells, drillholes and infiltration. Drainage Area B, in the Awbrey Butte area, is characterized by soils that are not well-draining. Drainage Area C, located in southwest Bend, has an impermeable layer of volcanic rock known as “tuff” and is generally not suitable for drywells or infiltration BMPs that cannot penetrate the upper layer of material. More details on each of these drainage areas can be found in GSI’s 2020 update.

The infiltration capabilities of underlying soil and rock are only one consideration in the siting and operation of infiltration facilities. State and federal regulations, drinking water wells located throughout the City, steepness of topography, protection of drinking water sources, and maintenance of these facilities are all issues to evaluate when considering whether to construct infiltration facilities. Current standards for new development also typically require all storm drainage to remain on-site using infiltration-focused surface or subsurface disposal methods, imposing another consideration.

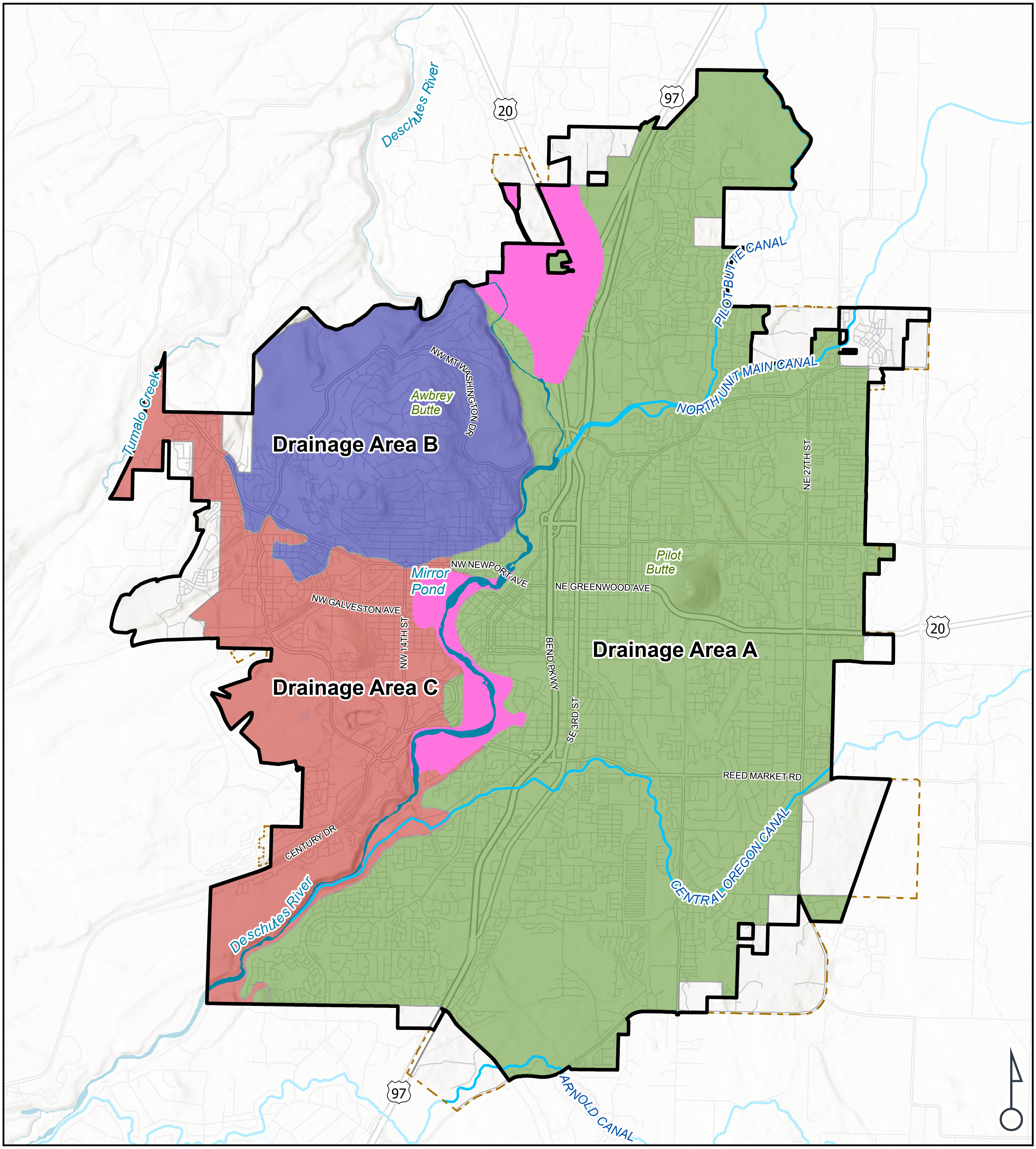

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FIGURE 5

DRAINAGE AREAS

BEND STORMWATER MASTER PLAN

BEND, OREGON

LEGEND

☐ Bend City Limits
⬚ Urban Growth Boundary
■ Perched Aquifer
— Streams
— Canals

Drainage Areas

🟩 Drainage Area A
🟪 Drainage Area B
🟥 Drainage Area C

Data Sources: City of Bend, USGS, Google Maps.
Date: 10/28/2025
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

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2.1.7. Water Quality

The City of Bend has a dual source drinking water supply system, with approximately 60 percent of water delivered by the City produced from the Bridge Creek surface water source located in the protected municipal watershed on US Forest Service land. The remainder of the drinking water supplied by the City, plus water supplied by private quasi-municipal sources, is groundwater, pumped from the Deschutes regional aquifer that underlies the City. The City has won several awards for the quality of its drinking water, and the City and its residents are committed to protecting this valuable resource.

Drinking water safety and quality are regulated through the SDWA. The SDWA and Oregon's equivalent rules establish protection areas and strictly regulate UICs that have the potential to contaminate or contribute to the contamination of sources of drinking water. Figure 6, Drinking Water Protection Areas, shows the two-year time of travel for groundwater travel to municipal and quasi-municipal drinking water wells. Figure 6 also shows two areas of shallow, perched groundwater (note that the entire City is underlain also by the deep, regional Deschutes Aquifer). The City's WPCF permit requires that UICs within these areas be equipped with additional protection measures to ensure that contaminants do not impact groundwater quality.

The City monitors the quality of stormwater entering UICs as required under the WPCF UIC permit from DEQ. Seven UICs are sampled annually with six high risk representative monitoring sites and one emerging pollutant site. These sites were selected based on land use zoning, access safety and average daily trip (ADT) data along with likeliness to receive adequate flow for sampling. Monitoring data is submitted annually to DEQ. Based on exceedances of permit-identified action levels, the City will initiate corrective actions and document activities conducted to resolve or address exceedances in the annual report. The City has experienced no exceedances to date.

The City has been collecting ambient water quality data from the Deschutes River since 2004 to assess water quality as the river enters, passes through, and exits the City (ESA, 2024). This voluntary collection of data is provided to DEQ and provides a basis for understanding water quality of surface waters within the City.

2.1.8. Population

Incorporated in 1905, Bend has grown from a small logging town of 300 residents to a City with an estimated population of 104,089 in 2024 (Portland State Population Research Center, 2024). Bend's abundant high-quality drinking water, dry climate, and year-round recreational opportunities have attracted many residents, and Bend is forecasted to continue its high growth rate. City planning staff are relying on growth projections that estimate the City population to exceed 130,000 by the year 2035.

The City is approximately 84.5% White, 9% two or more races, and two percent or less identify as American Indian/Alaska Native, Asian, Black or African American or Native Hawaiian or other Pacific Islander (US Census, 2020). Additionally, 9.2% identify as Hispanic or Latino of any race.

2.1.9. Land Use and Zoning

Land use in Bend currently consists of a mix of residential, commercial, public facility, and industrial uses. The downtown district is in the center of town near the Deschutes River. Figure 7, Zoning, depicts zoning by type within the current UGB.

Statewide Land Use Planning Goal 11 requires planning for water and sewer services within the City and all areas within an established UGB. This plan covers the City and UGB and does not call for piped facilities outside of the UGB. All evaluations and alternatives in this plan involve serving only areas within the UGB and this plan is consistent with Goal 11.

Approximately 84 public parks in and around the City are operated and managed by the Bend Park and Recreation District (BPRD) (Figure 8, Public Parks), and additional facilities are being planned. Drake Park along Mirror Pond and Juniper Park in the eastern part of the City are two of the largest parks in Bend. BPRD separated from the City government in 1974, and 22 of the City's stormwater outfalls still pass through BPRD parks adjacent to the river. Pilot Butte, a popular hiking trail and scenic overlook, is managed by the Oregon State Parks Department.

2.1.10. Industry

Central Oregon is home to a diverse group of industries. Top employers include health care, retail, hospitality, construction, professional services, and manufacturing industries (ECONorthwest, 2025). Recreation and tourism-related industries are key economic drivers for the City. As Bend grows, industries continue to diversify and provide more jobs.

2.2. Future Growth

Bend adopted its current UGB and growth plan in 2016. Oregon state law requires that Bend reevaluate the land inventory within the UGB every six years to accommodate twenty years of projected growth. The City identified ten expansion areas, which added 2,380 acres to the UGB and nine opportunity areas for strategic growth within city limits. The City has amended the UGB two additional times since 2016 to include sites on which substantial amounts of affordable housing will be developed. In 2024, the City initiated a process activated by Senate Bill 1537 that allowed qualifying local governments to add up to 100 acres of residential land to the UGB. The City has selected a location and intends to apply for a UGB Amendment.

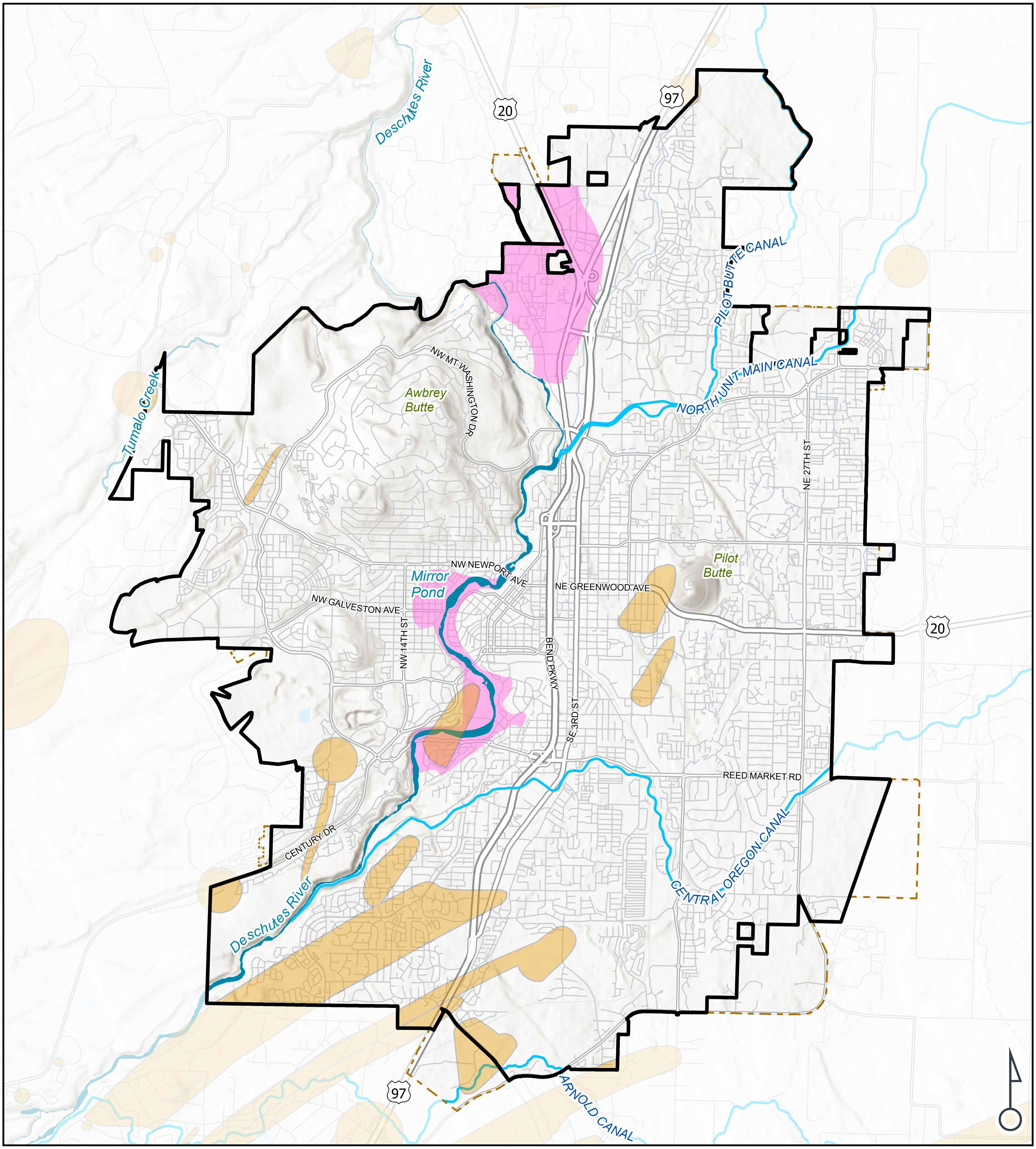

FIGURE 6

DRINKING WATER PROTECTION AREAS

BEND STORMWATER MASTER PLAN

BEND, OREGON

Data Sources: City of Bend, USGS, Google Maps.
Date: 10/28/2025
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

O:\PROJECT\20300\20359\04 CAD\GIS\APRX\20359 BEND MASTER PLAN MAPS JR.APRX

LEGEND

- ▭ Bend City Limits
- ⬚ Urban Growth Boundary
- 🟧 Two-year Time of Travel to Public Well Water Zones
- 🟪 Perched Aquifer
- — Streams
- — Canals

CITY OF BEND

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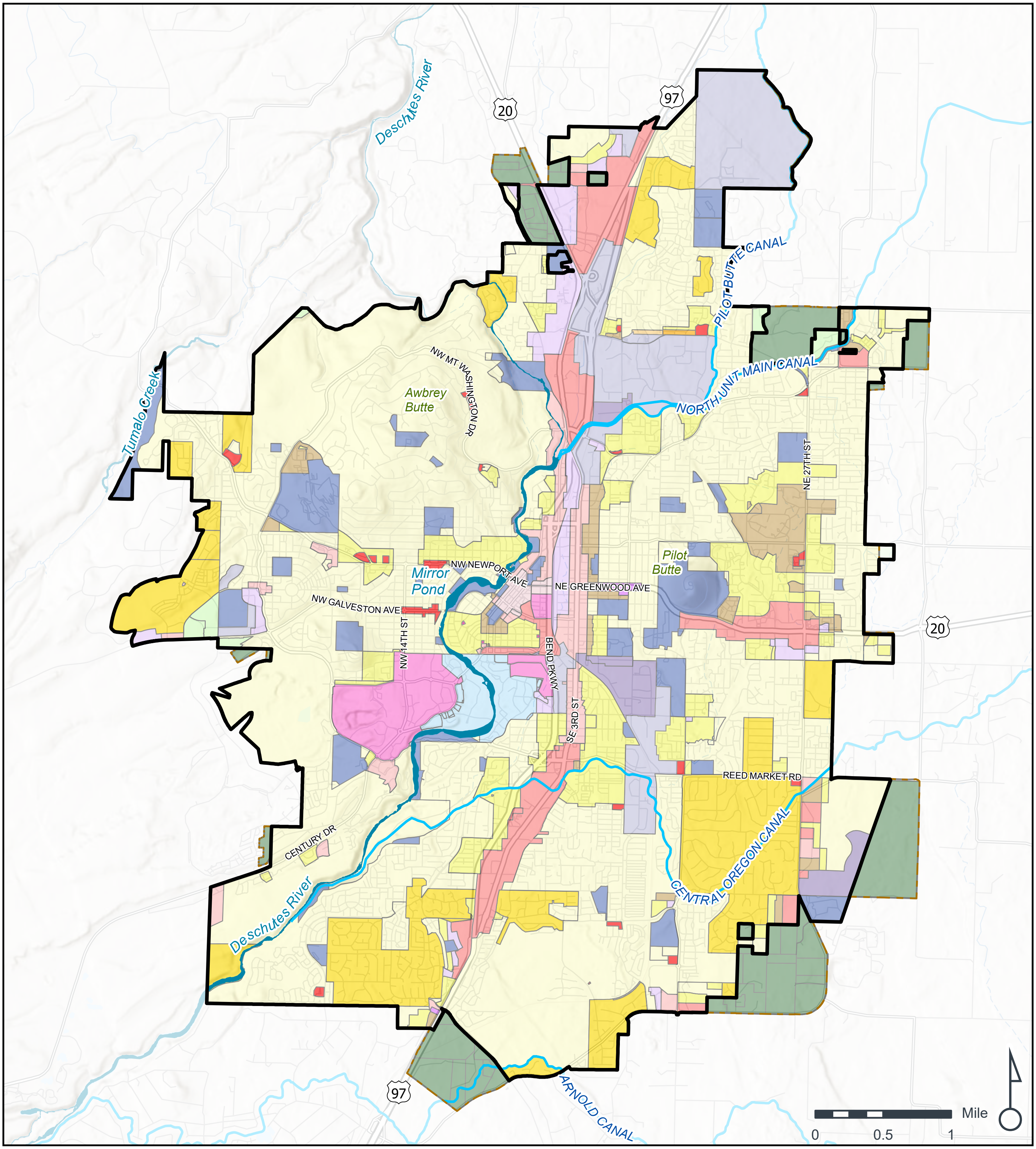

FIGURE 7
ZONING
BEND STORMWATER MASTER PLAN
BEND, OREGON

Bend City Limits
Urban Growth Boundary
Canals
Streams

ZONING

Central Business (CB)
Convenience Commercial (CC)
General Commercial (CG)
Limited Commercial (CL)
Neighborhood Commercial (CN)
Light Industrial (IL)
General Industrial (IG)
Mixed Employment (ME)
Mixed-Use Neighborhood (MN)
Mixed-Use Riverfront (MR)
Mixed-Use Urban (MU)
Public Facilities (PF)
Professional Office (PO)
PO/RM/RS
Low Density Residential (RL)
Standard Density Residential (RS)
Medium Density Residential (RM)
High Density Residential (RH)
Urban Area Reserve (UAR-10)
Urbanizable Area (UA)

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Data Sources: City of Bend, USGS, Google Maps.
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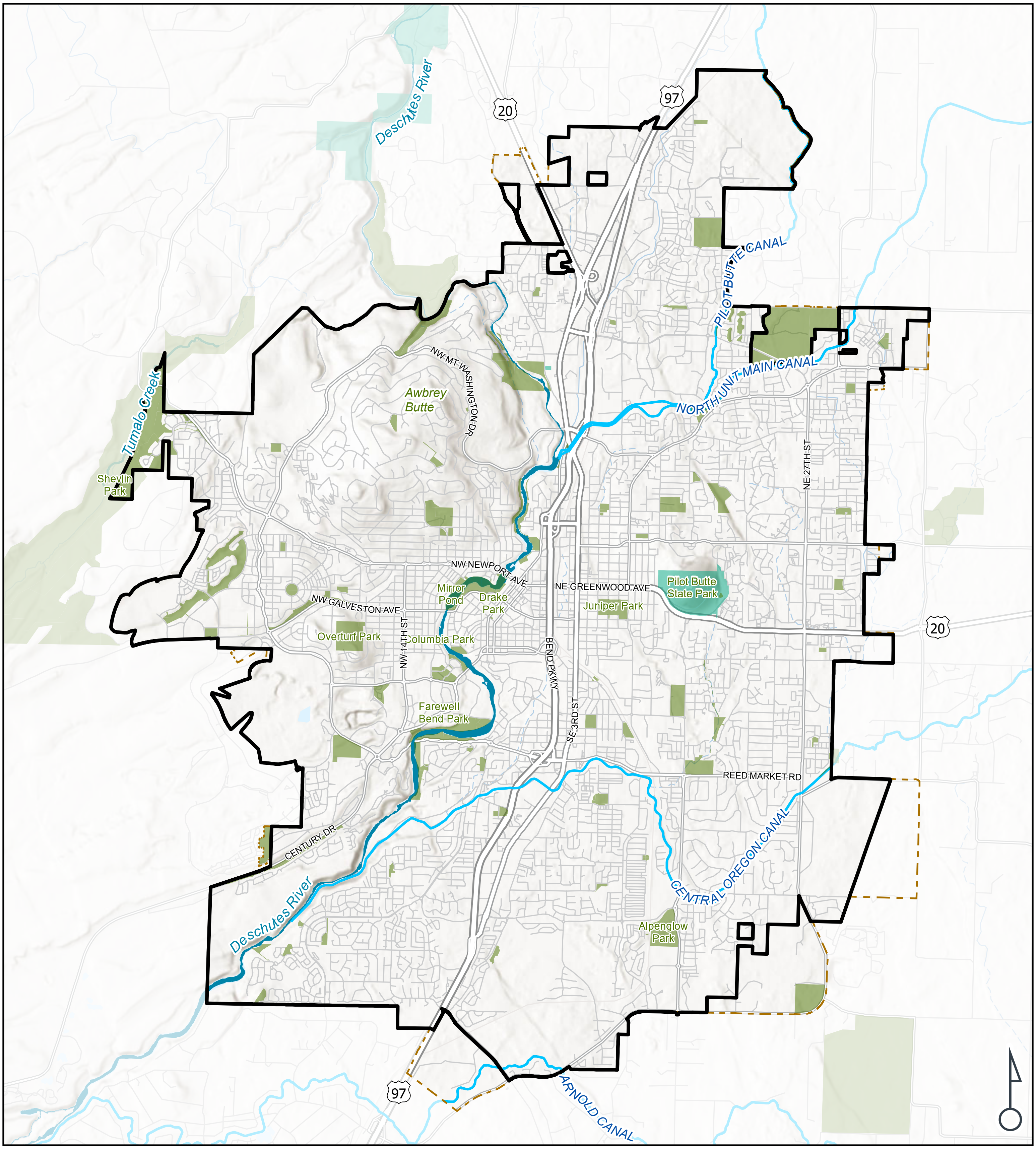

FIGURE 8

PUBLIC PARKS

BEND STORMWATER MASTER PLAN

BEND, OREGON

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LEGEND

▭	Bend City Limits	🟩	BPRD Parks
⬚	Urban Growth Boundary	🟦	Oregon State Parks
—	Streams		
—	Canals		

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Section 3. Planning Process & Analysis

This section describes the data collection, verification, and analysis processes used to create an inventory and describe the current system, locations of known problems and issues, and to begin further investigation into potential solutions. Otak worked closely with City of Bend project managers to identify appropriate data sets; interview engineering, planning, and operations staff; and make field visits to both verify known and potential issues and identify potential solutions.

This analysis generated the specific CIPs and programmatic recommendations to address conveyance and water quality issues contained in Section 4, Stormwater Capital Improvement Projects.

3.1. Initial Stormwater System Review

The first step in the planning process was a system analysis to identify issues by reviewing reports, plans, and the storm sewer asset databases and by interviewing City staff. Sources of information included the 2014 Stormwater Master Plan, existing City Capital Improvement Programs (CIPs), the 2023 Integrated Stormwater Management Program (ISWMP), drainage and groundwater protection studies, and regulatory documents such as the City's WPCF and MS4 Permits. A complete annotated bibliography of reviewed sources is contained in the Bend Stormwater Master Plan Discovery Phase Summary Memo (Appendix A). Certain sites were selected for further investigation with field visits.

3.1.1. Fieldwork

Fieldwork was conducted at several sites in spring of 2024 and 2025 to confirm or learn more about the known issues and recent projects. Consultant staff engineers were accompanied on these site visits by city staff from the Water Services and Engineering Departments. Data recorded included the primary observed problem, underlying issues, potential solutions, project feasibility, and potential impacts of alternative solutions.

3.1.2. Inventory of Current Stormwater System Assets

The City of Bend maintains a database of utility assets, which includes stormwater assets maintained by the City as well as some private stormwater assets. For the purposes of this SMP, only the public stormwater assets were used for analysis and planning, which included the categories of UICs (drywells and drillholes), swales, storm pipe, catch basins, outfalls, and sedimentation manholes. Each asset record includes information about location, type, material, size, condition, age, status, and the source of information.

As of July 2025, the City owns approximately 35,500 individual stormwater assets (Table 1). This inventory is constantly shifting as assets are created or decommissioned through new development, capital construction, and maintenance activities.

Table 1 Bend's Active Stormwater System Assets

Stormwater Asset	Service Provided	Count*
Outfall to Deschutes River**	Conveyance	36
Other Outfalls (non-MS4)	Conveyance	207
Drywell	Infiltration	6,083
Drillhole	Infiltration	933
Swale (Grass, Rock, Vegetation, Infiltration)	Infiltration and/or Water Quality	290
Storm Pipe Segment	Conveyance	13,690
Storm Filter Vault	Water Quality	18
Catch Basin	Collection	9,908
Sedimentation Manhole	Water Quality	1,495
Storm Distribution Box	Conveyance	79

** Existing, in-service assets owned and maintained by the City of Bend*
*** Number of outfall structures is greater than the number of outfall basins studied in the Outfall Retrofit Needs Assessment Memo (Appendix A)*

Collection & Conveyance

Bend does not have a piped storm drain system that serves the entire City; the lack of defined drainage ways, the expense of digging in rock, and the difficult topography have limited the installation of piping. Areas nearest the river drain through storm pipes to one of 36 outfalls to the Deschutes River. Areas of the City outside of the MS4 boundary (See Figure 10) convey stormwater to UICs and other infiltration facilities for discharge to the ground. UIC's also are located in many areas within the MS4 boundary as well, providing supplemental stormwater management.

Bend's storm system varies in design and material based on the era of construction. As of July 2025, the City has 13,690 segments of public storm pipes, approximately 80 miles in total length, in active use.

Infiltration

Infiltration through UICs and swales is a common method of managing stormwater in Bend.

Water Quality Facilities

Stormwater facilities, or water quality facilities (WQFs) are intended to mitigate the impacts of stormwater runoff on streams and natural systems at the point of discharge. WQFs can be designed to reduce pollutants and manage flow rates and/or volumes. Pollutant reduction can occur through settling or filtering the water through vegetation or soil. This can remove sediments and particulates; examples include vegetated swales, grassy filter strips, and vegetated planters. Facilities that manage flow rates and/or volume detain flows and release stormwater at a specific rate, such as with detention ponds. Some facilities are also designed to provide infiltration, which reduces the volume of stormwater released into surface water bodies.

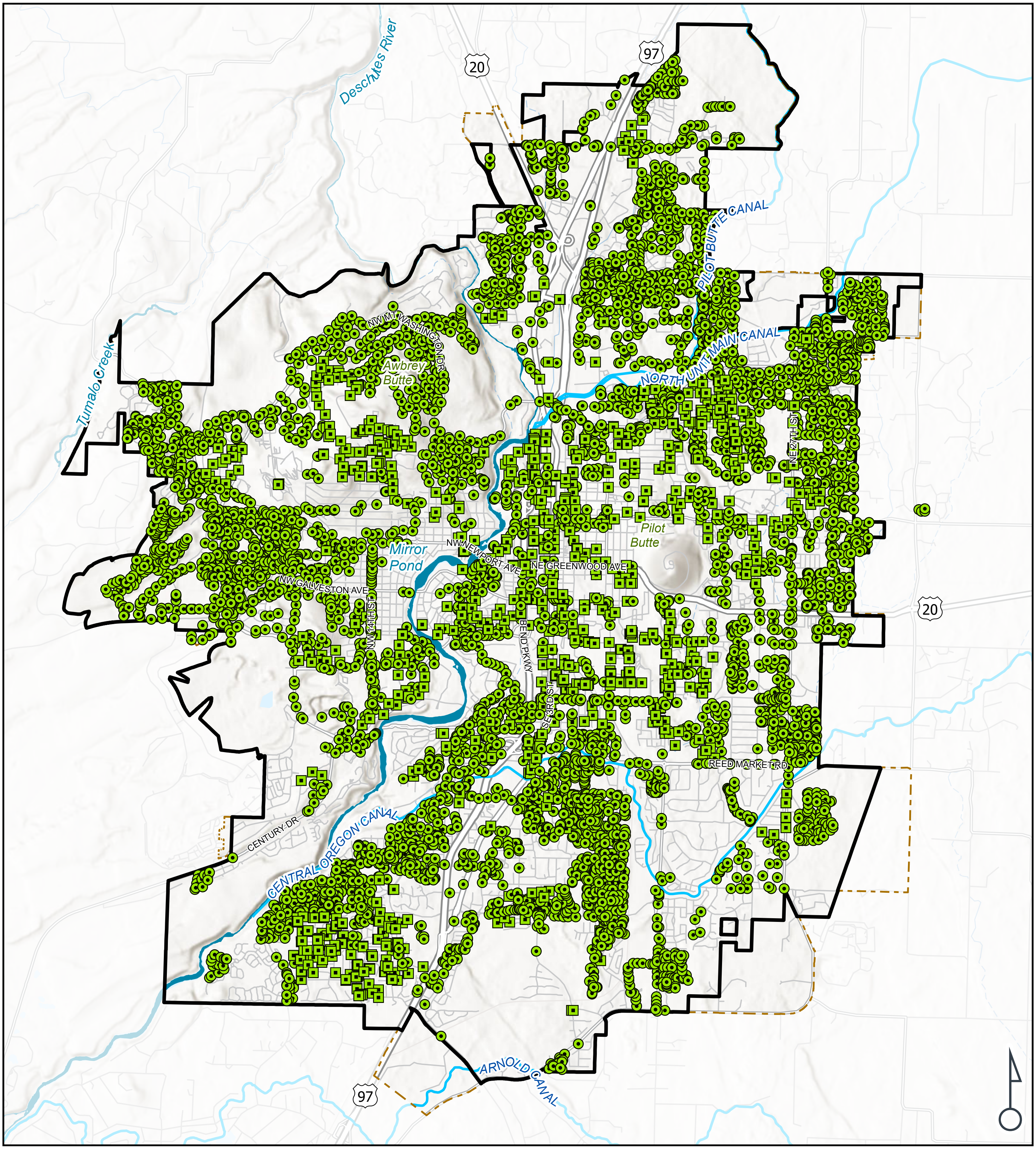

FIGURE 9

UIC SYSTEM EXTENT

BEND STORMWATER MASTER PLAN

BEND, OREGON

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LEGEND

- Bend City Limits
- Urban Growth Boundary
- Streams
- Canals

Underground Injection Control

- 🟩 Drillhole, Active
- ● Drywell, Active

Data Sources: City of Bend, Deschutes County, USGS, Google Maps.
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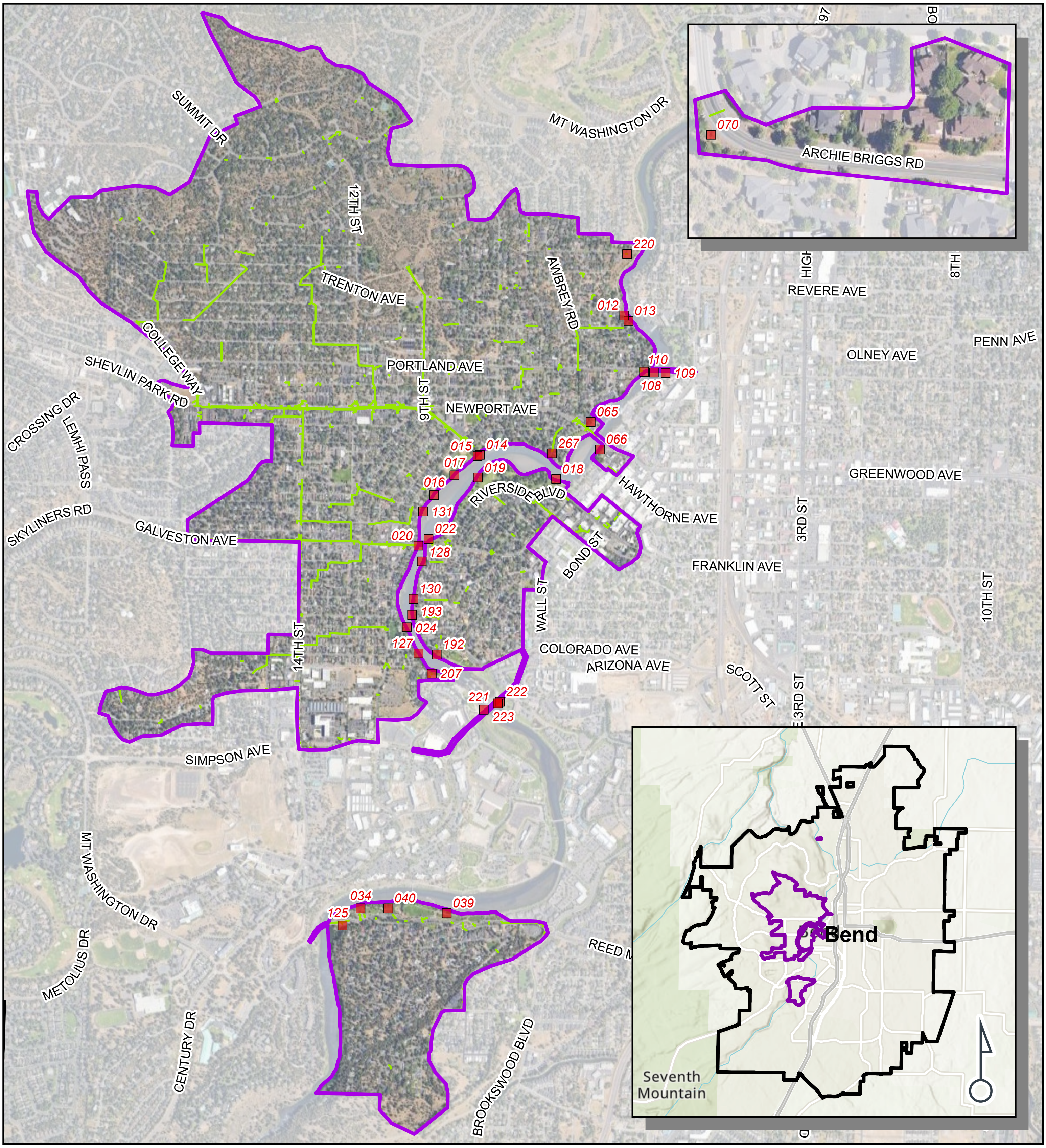

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FIGURE 10

MS4 SYSTEM

BEND STORMWATER MASTER PLAN

BEND, OREGON

LEGEND

☐	Bend City Limits
☐	MS4 Basin Delineation
—	Storm Main
🟥	Outfalls

Data Sources: City of Bend, USGS, Google Maps.
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3.2. System Analyses

Three studies were conducted to analyze specific components of Bend's storm system. The full text of the studies contained in technical memoranda are included in Appendix A. The findings, which are summarized below, helped inform and identify known issues.

3.2.1. Outfall Retrofit Prioritization

This study, conducted by Otak, examines 32 basins that discharge stormwater through City-owned outfalls to the Deschutes River. A stormwater quality retrofit program is a requirement in the City's MS4 Permit. To prioritize which outfalls should receive retrofits, aspects of the outfall tributary areas which may increase pollutants or sediment in stormwater runoff were analyzed. The amount of untreated contributing area, sedimentation potential from steep slopes, estimated pollutant load by zoned land use, and related known issues were scored for each outfall area resulting in a priority ranking for the City's outfalls. This analysis identified six high priority outfalls for further consideration in this SMP.

3.2.2. Deep Drywell Considerations and Siting

This study, conducted by GSI, provides the City with information about new-to-Oregon stormwater infiltration facilities such as deep drywells (also known as modified drywells). A deep drywell is deeper than a conventional drywell which is currently used throughout the City. While not widely used in Oregon, deep drywells have been used in the desert southwest and other areas of the Pacific northwest to infiltrate below low-permeability soils. Recommendations for siting criteria, construction practices, spill mitigation, pretreatment, and operations and maintenance are discussed to minimize potential risks of permitting and implementing deep drywells in Bend.

3.2.3. Drillhole Prioritization

This study, conducted by GSI, provides the City with a prioritization ranking for drillhole replacement and retrofits. The City of Bend has a large inventory of drillholes to infiltrate stormwater. These facilities are typically 6-inch-wide boreholes up to 100 feet deep. Drillholes are more common in areas of the City that do not infiltrate well. Construction of new drillholes is no longer permitted in public infrastructure by City standards due to maintenance issues, lack of pretreatment, and the difficulty and expense of retrofitting. This study analyzed which existing drillholes pose the greatest risk to groundwater resources.

3.3. Identified Known Issues

After studying Bend's storm system, a total of 103 known issues were compiled (see Figure 11).

A geodatabase was used to organize the known issue points by location and allow for spatial analysis and visualization. Each known issue was assigned a unique identification number (KI-ID) within the geodatabase. In addition to the issue location, attribute fields for its full name, long description of the issue, and notes collected during site visits provided descriptive information for each issue. The database also contained a set of fields to indicate the type of primary concern for each issue. The primary concern categories include drainage, condition, maintainability, erosion, groundwater quality, or surface water quality. Table 2 shows the number of issues that fall into each category.

Table 2 Count of Known Issues by Type

Type	Count	Category Description
Drainage	57	Drainage issues include ponding and flooding on streets and private properties where the drainage system is inadequate, damaged, or is not present
Water Quality – Groundwater	26	Groundwater quality issues are identified where UICs may pose a contamination risk to groundwater because they are located near drinking water wells or do not have a spill control structure
Condition	6	Condition issues are identified when the drainage system or stormwater facility is damaged
Water Quality – Surface Water	7	Surface water quality issues are identified by analyzing the pollutant-causing characteristics of Bend's outfall basins and then prioritizing those outfalls that may discharge the most pollutants to the Deschutes River
Maintainability	5	Maintainability issues are identified where the drainage system or stormwater facilities are difficult or dangerous for City staff to maintain due to location, design, or condition
Erosion	2	Erosion issues are identified where stormwater flows over denuded or sparsely vegetated landscapes or natural areas and deposits eroded soils into streets, catch basins, UICs, or other elements of the drainage system
Total	103	

About half of the Known Issues have a secondary issue type which contributes to the problem (Table 3). The most frequent combination is a groundwater quality issue paired with an infrastructure condition issue. Most of these are drillholes that may pose a risk to water quality because they are located within the two-year time of travel for drinking water wells and/or have been damaged by long-term sediment build-up which impacts their function.

Table 3 Frequency of Primary and Secondary Issue Type Combinations

Primary Issue Type	Secondary Issue Type								Grand Total
	No Secondary Issue Type	Drainage	Water Quality – Surface Water	Water Quality – Groundwater	Maintainability	Condition	Erosion	Sedimentation	
Drainage	41			2	1	2	10	1	**57**
Water Quality-Surface Water	7								**7**
Water Quality-Groundwater			1			25			**26**
Maintainability	3					2			**5**
Condition	3	2			1				**6**
Erosion		2							**2**
Grand Total	**54**	**4**	**1**	**2**	**2**	**29**	**10**	**1**	**103**

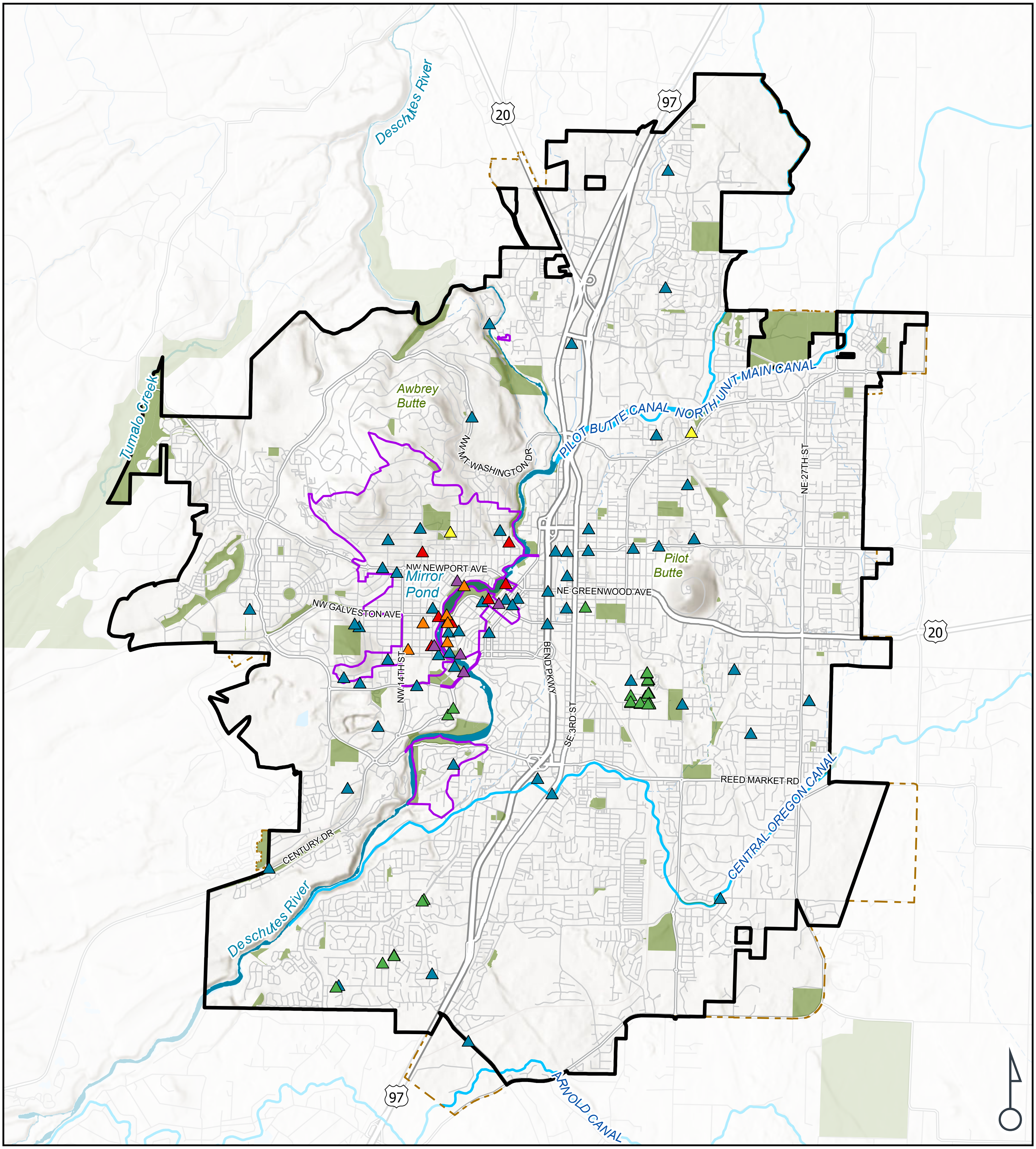

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FIGURE 11
STORMWATER KNOWN ISSUES
BEND STORMWATER MASTER PLAN
BEND, OREGON

LEGEND

- Bend City Limits
- Urban Growth Boundary
- MS4 Basin Delineation
- Parks
- Canals
- Streams

Stormwater Known Issue

- ▲ Drainage
- ▲ Water Quality-Surface Water
- ▲ Water Quality-Groundwater
- ▲ Maintainability
- ▲ Condition
- ▲ Erosion

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3.3.1. Disposition of Issues and Solutions from 2014 SMP

Unresolved projects from the 2014 SMP contributed to the collection of known issues. Two remaining high priority projects have not been fully implemented, and numerous of the 58 lower priority projects from the prior plan have not been implemented. The status of each of the 2014 high priority projects is included in Table 4, followed by a narrative explanation of the current progress on the incomplete projects.

Table 4 Status of 2014 SMP High Priority Projects

Project Name	Priority (2014)	Description (2014)	Status
Westside Village Shopping Center and Bend Fire Station	1	An old commercial development, this area sits over shallow tuff where infiltration does not appear to work. In addition, catch basins are located away from the curb, allowing water to bypass existing drywells. A cascading effect starts at Safeway, adds flows from Ray's Foods, prior to inundating the fire station and added flows from a storage facility, cause large volumes of water to flow into and through Nosler's manufacturing plant.	Partially Resolved; The Ray's Foods site was redeveloped and resolved some issues.
Franklin Underpass	2	A low spot surrounded by a large amount of paving, this area floods readily during storms. Drywells are unable to keep up with the volume and this area floods during many storm events.	Unresolved; Project 1RFGU on current CIP
3rd Street Railway Underpass	3	Similar to Franklin St., 3rd Street is a low spot surrounded by a large impervious area, and floods easily during storm events.	Completed 2013*
Archie Briggs West Side	4	Archie Briggs has a very steep roadway slope that collects water from an even steeper hillside. The roadway in the lower areas is damaged from the large amount of water coming through the area. Stormwater blocks one of the lanes of traffic and then leaves the uncurbed roadway to drain into residential property.	Solved but Monitor
Fairway Heights at Awbrey Butte	5	Both public and private stormwater combine to create this problem area. A large part of Awbrey Butte drains to culverts and through residential sites, at one point entering peoples' homes, prior to draining to the golf course below. Easements are located throughout the development, and on the golf course. However, they don't line up well and water tends to go straight, detouring around some of the easements.	Completed 2019

**Project was prioritized in the 2008 draft SMP and was completed before adoption of the plan in 2014.*

The Westside Village Shopping Center was not completed as a capital project and is not on the City's CIP schedule. While ranked as Priority 1 in the 2014 SMP, private development in the project area has reduced the severity of the issue and changed the scope of the project alternatives. In this SMP, the project has been reclassified into the Failing UIC Drainage Improvement Program.

The 2014 SMP identified the Franklin Street underpass as a high priority drainage project location and identified the Greenwood Street underpass as a lower-priority project. In the intervening time, the City began to think of and plan for both Franklin and Greenwood underpasses as a unified capital project (capital project budget number 1RFGU) under the same project umbrella. These underpasses are beneath BNSF rail tracks and frequently flood during rain events, halting east-west travel. The Franklin and Greenwood drainage basins were studied in a 2025 report by DOWL, LLC, *City of Bend Midtown Stormwater Improvements* (Appendix A). Stormwater improvements in these basins likely will be paired with transportation capital projects to improve the Franklin and Greenwood roadways and underpasses. While the projects are now paired in the CIP, as of July 2025, the City is currently planning to pursue only the Franklin underpass solution in the 1RFGU project. A recent “quick-build” transportation project on Greenwood did not include any of the drainage improvements recommended in the DOWL report. However, the City is gathering feedback to inform future changes of Greenwood, possibly including the drainage improvements.

The Archie Briggs project was not completed as proposed in the 2014 SMP. Instead, an asphalt berm was installed as a mitigation measure for flooding in the area and the problem appears to be resolved. Continued monitoring is recommended for the area. ODOT identified the Archie Briggs Road bridge, which crosses the Deschutes River, as structurally deficient. Because the bridge is downstream of the problem area, additional stormwater management measures should be considered in the design of the bridge if funding becomes available to replace or rehabilitate it.

The current stormwater CIP includes the South Awbrey Butte Drainage Improvements (1RSAB), which is a collection of drainage issues identified in the *South Awbrey Butte Drainage Stud*y (HDR, 2017). Developing this drainage plan was a non-priority stormwater infrastructure improvement project recommended in the 2014 SMP.

In addition to the five high priority projects, the 2014 SMP identified 58 potential stormwater improvement projects. Any of the projects from the 2014 SMP that have not been implemented and are still active issues were added to the known issues database. MB18A (Franklin Underpass), MB18B (Greenwood Underpass), MB14A Project 2 (NW Congress St), MB14A Project 3 (NW Riverfront St) were included in this SMP because the drainage issues in these locations are still active.

3.3.2. Issue Screening and Classification

The known issues list was screened to exclude any issues with a status that indicates it has been resolved or is in progress. The remaining active-status known issues were then grouped and classified with a solution type best aligned with the primary issue. Stormwater issues may be solved through individual capital projects, programmatic solutions, policy changes or a variety of other actions. Common types of solutions for each issue type are listed in Table 5.

Table 5 Primary Issue Types and Typical Solutions for Known Issues

Primary Issue Type	Typical Solutions				
		Programmatic Solution			
	CIP Project	Major Maintenance	Failing UICs	Drillhole Retrofit	Policy Change
Drainage / Flooding	x	x	x		x
Water Quality-Groundwater				x	x
Water Quality-Surface Water	x				x
Condition		x	x		
Maintainability		x			
Erosion		x			x

The 79 active known issues are shown by solution type in Figure 12. A small number of solution types do not fit the typical categories outlined in Table 5 or are too minor to qualify as a capital project or program. These are grouped as ‘Other’.

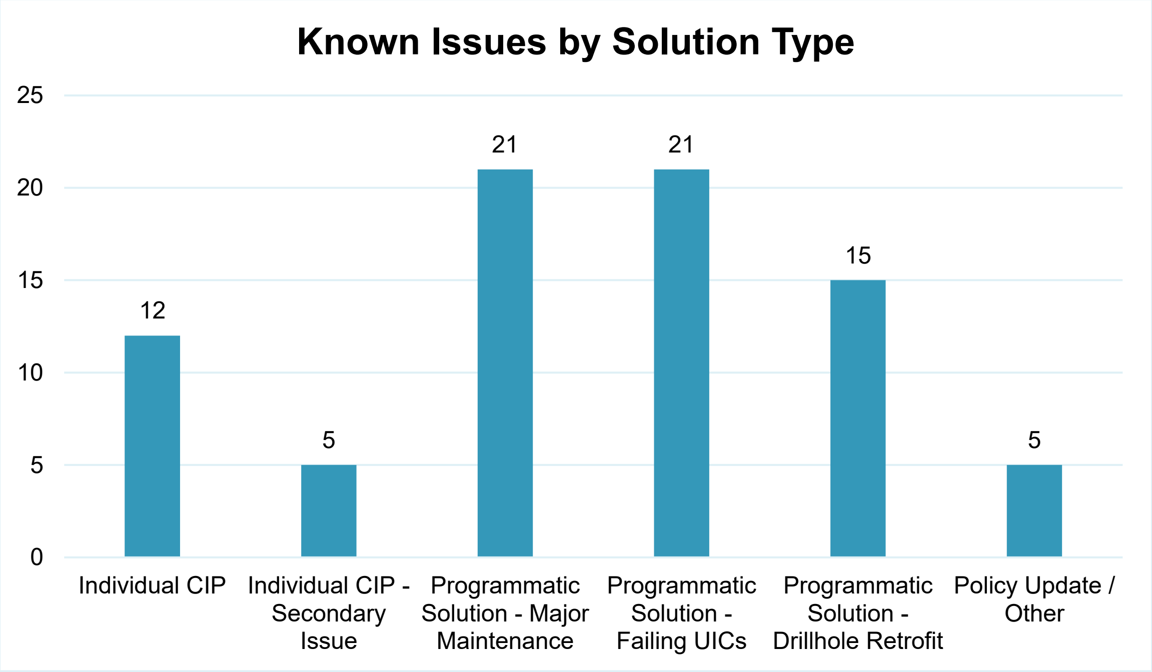

Figure 12 Chart of Recommended Solution Types for Known Issues

Individual CIPs are a solution type for large and/or complex drainage and surface water quality issues. These issues require complex site-specific engineering design. Either a significant improvement to existing facilities is needed, or storm system infrastructure is planned where none currently exists. Individual CIP Projects are often developed with the goal of solving multiple neighboring issues with a single project. *CIP-Secondary Issue* indicates that the known issue has been grouped with other issues to be solved with an individual CIP; these are common when several known issues are in proximity. CIPs are described in greater detail in Section 4, Stormwater Capital Improvement Projects.

Programmatic Solutions are a solution type when groups of issues have commonalities and can be solved with similar and easily implemented stormwater designs. These issues may not meet the criteria for individual CIPs. However, they are systematically tracked through the City's asset management program and grouped into programs to ensure they are addressed efficiently and consistently over time, The SMP recommends programmatic solutions for major maintenance, failing UICs, and drillhole water quality retrofits. These programs are described in greater detail in see Section 5, Programmatic

Policy Updates are a solution type when it becomes apparent that the City's policies for regulating, operating, or maintaining private or public stormwater systems contribute to systemic issues such as nuisance flooding or risk non-compliance with the City's stormwater-related permits from DEQ. Policy solutions require further evaluation and may involve recommendations for changes to internal policies or changes to the City's development codes or engineering standards. Three policy topics are explored further in Section 6, Policy Discussion.

Other solutions include education, enforcement, easement acquisition, and recommendations for further study before solution development.

A complete accounting of the 103 known issues, primary issue type, status, and solution type is included in Table 6.

Table 6 Stormwater Known Issues

Issue ID	Name	Primary Issue Type	Status	Solution Type
KI-1	1504 SW Overturf Drainage	Drainage	Active	Major Maintenance
KI-2	19th and Knoll Drainage	Drainage	Design	Study Recommended
KI-3	SE Dove Lane Flooding	Drainage	Active	Individual CIP - Drainage
KI-4	Stormwater Flooding Report 1515 NE 2nd St.	Drainage	Design	Solution Identified
KI-5	Stormwater Flooding Report 19 NW Mueller	Drainage	Active	Major Maintenance
KI-6	Stormwater Flooding Report 211-147-143 NW Congress	Drainage	Active	Individual CIP - Drainage
KI-7	Stormwater Flooding Report 717 NW Georgia	Drainage	Active	Failing UICs Program
KI-8	Stormwater Flooding Report 1213 Vicksburg Ave	Drainage	Active	Individual CIP - Drainage
KI-9	Stormwater Flooding Report 1300 SE 3rd St	Drainage	Active	Major Maintenance

Table 6 Stormwater Known Issues

Issue ID	Name	Primary Issue Type	Status	Solution Type
KI-10	Stormwater Flooding Report 1648 NE Eastwood Dr	Drainage	Active	Failing UICs Program
KI-11	Stormwater Flooding Report 2310 NE Shepard Rd	Drainage	Active	Failing UICs Program
KI-12	Stormwater Flooding Report 63673 Boyd Acres Rd (Cooley Neighborhood)	Drainage	Active	Major Maintenance
KI-13	Stormwater Flooding Report 19410 Century Dr	Drainage	Active	Individual CIP - Drainage
KI-14	Stormwater Flooding Report 633 NW York Dr	Drainage	Active	Major Maintenance
KI-15	Stormwater Flooding Report 63089 Nels Anderson Rd	Drainage	Active	Major Maintenance
KI-16	Stormwater Flooding Report 19650 SW Poplar	Drainage	Active	Major Maintenance
KI-17	Stormwater Flooding Report NW Summit/NW Mt. Washington	Drainage	Active	Failing UICs Program
KI-18	Stormwater Flooding Report 1936 SE Waco Dr	Drainage	Active	Major Maintenance
KI-19	Stormwater Flooding Report 858 NW Wall St	Drainage	Active	Failing UICs Program
KI-20	Stormwater Flooding Report 1125 NE 2nd St	Drainage	Active	Failing UICs Program
KI-21	Stormwater Flooding Report 1532 NE 9th St	Drainage	Active	Failing UICs Program
KI-22	Stormwater Flooding Report 902 SE Textron	Drainage	Solved, Monitor	Solved But Monitor
KI-23	Stormwater Flooding Report 1501 NE Neff Rd	Drainage	Active	Major Maintenance
KI-24	Stormwater Flooding Report 330 SE 15th St	Drainage	Active	Failing UICs Program
KI-25	Stormwater Flooding Report 151 SW Shevlin Ln	Drainage	Active	Failing UICs Program
KI-26	Stormwater Flooding Report 1212 SW Simpson (2014 SMP)	Drainage	Active	Failing UICs Program
KI-27	Stormwater Flooding Report 1757 Forest Ridge Ave	Drainage	Active	Failing UICs Program
KI-28	Stormwater Flooding Report 60924 SW McMullin	Drainage	Active	Failing UICs Program
KI-29	Stormwater Flooding Report 61553 Westridge Ave	Drainage	Active	Failing UICs Program
KI-30	Stormwater Flooding Report 63275 Wishing Well Ln	Drainage	Active	Failing UICs Program
KI-31	Stormwater Flooding Report 1567 SW Chandler Ave	Drainage	Active	Failing UICs Program

Table 6 Stormwater Known Issues

Issue ID	Name	Primary Issue Type	Status	Solution Type
KI-32	Stormwater Flooding Report NE 2nd St/NE Lafayette	Drainage	Active	Failing UICs Program
KI-33	Stormwater Flooding Report Ne 4th St/NE Revere Ave	Drainage	Active	Failing UICs Program
KI-34	Stormwater Flooding Report NE 4th at NE Olney Ave	Drainage	Active	Major Maintenance
KI-35	Stormwater Flooding Report 537 NW Riverfront	Drainage	Active	Individual CIP - Drainage
KI-36	Stormwater Flooding Report 1193 Ross Rd	Drainage	Active	Failing UICs Program
KI-37	Stormwater Flooding Report SE China Hat Rd-RR Tracks	Drainage	Active	Major Maintenance
KI-38	Stormwater Flooding Report 510 NW Sean Ct. (Overturf Park)	Drainage	Active	Failing UICs Program
KI-39	Stormwater Flooding Report 125 NE Franklin Ave.	Drainage	Design	Project in Process
KI-40	Stormwater Flooding Report 5 NW Greenwood	Drainage	Project in Process	Failing UICs Program
KI-41	Blocked Outfall in Miller's Landing Park (SMP Online Comment 2)	Drainage	Solved, Monitor	Solved But Monitor
KI-42	Damaged pipe in NW McKay Ave (SMP Online Comment 4)	Condition	Active	Major Maintenance
KI-44	Damaged pipe south of NW Baltimore Ave (SMP Online Comment 6)	Condition	Active	Major Maintenance
KI-43	Tear in pipe at NW Galveston Ave. (SMP Online Comment 5)	Condition	Active	CIP - Secondary Issue
KI-47	Inaccessible and damaged pipe, Drake Park (south) (SMP Online Comment 9)	Condition	Active	Major Maintenance
KI-46	Flooded home and damaged pipe at NW Hixon Ave (SMP Online Comment 8)	Condition	Active	CIP – Secondary Issue
KI-48	South Awbrey Butte Drainage Study	Drainage	Active	Project in Process
KI-49	Old Newport Ave. Outfall	Condition	Active	Major Maintenance
KI-50	Archie Briggs Rd Drainage Issues (2014 SMP)	Drainage	Solved, Monitor	Solved But Monitor
KI-51	Central District Lacks Drainage Options for Redevelopment	Water Quality-Groundwater	Active	Study Recommended
KI-52	Lack of easement for stormwater outfall and pipe	Maintainability	In Progress	Easement Acquisition
KI-53	Lack of easement for City stormwater facilities and outfall in Miller's Landing Park.	Maintainability	Active	Easement Acquisition

Table 6 Stormwater Known Issues

Issue ID	Name	Primary Issue Type	Status	Solution Type
KI-54	Lack of access to stormwater main	Maintainability	Active	CIP - Secondary Issue
KI-55	Sediment control at NW Congress and Louisiana	Drainage	Active	CIP - Secondary Issue
KI-56	Private drainage impacting ROW on Newport Ave	Drainage	Solved	Solved But Monitor
KI-57	Private drainage impacting public alley south of Newport Ave	Drainage	Solved	Solved But Monitor
KI-58	LID design causing maintainability issues	Maintainability	Active	Policy
KI-59	Stormwater Flooding Report, 576 NW Lindsay Ct. (Overturf Park)	Drainage	Solved	Solved But Monitor
KI-60	Stormwater Flooding Report, 59 SW Hayes Ave	Drainage	Active	Major Maintenance
KI-61	Stormwater Flooding Report, 162 NW Utica Ave	Drainage	Solved, Monitor	Solved But Monitor
KI-62	Stormwater Flooding Report, 1507 NE 1st St	Drainage	Active	Failing UICs Program
KI-63	Illicit discharge detected to outfall	Water Quality-Surface Water	Solved, Monitor	Education or Enforcement
KI-64	Location and status of outfall DOF000076 is unknown	Maintainability	Inactive	N/A
KI-65	Quiet Canyon Loop Erosion and Flooding	Erosion	Active	Education or Enforcement
KI-66	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Active	Drillhole Water Quality Retrofit
KI-67	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Solved	Drillhole Water Quality Retrofit
KI-68	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Active	Drillhole Water Quality Retrofit
KI-69	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Active	Drillhole Water Quality Retrofit
KI-70	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Active	Drillhole Water Quality Retrofit
KI-71	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Solved	Drillhole Water Quality Retrofit
KI-72	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Solved	Drillhole Water Quality Retrofit
KI-73	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Solved	Drillhole Water Quality Retrofit
KI-74	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Solved	Drillhole Water Quality Retrofit
KI-75	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Active	Drillhole Water Quality Retrofit

Table 6 Stormwater Known Issues

Issue ID	Name	Primary Issue Type	Status	Solution Type
KI-76	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Active	Drillhole Water Quality Retrofit
KI-77	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Solved	Drillhole Water Quality Retrofit
KI-78	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Solved	Drillhole Water Quality Retrofit
KI-79	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Solved	Drillhole Water Quality Retrofit
KI-80	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Active	Drillhole Water Quality Retrofit
KI-81	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Solved	Drillhole Water Quality Retrofit
KI-82	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Solved	Drillhole Water Quality Retrofit
KI-83	Flooding and ice at intersection	Drainage	Active	Individual CIP - Drainage
KI-84	Outfall Retrofit Need Identified, Outfall Basin 266 & 14N	Water Quality-Surface Water	Active	Individual CIP - Outfall Retrofit
KI-85	Outfall Retrofit Need Identified, Outfall Basin 024	Water Quality-Surface Water	Active	Individual CIP - Outfall Retrofit
KI-86	Outfall Retrofit Need Identified, Outfall Basin 020	Water Quality-Surface Water	Active	Individual CIP - Outfall Retrofit
KI-87	Outfall Retrofit Need Identified, Outfall Basin 013	Water Quality-Surface Water	Active	Individual CIP - Outfall Retrofit
KI-88	Outfall Retrofit Need Identified, Outfall Basin 018	Water Quality-Surface Water	Active	Individual CIP - Outfall Retrofit
KI-89	Outfall Retrofit Need Identified, Outfall Basin 128	Water Quality-Surface Water	Active	Individual CIP - Outfall Retrofit
KI-90	Flooding and ice at intersection	Drainage	Active	CIP – Secondary Issue
KI-93	Stormwater Flooding Report 21040 SE Gardenia Ave	Drainage	Active	Major Maintenance
KI-94	Stormwater Flooding Report 805 NW Columbia St	Drainage	Active	Major Maintenance
KI-95	Stormwater Flooding Report 61190 SE Ferguson Rd	Drainage	Active	Major Maintenance
KI-96	Stormwater Flooding Report 20019 SW Alderwood Cir	Drainage	Active	Major Maintenance
KI-97	Drillhole Decommissioning Location - Priority Rank 2	Water Quality-Groundwater	Active	Drillhole Water Quality Retrofit
KI-98	Drillhole Decommissioning Location - Priority Rank 2	Water Quality-Groundwater	Active	Drillhole Water Quality Retrofit
KI-99	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Active	Drillhole Water Quality Retrofit

Table 6 Stormwater Known Issues

Issue ID	Name	Primary Issue Type	Status	Solution Type
KI-100	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Active	Drillhole Water Quality Retrofit
KI-101	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Active	Drillhole Water Quality Retrofit
KI-102	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Active	Drillhole Water Quality Retrofit
KI-103	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Active	Drillhole Water Quality Retrofit
KI-104	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Active	Drillhole Water Quality Retrofit
KI-105	Stormwater Flooding Report NW Albany Ave & NW Allen Rd	Drainage	Active	Major Maintenance
KI-106	Stormwater Flooding Report NW 8th St & NW Trenton Ave	Erosion	Active	Major Maintenance

3.4. Potential Projects

The next step for active known issues that have an individual CIP or a programmatic solution type is to develop a project concept and group the projects into programs. Two types of individual CIPs were developed, Drainage and Outfall Retrofit, as well as programmatic solutions for three groups of issues: major maintenance, failing UICs, and drillholes retrofits to protect groundwater quality.

CIP – Drainage

A stormwater CIP is a standalone project to manage runoff which may have a design requiring significant engineering and/or may have a higher construction cost estimate. A drainage project is designed to reduce the severity and frequency of flooding on streets and sidewalks after rainstorms. Flooding on private property due to uncontrolled runoff from City streets may also be addressed.

CIP – Outfall Retrofit

An outfall retrofit CIP project is designed to limit untreated stormwater from flowing into the Deschutes River from existing outfalls. These projects remove urban pollutants and reduce sediment in stormwater runoff before it reaches the river. These projects assist the City in complying with the NPDES MS4 permit from DEQ.

Major Maintenance Program

The purpose of this program is to apply more targeted maintenance, improve access to the existing stormwater system, or to manage a small drainage issue on a public street, sidewalk, or private property when caused by runoff from City infrastructure. Projects may repair, replace, or add a small number of less complex structures (e.g. new inlets). Construction costs are typically less than $1 million, however final costs may vary depending on implementation circumstances determined by City staff.

Failing UICs Drainage Improvements Program

This program is to reduce nuisance flooding on streets and sidewalks by replacing UICs that no longer function or adding new UICs to an underperforming system. Drywells or deep drywells may be used, depending on site conditions.

Drillhole Water Quality Retrofit Program

The program is to protect the quality of groundwater resources by adding pre-treatment to existing drillholes that may be at risk of discharging pollutants to the aquifer. The program prioritized 15 drillholes that are within the 2-year time of travel of wells that are used as public drinking water wells. Two-year time of travel is a measurement of how far groundwater, or in this case potential pollution or contaminants that have entered groundwater, travels to a specific point over a period of two years.

Potential project by program are listed in Table 7 and shown on Figure 13.

Table 7 Potential Projects by Program

Potential Project ID	Project Name	Program
PP-1	Dove Lane Drainage Improvement	CIP - Drainage
PP-14	NW Congress Drainage Improvement	CIP - Drainage
PP-16	Campbell Rd Drainage Improvement	CIP - Drainage
PP-42	Downtown Pedestrian Safety Drainage Improvements Program	CIP - Drainage
PP-46	Vicksburg Ave Drainage Improvement	CIP - Drainage
PP-12	Columbia Park Outfall 024 Retrofit	CIP - Outfall Retrofit
PP-35	Riverfront St Stormwater Improvements	CIP - Outfall Retrofit
PP-43	Saginaw Ave Stormwater Quality Improvement	CIP - Outfall Retrofit
PP-44	Drake Park Stormwater Improvements	CIP - Outfall Retrofit
PP-47	Galveston Ave Stormwater Quality Improvement	CIP - Outfall Retrofit
PP-48	Fresno Ave Drainage Improvement	CIP - Outfall Retrofit
PP-45	12th St Stormwater Quality Improvement	CIP - Outfall Retrofit
PP-62	Drillhole Retrofit (DDH009510)	Drillhole Water Quality Retrofit
PP-63	Drillhole Retrofit (DDH009513)	Drillhole Water Quality Retrofit
PP-64	Drillhole Retrofit (DDH009514)	Drillhole Water Quality Retrofit
PP-66	Drillhole Retrofit (DDH009727)	Drillhole Water Quality Retrofit
PP-67	Drillhole Retrofit (DDH009728)	Drillhole Water Quality Retrofit
PP-68	Drillhole Retrofit (DDH009766)	Drillhole Water Quality Retrofit
PP-71	Drillhole Retrofit (DDH009875)	Drillhole Water Quality Retrofit
PP-72	Drillhole Retrofit (DDH009932)	Drillhole Water Quality Retrofit
PP-70	Drillhole Retrofit (DDH009485)	Drillhole Water Quality Retrofit
PP-74	Drillhole Retrofit (DDH002049)	Drillhole Water Quality Retrofit
PP-75	Drillhole Retrofit (DDH009482)	Drillhole Water Quality Retrofit
PP-76	Drillhole Retrofit (DDH009446)	Drillhole Water Quality Retrofit
PP-77	Drillhole Retrofit (DDH009447)	Drillhole Water Quality Retrofit
PP-78	Drillhole Retrofit (DDH010013)	Drillhole Water Quality Retrofit
PP-79	Drillhole Retrofit (DDH009381)	Drillhole Water Quality Retrofit
PP-8	NW Georgia Avenue Drainage Improvement	Failing UICs Drainage Improvement
PP-9	NE Shephard Road Drainage Improvement	Failing UICs Drainage Improvement
PP-15	NE Eastwood Drainage Improvement	Failing UICs Drainage Improvement

Table 7 Potential Projects by Program

Potential Project ID	Project Name	Program
PP-17	NW Clearwater Dr Drainage Improvement	Failing UICs Drainage Improvement
PP-20	NW Summit Dr Drainage Improvement	Failing UICs Drainage Improvement
PP-22	NW Wall Street Drainage Improvement	Failing UICs Drainage Improvement
PP-23	NE Hawthorne Ave Drainage Improvement	Failing UICs Drainage Improvement
PP-24	NE 9th Street and Penn Drainage Improvement	Failing UICs Drainage Improvement
PP-25	SE 15th Street Drainage Improvement	Failing UICs Drainage Improvement
PP-26	SW Shevlin Hixon Dr Drainage Improvement	Failing UICs Drainage Improvement
PP-27	SW Simpson Ave Drainage Improvement (2014 SMP)	Failing UICs Drainage Improvement
PP-28	SW Forest Ridge Ave Drainage Improvement	Failing UICs Drainage Improvement
PP-29	McMullin Dr Drainage Improvement	Failing UICs Drainage Improvement
PP-30	SW Westridge Ave Drainage Improvement	Failing UICs Drainage Improvement
PP-31	NE Morningstar Dr Drainage Improvement	Failing UICs Drainage Improvement
PP-32	SW Chandler Ave Drainage Improvement	Failing UICs Drainage Improvement
PP-33	NE 2nd St Drainage Improvement	Failing UICs Drainage Improvement
PP-34	NE Revere Ave Drainage Improvement	Failing UICs Drainage Improvement
PP-36	NE Ross Rd Drainage Improvement	Failing UICs Drainage Improvement
PP-38	NW Sean Ct Drainage Improvement	Failing UICs Drainage Improvement
PP-41	NW Olney Ave Drainage Improvement	Failing UICs Drainage Improvement
PP-10	Wagontire Way Drainage Improvement	Major Maintenance
PP-11	Overturf Ct. Cul-de-sac Drainage Improvement	Major Maintenance
PP-13	NW Mueller Avenue Alley Drainage Improvement	Major Maintenance
PP-18	NE Nels Anderson Rd Drainage Improvement	Major Maintenance
PP-19	Poplar Street Drainage Improvement	Major Maintenance
PP-21	SE Waco Dr Drainage Improvement	Major Maintenance
PP-37	China Hat Rd Drainage Improvement	Major Maintenance
PP-40	SW Hayes Ave Drainage Improvement	Major Maintenance
PP-49	SE 3rd Street South of Brosterhous	Major Maintenance
PP-50	NW McKay Ave Pipe Repair	Major Maintenance
PP-55	SW Alderwood Cir Drainage Improvement	Major Maintenance
PP-56	NW Columbia St Drainage Improvement	Major Maintenance
PP-57	Newport Outfall Maintenance	Major Maintenance
PP-58	NW Tumalo at Drake Park Pipe Repair	Major Maintenance
PP-59	NW Baltimore Pipe Repair	Major Maintenance
PP-60	SE Ferguson Rd Drainage Improvement	Major Maintenance
PP-61	SE Gardenia Ave Drainage Improvement	Major Maintenance
PP-73	NE Olney Ave Drainage Improvement	Major Maintenance
PP-80	NE Penn/NE Neff Drainage Improvement	Major Maintenance

Table 7 Potential Projects by Program

Potential Project ID	Project Name	Program
PP-81	NW Trenton Ave Drainage Improvement	Major Maintenance
PP-82	NW Allen Rd Drainage Improvement	Major Maintenance

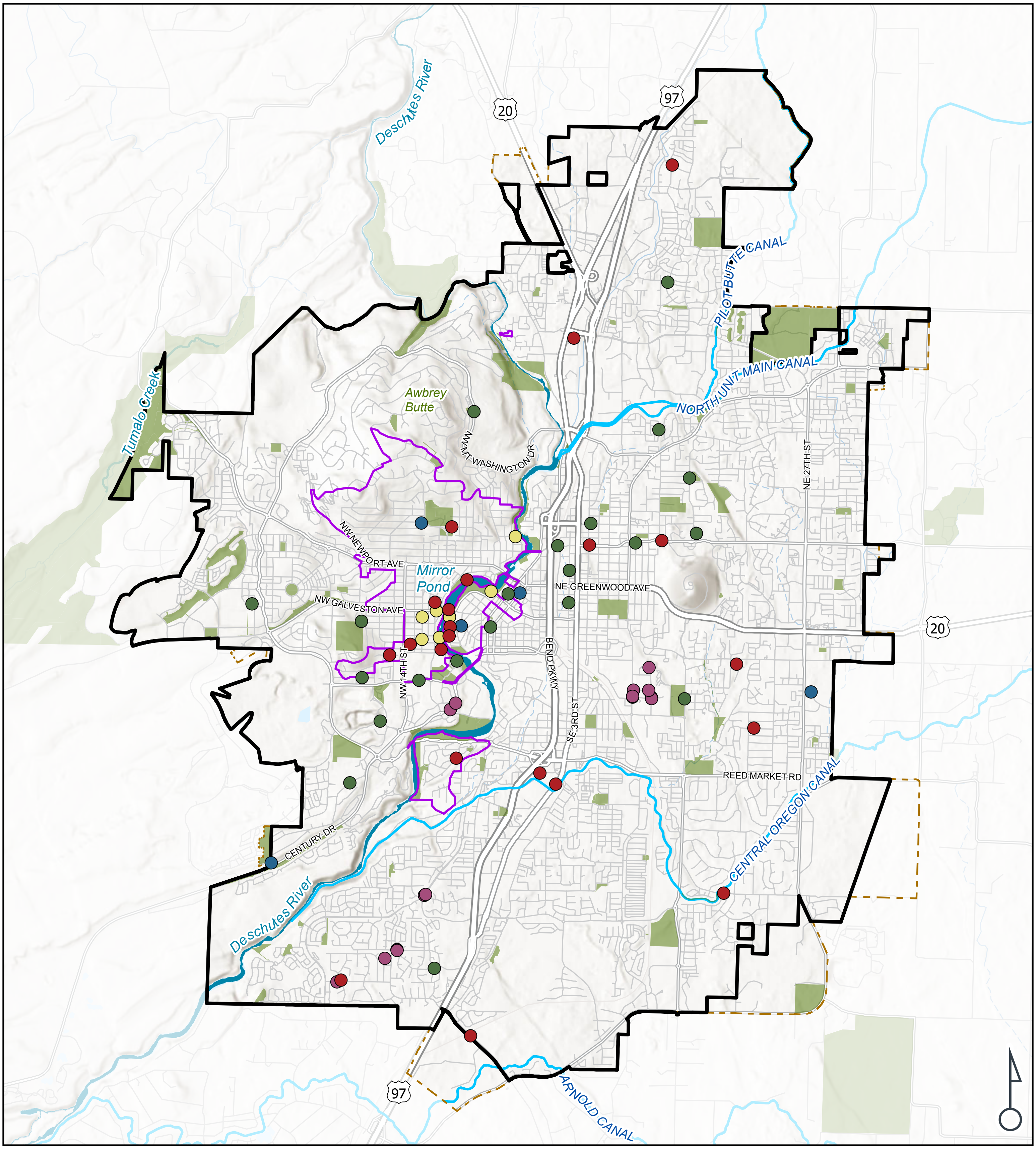

FIGURE 13

POTENTIAL PROJECTS

BEND STORMWATER MASTER PLAN

BEND, OREGON

LEGEND

- ▭ Bend City Limits
- ┅ Urban Growth Boundary
- ▭ MS4 Basin Delineation
- 🟩 Parks
- — Streams
- — Canals

Program

- ● CIP - Drainage
- ● CIP - Outfall Retrofit
- ● Drillhole Water Quality Retrofit
- ● Failing UICs Drainage Improvement
- ● Major Maintenance

0 0.5 1 Mile

Data Sources: City of Bend, USGS, Google Maps.
Date: 10/28/2025
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

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3.5. Relationship to Other Planning Efforts and City Programs

In addition to the regulatory requirements for stormwater management discussed in Section 1.3, the City of Bend has several current planning efforts, programs, and projects that align with the goals of this SMP and were considered in the planning process and solution development.

3.5.1. Capital Projects and Planning

There are several planned capital projects in Bend that have stormwater components or opportunities for synergistic stormwater projects. The 2020 Transportation System Plan identified 46 near-term transportation projects. Where possible, including stormwater projects would help address known issues included in this plan. The following current projects overlap with several potential projects.

- **Galveston Corridor**: This transportation project aims to improve multi-modal mobility on Galveston Avenue. Initial design included improved stormwater infrastructure, but the project was scaled back in 2025 to focus on pedestrian crossing and sidewalk improvements.
- **Riverfront Street Redesign**: This transportation project aims to improve the road conditions on Riverfront Street and connect pieces of the Deschutes River Trail by constructing pedestrian and bicycle infrastructure. Upgrades to the existing stormwater system are intended to accompany the street redesign.
- **Midtown Crossing**: This transportation project aims to improve east-west travel on Greenwood Avenue, Hawthorne Avenue, Franklin Avenue, and 2nd Street. The proposed improvement includes an overcrossing at Hawthorne Ave, improvements to the undercrossings at Franklin and Greenwood and modernization of 2nd Street. The 2nd Street modernization was completed in June of 2025, and included stormwater improvements. The undercrossing projects were each identified as projects in the 2014 SMP are a currently being implemented by the City as a stormwater CIP.

3.5.2. Tree Preservation

Preserving and protecting trees during development is an important facet of urban stormwater management. Trees help absorb rainwater, slow the flow of runoff, and provide a host of other ecosystem services. Bend's tree preservation program on parcels is formalized through its municipal and development codes. Planter strip landscaping in the right-of-way is regulated by the Bend Development Code and the City's Standards and Specifications. The Stormwater Tool Kit developed for this plan introduces a Stormwater Tree (See Appendix B) as a potential stormwater facility to implement in Bend. This facility is designed to improve the water quality of runoff while providing the other benefits of urban trees. Development or redevelopment projects may need to meet certain landscaping or street tree requirements, and the City should consider specifically allowing Stormwater Trees as an acceptable alternative in its development code.

3.5.3. Core Area Redevelopment Programs and Plans

Bend has identified three areas where tax increment financing may be used to reinvest or rebuild parts of the City that have infrastructure and structures in deteriorated conditions and decreasing property values due to blight and disinvestment: Core Area, Juniper Ridge, and Murphy Crossing. The City plans for much of its future housing and employment growth to be contained within the Core Area. Several infrastructure improvement projects are planned for the Core Area to improve utility services, public safety, and connections to downtown Bend. The City plans to partner with and offer support to private and non-profit entities to improve both housing and business development opportunities in the Core Area. Support options identified in the Tax Increment Finance Plan include, but are not limited to, off-site infrastructure improvements which could involve stormwater drainage and facilities (Ordinance No. 2379, 2020).

The Guiding Principles of the Core Area are:

- Create a place where you can live, work, and play.
- This is a walkable area with a balanced transportation system.
- This area removes barriers and connects the East and West sides of Bend.
- This plan leads to direct outcomes, if it is implemented.
- Affordability is preserved.
- Public investments incentivize and catalyze private development.
- The planning process is transparent and open to ensure that those affected by the decisions are involved in the process.
- This area incorporates sustainable and low impact development principles and practice.

Densities allowed in the Core Area could impact space available for stormwater management on development sites, which is a topic of concern addressed in this SMP and described in greater detail in the white paper Drainage and Density: Stormwater Management Options for Increasingly Dense Development (Appendix D). Some of the Core Area will have small setbacks for redevelopment. Similarly, the City's designated Climate Friendly Areas may have some of the setback or density issues that the Core Area may experience. Investing in regional stormwater facilities may spur private development by reducing the need for and cost of individual stormwater infrastructure on the site of development, which may have limited space for stormwater facilities due to allowable small setbacks. If the City chooses to pursue a regional approach to stormwater management in this area, then a separate stormwater plan should be developed for the Core Area.

Section 4. Stormwater Capital Improvement Projects

This section describes the evaluation and analysis done to develop a prioritized CIP project list that is expected to be achievable over a 20-year timeframe. Rated projects include both drainage CIPs and outfall retrofit CIPs.

4.1. Rating Criteria and Ranking Process

4.1.1. Develop Rating Criteria

During a series of workshops and meetings starting in the summer of 2024, City staff and stakeholders from the Water Advisory Group (WAG, then known as Utilities Public Advisory Group (UPAG)) explored the drivers and goals of the SMP.

Five project scoring categories were developed, each having a set of weighted criteria with scores from 0 through 5 based on defined values (see Table 8 for the scoring categories). The final project rating criteria reflect comments from both staff and WAG. The full rating criteria are provided in Appendix E.

Table 8 CIP Project Rating Criteria

Categories	Criteria	Weight	Scoring Concept
Conveyance & Flooding Improvements	Frequency of Flooding	2	Projects that address more frequent storm system-related flooding receive more points.
	Flooding Severity / Risk Avoidance	2	Projects that address flooding that damages private property or have serious traffic impacts or impact pedestrian safety receive more points.
Water Quality Improvements	River & Groundwater Protection	3	Projects that address water quality for already prioritized drillholes and outfalls receive more points.
	Permit Compliance	1	Projects that assist in meeting WPCF or MS4 Permit requirements receive more points.
Multiple Benefits	Increases Equitable Distribution of Public Stormwater Assets	1	Projects that are located where City storm system is not present and that will serve populations living below the federal poverty level (by Census Block Group) or have a relatively high minority populations receive more points.
	Supports Housing or Economic Development	1	Projects receive more points if they are located at the intersection of more City focus areas such as: - Urban Renewal District - Economic Improvement District - Enterprise Zone - Opportunity Area - Potential Climate Friendly Area

Table 8 CIP Project Rating Criteria

Categories	Criteria	Weight	Scoring Concept
	Maintenance Safety / Access	0.5	Projects receive maximum points if maintenance access/safety is improved, or drainage complaints requiring urgent response (callouts) will be reduced.
	Green Infrastructure / Ecosystem Services	0.5	Projects that are likely to include an above-ground component that is vegetated, such as swales, stormwater trees, and others receive maximum points.
	System Longevity	0.5	Projects receive maximum points if they rehabilitate or increase longevity of an existing asset.
	Community Partnerships	0.5	Projects receive maximum points if they are developed in partnership with another agency or organization such as Bend Park and Recreation District or Deschutes Watershed Council.
Recognized Priority Projects	Staff Priority	2	Projects solving issues identified as highest priority by Water Services Operations staff receive maximum points, and projects addressing issues identified as a priority by Water Services Compliance staff receive fewer points.
Feasibility & Cost	Complexity / Site Constraints	1	Projects receive more points when they have less complex site conditions.
	Low Cost[1]	1	Projects with low initial capital costs and low ongoing maintenance costs receive maximum points. Points reduce with higher capital cost and higher ongoing maintenance cost.

Note 1. Project scoring was completed during the initial concept stage of project development. Some project concepts altered with further project development, changing the relative costs, but projects were not scored again.

4.1.2. Scoring

All locations (24) that were initially deemed eligible for potential project concept development were scored. After further evaluation, about half were reclassified into the Major Maintenance program or other programs and removed from the CIP project list. Twelve CIPs were ultimately scored and ranked (Table 9). After final ranking, a project in Columbia Park was deemed infeasible and removed.

Table 9 Project Scores and Ranks

Rank	Project ID	Name	Score
1	PP-35	Riverfront Street Stormwater Improvements	51.0
2	PP-42	Downtown Pedestrian Safety Drainage Improvements	45.5
3	PP-44	Drake Park Stormwater Quality Improvements	36.0
4	PP-14	Congress Street Drainage Improvements	34.0
4	PP-46	Vicksburg Street Drainage Improvements	34.0
6	PP-47	Galveston Avenue Stormwater Quality Improvements	33.0
7	PP-48	Fresno Avenue Stormwater Improvements	32.5
8	PP-12*	Columbia Park Stormwater Outfall 024 Retrofit	29.5
9	PP-45	12th Street Stormwater Quality Improvements	28.5
10	PP-1	Dove Lane Drainage Improvements	27.5
11	PP-43	Saginaw Avenue Stormwater Quality Improvements	26.0
12	PP-16	Campbell Road Drainage Improvements	23.0

** PP-12, Columbia Park Stormwater Outfall 024 Retrofit project was later removed because it is infeasible.*

4.2. Stormwater CIP Project List

The Stormwater CIP project list consists of the new ranked projects in this plan and other stormwater projects that the City is in the process of implementing or has budgeted for beginning in Fiscal Year (FY) 2026 (Table 10).

The final project list reflects the City's priorities of ensuring adequate drainage on streets and in the storm sewer system as well as improving the water quality of runoff discharged from outfalls to the Deschutes River or through UICs to the ground. A map of the Stormwater CIP projects is presented in Figure 14, Stormwater Capital Improvement Projects.

Table 10 Stormwater CIP Projects

Project ID	Rank*	Project Name	Score	Primary Project Benefit	Cost (2025)†
Existing CIP					
1RSAB	1A	South Awbrey Butte Drainage	-	Drainage	$15,450,000
1RFGU	1A	Franklin Underpass, Phase 1	-	Drainage	$1,216,000
1RFGU	1A	Greenwood Underpass, Phase 1	-	Drainage	$1,824,000
1SSW3	1A	SW Sewer Basin Improvements, Phase 3‡	-	Drainage	$500,000
Planned CIP					
1RFGU	1B	Franklin Underpass, Phase 2	-	Drainage	§
1RFGU	1B	Greenwood Underpass, Phase 2	-	Drainage	§
PP-35	1	Riverfront Street Stormwater Improvements	51.0	Water Quality	$880,000
PP-42	2	Downtown Pedestrian Safety Drainage Improvements	45.5	Drainage	$770,000
PP-44	3	Drake Park Stormwater Quality Improvements	36.0	Water Quality	$4,140,000
PP-14	4	Congress Street Drainage Improvements	34.0	Drainage	$1,320,000
PP-46	4	Vicksburg Avenue Drainage Improvements	34.0	Drainage	$490,000
PP-47	6	Galveston Avenue Stormwater Quality Improvements	33.0	Water Quality	$5,820,000
PP-48	7	Fresno Avenue Stormwater Improvements	32.5	Water Quality	$4,230,000
PP-45	9	12th Street Stormwater Quality Improvements	28.5	Water Quality	$1,040,000
PP-1	10	Dove Lane Drainage Improvements	27.5	Drainage	$390,000
PP-43	11	Saginaw Avenue Stormwater Quality Improvements	26.0	Drainage	$2,620,000
PP-16	12	Campbell Rd Drainage Improvements	23.0	Drainage	$130,000

** Ranks 1A and 1B are given to projects that were not ranked by the SMP project team but are considered high priority because they are either ongoing or budgeted capital improvements (1A) or contained in an existing master plan or infrastructure improvement plan that is being implemented by the City (1B)*

† Costs are in 2025 dollars and should be escalated when a project is programmed for design and construction

‡ Stormwater portion of a sanitary sewer capital project

§ Preferred Phase 2 improvements may be addressed through a City-funded CIP or through private development

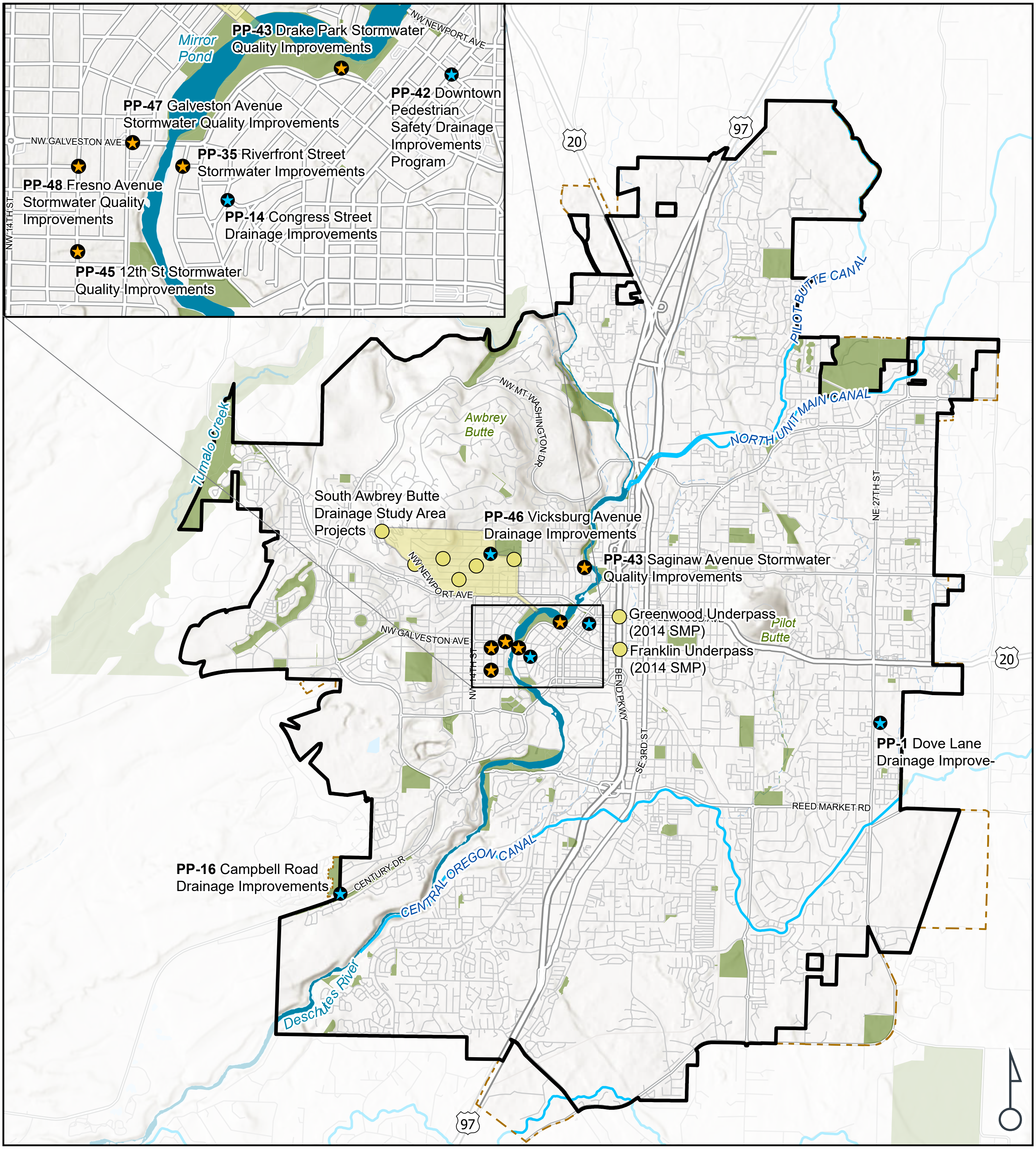

FIGURE 14

STORMWATER CAPITAL IMPROVEMENT PROJECTS

BEND STORMWATER MASTER PLAN
BEND, OREGON

Data Sources: City of Bend, Deschutes County, USGS, Google Maps.
Date: 10/28/2025
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

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LEGEND

- ▭ Bend City Limits
- ▭ Urban Growth Boundary
- — Streams
- — Canals

Program

- ★ CIP - Drainage
- ★ CIP - Outfall Retrofit
- ● CIP In Progress

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4.3. Project Development and Descriptions

A planning-level design was prepared for each new stormwater CIP and benefits, design and implementation considerations, and costs were documented. Each project is summarized below. Stormwater CIP Project Fact Sheets are included in Appendix B. New CIPs are listed in order of priority ranking, followed by CIPs that are still active from the prior SMP.

PP-35: Riverfront Street Stormwater Improvements

This project seeks to improve stormwater quality discharging to the Deschutes River from Outfall 128 and improve neighborhood drainage.

PP-42: Downtown Pedestrian Safety Drainage Improvements

This project seeks to improve a series of drainage problems within a study area in downtown Bend. There are several intersections that, during moderate rain events, do not drain properly and block access to the curb's ADA ramps. In cold weather, this freezes over, causing hazardous pedestrian conditions. Project benefits include increased flood mitigation, pedestrian safety, and road safety.

PP-44: Drake Park Stormwater Quality Improvements

This project seeks to improve stormwater quality discharging to the Deschutes River from Outfall 018 and improve conveyance of runoff in parts of Old Bend near Drake Park. Project benefits include increased surface water quality, local infiltration, and a better understanding of the area's existing stormwater system.

PP-14: Congress Street Drainage Improvements

This project seeks to improve drainage in an area of Old Bend that does not have sufficient existing infrastructure. During rain events, stormwater in this area exceeds the curb height of the ROW and floods causes undesirable overland flow. Project benefits include increased flood mitigation and road safety.

PP-46: Vicksburg Avenue Drainage Improvements

This project seeks to improve drainage in the Awbrey Butte area that does not have sufficient existing infrastructure. During rain events, runoff from the ROW causes undesirable overland flow. Mitigation strategies have only pushed the problem to different properties, and flooding remains a problem during large rain events. Project benefits include increased flood mitigation and road safety.

PP-47: Galveston Avenue Stormwater Quality Improvements

This project seeks to improve stormwater quality discharging to the Deschutes River from Outfall 020. A combination of solutions will treat the runoff from an estimated 18.56 acres of impervious surface. Project benefits include increased surface water quality and integration of innovative green solutions.

PP-48: Fresno Avenue Stormwater Improvements

This project seeks to improve stormwater quality discharging to the Deschutes River from Outfall 020. This will be achieved by improving infiltration in the neighborhood and repairing damaged infrastructure. Project benefits include increased surface and ground water quality, flood mitigation, and road safety.

PP-45: 12th Street Stormwater Quality Improvements

This project seeks to improve stormwater quality discharging to the Deschutes River from Outfall 024. This project will treat an estimated 3 acres of impervious surface. Project benefits include increased surface water quality.

PP-1: Dove Lane Drainage Improvements
Formerly unincorporated Deschutes County land, this location does not have stormwater infrastructure. During rain events, runoff from the ROW flows overland. Mitigation strategies have not been successful, and overland flow remains a problem during large rain events. This project will install stormwater infrastructure to manage runoff from approximately 2.25 acres of contributing area. Project benefits include increased flood mitigation and road safety.

PP-43: Saginaw Avenue Stormwater Quality Improvements
This project seeks to improve stormwater quality discharging to the Deschutes River from Outfall 012. This will be achieved through installation of “stormwater trees,” which are tree planter inlet and pass-through vault structures which use biofiltration as well as plant transpiration to reduce pollutants and runoff volume on neighborhood streets, and underground treatment facilities that will filter out sediments and pollutants. Project benefits include increased surface water quality, increased tree canopy, and improved stormwater conveyance.

PP-16: Campbell Rd Drainage Improvements
This project seeks to improve drainage on W Campbell Ave to prevent downstream impacts on SW Century Drive. Stormwater runoff from the ROW and unimproved land flows overland, depositing debris and causing localized flooding. Ponding on SW Century Drive impacts road safety. Project benefits include reduced maintenance needs and increased flood mitigation and road safety.

1RSAB: South Awbrey Butte Drainage Improvements – In Progress
This project is an in-progress project from the 2014 SMP. Drainage issues in the area have persisted for decades due to limited piped infrastructure and somewhat poor natural infiltration. Seven potential improvement areas (PIAs) were identified within South Awbrey Butte that will be completed over the next several years. To date, one PIA-1, Newport Ave, has been completed.

1RFGU: Franklin & Greenwood Underpasses – In Progress
The underpasses at Franklin Avenue and Greenwood Avenue beneath the BNSF tracks were identified as potential projects in the 2014 SMP. During moderate to heavy rain events, the existing drywells are insufficient and the roadway floods, causing closure to traffic and disrupting east-west travel. Both underpass projects are in progress under the same project ID. This project will mitigate flooding impacts at the two underpasses by treating and infiltrating excess stormwater with improved standard drywells. Pumping excess stormwater to the Deschutes River was proposed in the 2014 SMP and is no longer a preferred alternative by the City.

As described in the Midtown Crossing Stormwater Report, there are two phases to each underpass project. Phase 1 addresses drainage problems in the contributing basins at each Undercrossing Improvement area. Phase 2 aims to maximize collection, treatment, and disposal of stormwater in the associated Upper Basin Improvement areas.

4.4. Cost Estimating Procedure

Based on the planning-level design of each CIP, Class 5 cost estimates, as established by Association for the Advancement of Cost Engineering (AACE), were prepared using the methods detailed below. Costs are presented in 2025 dollars.

4.4.1. Stormwater Tool Kit

Project costs were developed based on a simplified Stormwater Tool Kit (Table 11). A single price was established for the construction of each tool in the kit. This tool price list was then used to establish the base construction cost for each project. See Appendix B for stormwater tool kit fact sheets.

Table 11 Stormwater Tool Kit Details and Estimated Costs

	Tool Name	Tool Detail	Unit	Cost Per Unit*
1	Stormwater Pond	-	CF	$7
2	Outfall Scour Protection	for pipe less than 30-in diameter	EA	$2,050
		for pipe 30-in to 48-in diameter	EA	$7,000
3	Infiltration Trench	-	SF	$30
4	Pre-Treatment	for small drainage basin (less than 1 acre)	EA	$12,000
		for medium drainage basin (1-5 acre)	EA	$18,000
		for large drainage basin (5-15 acre)	EA	$43,500
5	Storm Sewer Pipe	12-inch diameter	LF	$180
		18-inch diameter	LF	$220
		24-inch diameter	LF	$280
6	Underground Storage	-	CF	$18
7	Permanent Stabilization	-	SF	$6
8	Drywell	-	EA	$32,000
9	Stormwater Planter	-	SF	$170
10	Deep Drywell	-	EA	$78,500
11	Stormwater Trees	-	EA	$5,400
12	Proprietary Filter System	Catch Basin-style	EA	$11,500
		Manhole-style	EA	$44,500
		Vault-style	EA	$100,500
13	Swale/Infiltration Swale	-	SF	$60

**Tool kit cost estimates are in 2025 dollars*

Unit costs for construction and materials were drawn from a variety of sources, including bid tabulations from recent water quality facility rehabilitation projects within the City of Hillsboro and City of Tigard in Oregon, bid tabulations provided by the City of Bend, and average 2024 Oregon Department of Transportation (ODOT) bid tabulations. The ODOT 2024 bid tabulations were the latest available at the time the cost estimates were developed. From the available data, the consultant’s engineers used professional judgement to estimate unit prices for each tool.

Detailed descriptions of the stormwater tool kit tools containing uses, benefits, and cost assumptions are included with this plan in Appendix B.

4.4.2. Other Construction Costs

Other typical construction costs were estimated by percentage.

Table 12 Construction Costs by Line Item

Project Unit Costs	Calculation Method
Construction Mobilization	10% of total Construction Costs
Erosion and Sediment Control	2% of total Construction Costs
Traffic Control	4% of total Construction Costs
Construction Contingency	Three tiers were established using an inverse correlation. A 30% contingency was applied when total construction costs exceeded $1 million,40% when total construction costs were between $400,000 and $1 million, and 50% was applied when it was less. In some cases, engineering judgement was used to apply an additional 15% contingency. This was applied to projects which are anticipated to encounter significant utility conflicts.

4.4.3. Other Costs

Costs were estimated for engineering, administration, easement acquisition, and permitting.

Engineering

Engineering costs cover technical activities such as design, drafting, feasibility studies, specifications, field inspections, and quality control. This cost was calculated as 20% of the construction subtotal.

Administration

Administration costs cover project management, contract administration, scheduling, compliance, and general office support. This cost was calculated as 10% of the construction subtotal.

Easement Acquisition

Acquisition of permanent easements was estimated at $9.00 per square foot.

Permitting

Permitting costs depended on the permitting requirements. All projects were assumed to require a basic level of permitting, which was valued at $3,000. Projects which include any portion of the project located in the WOZ were assumed to require an additional $3,000 permitting cost.

Section 5. Programmatic Solutions

Known issues that were similar in scope and approach were grouped into programmatic improvements for resolution. Programs are groups of similar small and medium projects that are addressed systematically over time and sometimes have fixed yearly funding allocated to the effort. Each of the programs is summarized below and in the programmatic fact sheets included in Appendix C.

5.1. UIC Priorities

The City owns and operates approximately 7,000 UICs, about 6,000 of which are drywells and 1,000 of which are drillholes. A drywell is an underground structure designed to temporarily hold and slowly infiltrate stormwater. A drillhole is a borehole that is drilled through impermeable geologic layers and is also designed to infiltrate stormwater.

Drywells can fail to provide appropriate drainage when they become clogged with sediment, surrounding soil becomes compacted, suffer from poor design and siting, or suffer from structural failure. Drywells and pretreatment devices need to be protected from the high sediment loads from unpaved streets, erosion, and road traction material by an efficient upstream sediment removal device or effective operational controls.

In Bend, drillholes were used for disposal of stormwater in areas where drywells do not function. Many of the existing drillholes were installed earlier in the City's history before drywells became common practice. Drillholes are typically 6 to 8 inches in diameter and extend deep into the ground. Because of their depth, drillholes pose a potential threat to groundwater and DEQ does not allow them to exceed 100 feet in depth unless they are covered under a UIC WPCF Permit and meet requirements for groundwater protection. Due to sizing, maintenance challenges, and spill risks associated with their deeper depths, the City no longer allows drillholes to be used for public infrastructure. As existing drillholes come to the end of their functional life, they should be replaced by more reliable facilities.

Two programmatic solutions focus on Bend's UICs: the Failing UIC Drainage Improvement Program and the Drillhole Water Quality Retrofit Program (Figure 15).

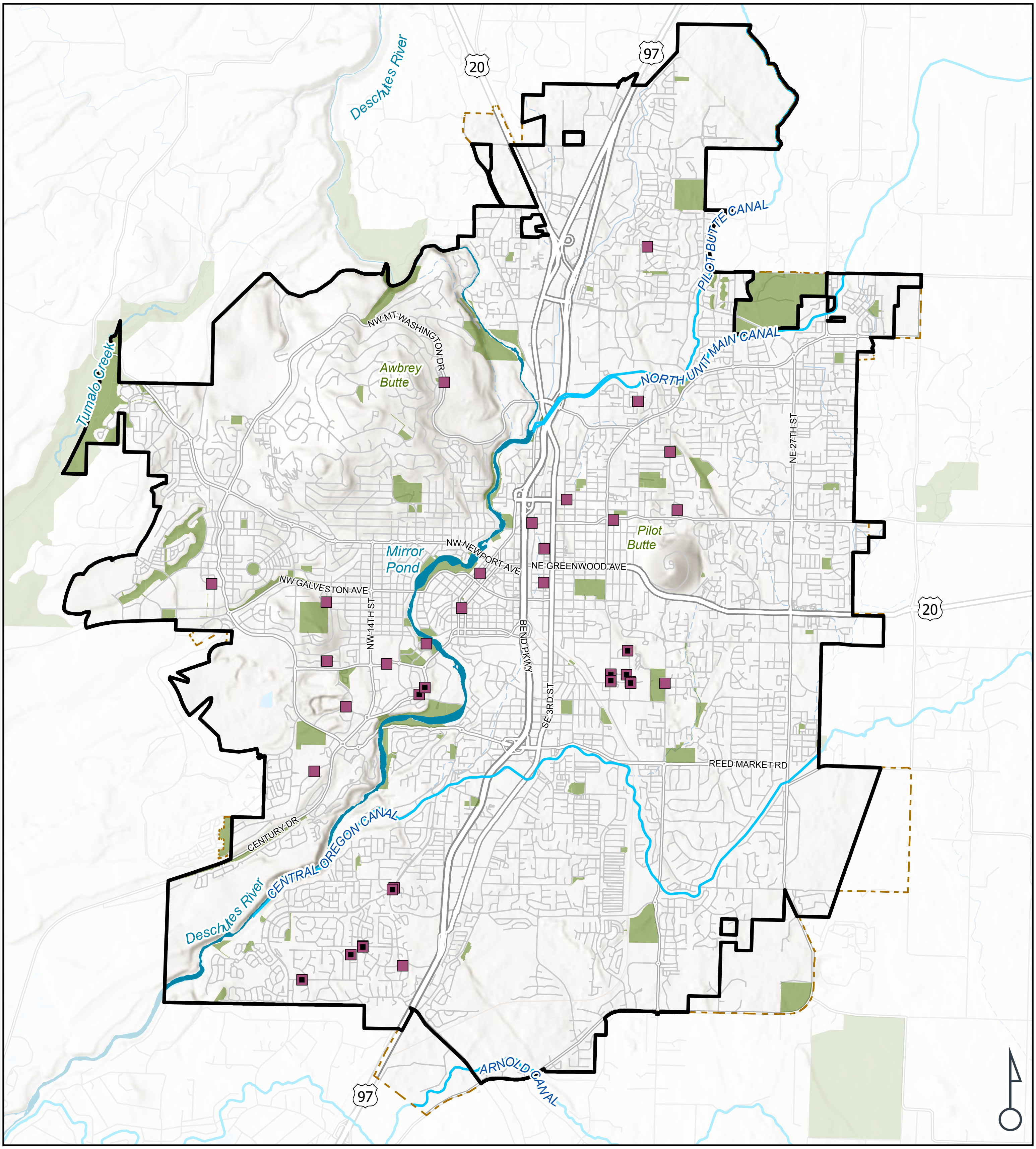

FIGURE 15
UIC PRIORITY PROGRAMS
BEND STORMWATER MASTER PLAN
BEND, OREGON

0 0.5 1 Mile

LEGEND
- ▭ Bend City Limits
- ⬚ Urban Growth Boundary
- 🟩 Parks
- — Streams
- — Canals
- ■ Failing UIC Drainage Improvements Program
- ▣ Drillhole Water Quality Retrofit Program

Data Sources: City of Bend, Deschutes County, USGS, Google Maps.
Date: 10/28/2025
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

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5.1.1. Failing UIC Drainage Improvement Program

The Failing UIC Drainage Improvement Program intends to either replace UICs that no longer function with drywells or deep drywells, or to add capacity to an existing drillhole or drywell that does not have capacity for the runoff it receives. The failing UICs in this program tend to have less complex solutions that can sometimes be implemented in-house by City personnel. The span of time for implementing the program is 10 years. With 21 identified locations of failing UICs (Table 13), the total cost of this program is estimated to be $5,340,000. This program will implement one to two projects per year. It is recommended that Potential Projects in this program that have water quality as a secondary issue be prioritized for implementation.

Table 13 Potential Projects in the Failing UIC Drainage Improvement Program

Potential Project ID	Project Name
PP-8	NW Georgia Avenue Drainage Improvement
PP-9	NE Shephard Road Drainage Improvement
PP-15	NE Revere Ave Drainage Improvement
PP-17	NW Clearwater Dr Drainage Improvement
PP-20	NW Summit Dr Drainage Improvement
PP-22	NW Wall Street Drainage Improvement
PP-23	NE Hawthorne Ave Drainage Improvement
PP-24	NE 9th Street and Penn Drainage Improvement
PP-25	SE 15th Street Drainage Improvement
PP-26	SW Shevlin Hixon Dr Drainage Improvement
PP-27	SW Simpson Ave Drainage Improvement (2014 SMP)
PP-28	SW Forest Ridge Ave Drainage Improvement
PP-29	McMullin Dr Drainage Improvement
PP-30	SW Westridge Ave Drainage Improvement
PP-31	NE Morningstar Dr Drainage Improvement
PP-32	SW Chandler Ave Drainage Improvement
PP-33	NE 2nd St Drainage Improvement
PP-34	NE Eastwood Drainage Improvement
PP-36	NE Ross Rd Drainage Improvement
PP-38	NW Sean Ct Drainage Improvement
PP-41	NW Olney Ave Drainage Improvement

The City may continue to add to this list over time in response to new drainage complaints related to failing UICs. It can be noted that some drainage issues associated with failing UICs have been grouped instead into the Major Maintenance Program, described later; these tend to be the higher priority or more complex failing UICs (Table 15).

5.1.2. Drillhole Water Quality Retrofit Program

This program focuses on protecting groundwater quality by either decommissioning or retrofitting existing drillholes. Decommissioned drillholes will be replaced by a new infiltration facility (a drywell or deep drywell) and appropriate pre-treatment outside the two-year time of travel of zone for municipal and quasi-municipal drinking water wells. Retrofitted drillholes will remain, be re-drilled if necessary, and preceded by an appropriate pre-treatment facility. A 2025 technical memorandum prepared by GSI Water Solutions, Inc. (Appendix A), developed a framework to prioritize the decommissioning of drillholes in Bend. This framework calculated a risk score for each drillhole based on land use, traffic volume, risk to drinking water quality, groundwater depth, and current condition.

Based on this assessment, 23 drillholes were categorized as Priority 1. These are located within the 2-year time of travel zone of municipal and quasi-municipal drinking water wells. Two drillholes are Priority 2, and 85 drillholes are Priority 3.

Of the 23 drillholes that are the high priority for a retrofit, ten were retrofitted with a sedimentation manhole for pretreatment during the writing of this plan. The remaining Priority 1 and Priority 2 drillholes, 15 in total, will be retrofitted in the manner described by this program over the course of five years (Table 14). The City may continue retrofitting drillholes ranked Priority 3 through 5 as resources allow.

Table 14 Priority 1 and Priority 2 Drillholes

Priority	Potential Project ID	Drillhole ID	Year Completed
1	-	DDH009763	FY 2023-24
1	-	DDH009764	FY 2023-24
1	-	DDH009765	FY 2023-24
1	-	DDH009498	FY 2024-25
1	-	DDH009520	FY 2024-25
1	-	DDH009550	FY 2024-25
1	-	DDH009625	FY 2024-25
1	-	DDH009841	FY 2024-25
1	PP-65	DDH009624	FY 2025-26
1	PP-69	DDH009767	FY 2025-26
1	PP-62	DDH009510	-
1	PP-63	DDH009513	-
1	PP-64	DDH009514	-
1	PP-66	DDH009727	-
1	PP-67	DDH009728	-
1	PP-68	DDH009766	-
1	PP-70	DDH009485	-
1	PP-74	DDH002049	-
1	PP-79	DDH009381	-
1	PP-76	DDH009466	-
1	PP-77	DDH009477	-
1	PP-75	DDH009482	-
1	PP-78	DDH010013	-
2	PP-71	DDH009875	-
2	PP-72	DDH009932	-

A high and low cost estimate was developed for this program, based on addressing the 15 remaining high-priority drillholes. The higher cost option decommissions the drillholes and replaces the facilities with drywells outside of the two-year time of travel zone of municipal water wells. The lower cost option includes redrilling the drillhole to improve infiltration capacity and installing a connecting catch basin and water quality manhole to control sediment, oils, and trash. The total cost of this program is between $1,690,000 and $3,970,000, depending on the solution used.

5.2. Major Maintenance Program

The Major Maintenance Program is an existing program, currently known as the Stormwater Capital Repair and Replacement Program, within the Water Services Department and the Engineering Department and is currently budgeted as 1RCAP in the stormwater fund Biennial Budget. Projects in this program are intended to be completed as resources or synergy opportunities become available.

Potential Projects marked for the Major Maintenance Program are moderately complex repair, replacement, or drainage projects to maintain functional condition, improve access, or manage small drainage issues (Figure 16). These projects may be designed by in-house personnel or consultants. The program is assumed to be implemented indefinitely because repair, replacement, synergy opportunities, and small drainage projects will continue to arise over time, especially if the City were to implement a systematic inspection program for its stormwater pipe system.

The City plans to conduct an in-house prioritization of the identified Major Maintenance projects in this SMP (Table 15) and will re-prioritize as other project needs are identified in the future. Several Major Maintenance projects are prioritized as 'High' in this plan because the City intends to resolve these issues in the near-term based on recent significant stormwater runoff impacts.

Table 15 Potential Projects in the Major Maintenance Program

Potential Project ID	Project Name	Priority
PP-13	NW Mueller Avenue Alley Drainage Improvement	High
PP-80	NE Penn Ave/NE Neff Rd Drainage Improvement	High
PP-81	NW Trenton Drainage Improvement	High
PP-10	Wagontire Way Drainage Improvement	TBD
PP-11	Overturf Ct Cul-de-sac Drainage Improvement	TBD
PP-18	NE Nels Anderson Rd Drainage Improvement	TBD
PP-19	Poplar Street Drainage Improvement	TBD
PP-21	SE Waco Dr Drainage Improvement	TBD
PP-37	China Hat Rd Drainage Improvement	TBD
PP-40	SW Hayes Ave Drainage Improvement	TBD
PP-49	SE 3rd Street South of Brosterhous	TBD
PP-50	NW McKay Ave Pipe Repair	TBD
PP-55	SW Alderwood Cir Drainage Improvement	TBD
PP-56	NW Clearwater Dr Drainage Improvement	TBD
PP-57	Newport Outfall Maintenance	TBD
PP-58	NW Tumalo at Drake Park Pipe Repair	TBD
PP-59	NW Baltimore Pipe Repair	TBD

Table 15 Potential Projects in the Major Maintenance Program

Potential Project ID	Project Name	Priority
PP-60	SE Ferguson Rd Drainage Improvement	TBD
PP-61	SE Gardenia Ave Drainage Improvement	TBD
PP-73	NE Olney Ave Drainage Improvement	TBD
PP-82	NW Allen Drainage Improvement	TBD

The City will continue to add to the Major Maintenance list over time in response to new inspection results of individual public facilities, drainage complaints, and condition assessments of pipes.

5.3. Programmatic Solution Cost Summary

Program-level costs were developed using the stormwater toolkit and construction assumptions developed for this plan for the identified issues or projects in each programmatic solution. A recommended implementation timeframe is noted. The Drillhole Water Quality Retrofit Program has up to116 project locations (Priority Ranks 1-5) and may end after all drillholes that may impact groundwater quality have been retrofitted. The Failing UIC Drainage Improvement Program and the Stormwater Major Maintenance Improvement Program likely will need to continue indefinitely after the identified projects have been addressed.

Table 16 Programmatic Solution Cost Summary

ID	Program Name	Cost (2025 $)	Notes
1RDHD	Drillhole Water Quality Retrofit Program	$5,700,000	Total costs include the priority locations documented in the fact sheet for a five-year implementation schedule ($3,970,000) and subsequent lower-priority projects implemented at a slower pace in future years ($1,730,000); Currently "Drillhole Decommissioning" (1RDHD) in 2025-27 Biennial Budget.
TBD	Failing UIC Drainage Improvement Program	$5,340,000	The cost is to address the identified known issues in this plan over a 10-year implementation schedule to begin after completion of the high priority projects in the Drillhole Water Quality Retrofit Program, above. Program will likely need to continue indefinitely or be rolled into Stormwater Major Maintenance after the issues identified in this SMP have been addressed.
1RCAP	Stormwater Major Maintenance Program	$7,500,000	The cost is for five years of this program using a variable annual budget allocation. Currently "Stormwater Capital Repair and Replacement" (1RCAP) in 2025-27 Proposed Biennial Budget. Assume continuation of this program at a set annual level of $1.5 million from years 6 to 20 (cost not included in this table).
	Total	**$18,540,000**	

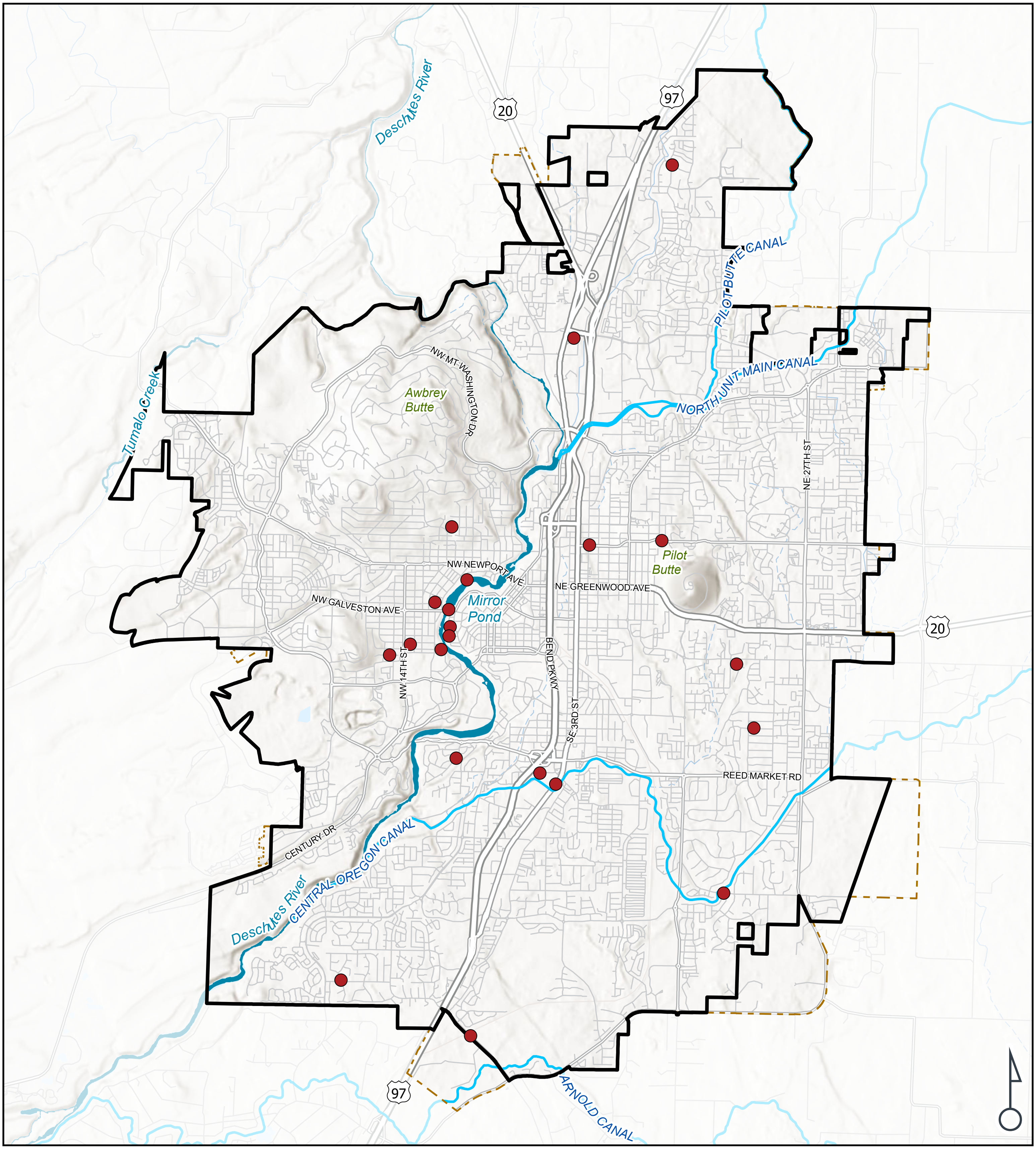

FIGURE 16

MAJOR MAINTENANCE PROGRAM

BEND STORMWATER MASTER PLAN

BEND, OREGON

LEGEND

- ▭ Bend City Limits
- ┅ Urban Growth Boundary
- — Streams
- — Canals
- ● Major Maintenance Program

Data Sources: City of Bend, USGS, Google Maps.
Date: 10/28/2025
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Section 6. Policy Discussion

Two white papers were developed for this SMP to advance policy development or strategic planning around issues and challenges facing stormwater management in Bend. Drainage and density, level of service, climate change, and new stormwater management techniques were selected as topics of interest. Each issue is summarized below, and supporting materials are provided in Appendix D.

6.1. Drainage and Density

Bend's 2016 Comprehensive Plan identified the need for 17,234 new housing units and the City is also planning for over 60,000 new jobs by 2028. Various recent state laws direct cities to allow more types of housing. To accommodate this growth, the City has enacted policies to create a diversity of housing options and to identify land to support economic development. With rapid growth, the City is densifying. Increasingly, lots are smaller, leaving little room for construction of stormwater management facilities. An increasing number of lots with geology and site conditions that are not conducive to stormwater management are being developed. Therefore, City staff and developers are calling for more options to manage stormwater both on-site and in a more centralized or regional fashion. A white paper explores some of the opportunities and limitations of Bend's existing policies and approaches to managing stormwater, and it contemplates additional options.

6.1.1. Stormwater Policy for Development

Bend's default and most common pattern for stormwater system development is decentralized and privatized. Unless alternate allowable arrangements are made, stormwater runoff must be kept on the lot of origin and managed by the property owner. This document refers to this method of managing stormwater on individual lots as "lot-scale stormwater management." Lot-scale stormwater management is described in the following codes and standards:

- Bend Municipal Code (BMC) Title 16 – Grading, Erosion Control, Stormwater, Illicit Discharge, Tree Protection, and Wells
- Bend Design Standards and Specifications, Part II, Chapter 6, Stormwater
- Central Oregon Stormwater Manual (COSM)
- Bend Development Code (BDC) Title 2, Land Use Districts
- BDC Title 3, Design Standards
- BDC Title 4, Applications and Review Procedures

To comply with the MS4 Permit, Bend is updating its stormwater development procedures in 2025 to seek more consistent enforcement of stormwater standards and more effective facility design and construction on residential lots for subdivision and short plat applications.

While the lot-scale pattern described in these codes and standards relieves the City of providing an all-inclusive public stormwater system, it has drawbacks. Disadvantages include the following:

- Crowding out owner-preferred elements of residential landscaping/hardscaping such as lawns, planting beds, or patios on small lots.
- Assuming that individual lots have capacity to manage urban stormwater runoff, including appropriate geology, and space to place facilities outside of setbacks to other properties, streets, and hazardous features such as steep slopes.

- Entrusting individual property owners or HOAs with responsibility for systems that can be difficult to inspect, operate, and maintain.
- The frequently long time period between land disturbance on individual lots (grubbing, rough grading) and provision of stormwater facilities during development of some large subdivisions can mean that stormwater facilities in the streets are exposed to more sediment running off of lots that have not been stabilized.

The review of the existing codes and standards revealed that alternate stormwater system development options are allowable but face administrative barriers, are not widely known or understood, and are infrequently used.

6.1.2. Alternatives to Lot-Scale Stormwater Management

To mitigate some of the disadvantages of lot-scale stormwater management, the white paper explores alternatives the City could allow or promote. The options include techniques other than lot-scale stormwater management that are allowed but infrequently used as well as techniques that may not currently be allowed in Bend.

Centralized On-site Stormwater Management

One option is centralized on-site stormwater management, defined as the provision of a unified stormwater conveyance network and centralized stormwater treatment facilities which may manage runoff from both private lots and public streets. Centralized on-site stormwater management is allowed in Bend through a master planned development and may also be allowed in other circumstances. However, it is rarely used. The review of governing policies found that:

- The drainage submittal requirements in BMC 16.15.010.B allow for residential, commercial, institutional, or industrial development to apply stormwater management standards to the common land development plan, rather than lot by lot, if the development has a master plan that includes formal arrangements for stormwater drainage across multiple properties. However, Specification 6.4.1 allows only residential developments to pipe runoff to the ROW. City staff have indicated that no commercial or industrial projects have been permitted to comingle runoff with public runoff in the ROW.
- BMC 16.15.040.A.4 requires stormwater drainage in excess of the predevelopment rates or volumes to be retained on the lot of origin and not trespass onto the public right-of-way or private property except: a) if City determines retaining would pose a threat to public safety or adjacent properties, b) when the owners of the lots of origin compensate the City for the cost of constructing, operating, and maintaining additional stormwater drainage and treatment capacity, c) access is provided to on-site stormwater facilities, or d) if the development has a master plan that includes formal arrangements for stormwater drainage across multiple properties
- BMC 16.15.040.A.6 allows stormwater facilities within residential subdivisions to serve multiple lots and/or combination of lots and roadways if stormwater facilities are located on a lot owned and maintained by an HOA.

The white paper explores how centralized on-site stormwater management has been used successfully for residential subdivisions and non-residential site development in Bend and other Oregon communities. It identifies infill as a type of development that could benefit from more investigation into the barriers to and opportunities for centralizing stormwater management systems. See Table 17.

Table 17 Summary of Centralized On-Site Stormwater Management Options

Development Type	Location of Stormwater Facility	Who is Draining	Facility Owner Existing Options [Recommended Options]	Approval Process
Residential Subdivision, streets and lots managed together	Street, tract, or individual lot, or combination	Lots and Street	Varies, HOA or City [HOA on tract; City in ROW]	Typically Type II*
Non-Residential Site Development	Lot	Lot	Commercial/Multifamily property owner [Commercial/Multifamily property owner]	Typically Type II*
Infill	Private property within easement or street, in limited cases	Private	Private, could be HOA or individual owners	Minimum Development Standards (MDS) Review**

** Type II decisions are made by the Community and Economic Development Director following public notice and an opportunity for parties to comment but without a public hearing. (BDC 4.1.415)*

*** MDS Applications are generally reviewed under the Type I process, which may be handled administratively by the Community and Economic Development Director without public notice or hearing because this is neither a land use decision nor a limited land use decision (BDC 4.1.310). MDS are defined within BDC 4.2.*

The white paper explores the barriers to centralized on-site stormwater management, which include current code, standards, procedures, and public funding.

ROW Comingled Stormwater Management Options

Another alternative for stormwater management is to allow private or comingled public/private stormwater facilities in the City's ROW. Managing lot runoff in the ROW could be accomplished either by allowing a development such as infill to drain to existing public conveyances and facilities or allowing a development to construct a system in the ROW. Managing lot runoff in the ROW would be a bigger departure from current practice than centralized on-site stormwater management. ROW stormwater management options may be most needed for infill that does not have adequate space for functional on-lot or multi-lot facilities.

The review of governing policies found that BMC 16.15.040.A.4 allows drainage from private property to enter the ROW when the owners of the lots of origin compensate the City for the cost of constructing, operating, and maintaining additional stormwater drainage and treatment capacity. This option is not approvable because the City has established neither a mechanism for calculating, charging, collecting, and using such a fee nor standards for demonstrating that an existing public system has adequate capacity. In addition, developments that might benefit from this option (infill) typically go through the MDS Review instead of full land use review, and the purpose of the MDS Review is to streamline and simplify approvals for development. If this option were approvable, then the applicant could connect to or construct a stormwater facility in the ROW as part of an infill land division. Facilities would require a ROW permit and would be built to public improvement standards. The City would need to establish a mechanism and determine if the applicant would reimburse the City for future operation and maintenance, and the City would then own and operate the facilities.

The white paper explores the barriers to ROW comingled stormwater management, which include the MDS Review process, lack of funding for maintenance of more public stormwater facilities, and perception of fairness when using public assets to provide a service that is typically provided by private parties.

Regional Facilities or Regional Stormwater Strategies
The City of Bend is investing in several locations such as Central Core/Midtown with the multiple aims of supporting economic development, improving public safety, providing adequate housing inventory, improving circulation, and beautification. Creation of regional stormwater strategies and/or regional stormwater facilities can support these aims by planning for or providing required infrastructure in advance of redevelopment, which could reduce costs and streamline permitting. A regional stormwater strategy addresses conveyance, water quantity control, and water quality treatment through a planned set of public, private, and/or public and private stormwater infrastructure. A regional stormwater strategy could include several types of solutions to manage runoff in a coordinated manner. A regional stormwater facility is typically described as a large stormwater management solution strategically situated and designed to serve multiple properties, which often are under varied ownership and span a large area, to optimize stormwater management as part of a development project or to facilitate redevelopment.

Regional stormwater planning requires significant investment from the City, starting with commitment to exploring opportunities and then coordinating with community stakeholders, identifying or developing a funding mechanism, and permitting implementation by updating policies and codes. The white paper explores these steps in greater detail and provides numerous successful examples from the Pacific Northwest.

6.1.3. Recommendations and Next Steps

The recommendation is for Bend to provide more flexible options for managing stormwater on development and redevelopment sites. Bend must also maintain compliance with NPDES and WPCF permits from the state and protect public safety by regulating conveyance capacity, downstream impacts, and technical feasibility of stormwater facilities based on site conditions. City staff have articulated the following overarching tenets for guiding further investigation or implementation of changes to stormwater management policies:

- Public stormwater facilities should be constructed to public improvement standards and provide adequate access for maintenance.
- Stormwater facilities in the ROW should be owned and operated by the City.
- The City should identify adequate resources to maintain a larger inventory of public facilities if any recommendations to allow more public facilities are pursued and implemented.
- The City should establish an internal committee to determine the steps necessary to implement recommendations in this SMP, including code/standards updates, development permitting processes, fees/funding adjustments if needed, and stakeholder involvement.
- The City should evaluate the budget and planning resources necessary to develop a specific stormwater master plan for the Central Core/Mid Town area that evaluates and recommends district-specific public-private stormwater management.

The white paper lists specific policies and technical standards which the City may explore updating.

6.2. Stormwater Operations Level of Service

The City hopes to establish a target Level of Service (LOS) for key aspects of the stormwater utility because identifying a baseline and target LOS are foundational steps in asset management. The SMP begins the LOS analysis and recommends next steps.

Defining LOS targets helps guide investment decisions, optimize operations, communicate service expectations, and manage performance trade-offs. These targets can range from broad, strategic goals at the agency level to specific performance standards for individual assets or components. LOS is not static and may evolve according to changes in customer demands, regulatory requirements, system condition, and fiscal constraints. A well-structured LOS framework will enable Bend's stormwater utility to balance service delivery, affordability, and long-term sustainability, ensuring that the right level of service is delivered at the right cost with an acceptable level of risk.

Eleven categories of service were explored through workshops and conversations with City staff. The LOS for each category was subjectively assessed on a scale of low, moderate, and high (Table 18). A "low" LOS indicates a reactive service with limited investment or capacity. "Moderate" indicates a balanced service with funding that meets permit requirements or performance goals. "High" indicates proactive or preventative services with increased investment that does or may exceed regulatory mandates. Implementing a recommendation to increase LOS may incur additional costs for staff or equipment that have not been quantified for this assessment.

Table 18 Recommended LOS Strategies and Goals

Category	Current LOS	Target	Regulatory Requirements	Recommendations
A. Drainage Complaint Immediate Response	High	Respond to drainage complaints within 72 hours.	N/A	▪ Maintain LOS ▪ Continue current activities ▪ Explore process improvements including a decision tree to clarify internal and cross-department responsibilities for various types of complaints
B. Inspection & Maintenance of Underground Facilities	High	Inspect underground facilities (excluding pipes) once per year	MS4 Permit (A.3.f.ii.) ISWMP BMP OM-2	▪ Maintain LOS ▪ Continue current activities ▪ Implement process improvements
C. Inspection of Storm Pipes	Low	Inspect the entirety of the City's storm pipe system and establish a frequency for re-inspection	MS4 Permit (A.3.f.ii.) ISWMP BMP OM-2	▪ Increase LOS to ensure system condition is known and kept up to date Establish a percentage of storm pipe system to be inspected per year ▪ Pursue implementation planning for pipe inspections

Table 18 Recommended LOS Strategies and Goals

Category	Current LOS	Target	Regulatory Requirements	Recommendations
D. Inspection of Aboveground Water Quality Facilities	High	Inspect water quality facilities at least once per year	MS4 Permit (A.3.e.) ISWMP BMP PC-3	▪ Maintain LOS ▪ Continue current activities ▪ Explore process improvements for efficiency
E. Maintenance of Aboveground Water Quality Facilities	Low	Maintain water quality facilities to ensure function, including water quality and aesthetics (trash and weed management)	MS4 Permit (A.3.e.) ISWMP BMP PC-3	▪ Increase LOS to ensure regular and ongoing proper functioning of facilities ▪ Improve capacity for in-house and/or contracted vegetation management for ROW facilities to improve frequency of maintenance and recognize increasing inventory ▪ Establish a maintenance checklist that addresses vegetation management, sedimentation buildup, irrigation performance, and effects of roadway applications such as deicers and cinders
F. Ground Water Quality Protection Retrofit Projects	Low	Yearly progress in completing UIC retrofits	WPCF Permit ISWMP BMP PL-2	▪ Increase LOS to be able to implement recommended list of projects ▪ Implement drillhole retrofit strategy ▪ Complete priority drillhole retrofits
G. Capital Project Implementation	Moderate	Plan, fund, and construct stormwater capital improvements, which include drainage and surface water quality retrofit projects, as identified in the CIP.	MS4 Permit (A.3.f.x.)	▪ Maintain LOS ▪ Maintain or increase pace of project implementation based on prioritized list in 2025 SMP; Improve synergy with other City departments. ▪ Ensure surface water quality retrofit projects are implemented per MS4 Permit requirements
H Major Maintenance Program Implementation	Low	Prioritize, fund, and complete major maintenance projects.	N/A	▪ Increase LOS ▪ Monitor utilization of increased budget on identified major maintenance and synergy projects ▪ Prioritize major maintenance projects recommended in the 2025 SMP

Table 18 Recommended LOS Strategies and Goals

Category	Current LOS	Target	Regulatory Requirements	Recommendations
I. Street Sweeping	Moderate	Sweep streets within the MS4 area once per quarter.	MS4 Permit (A.3.f.iii.) ISWMP BMP OM-3	▪ Maintain LOS ▪ Update collection and management of sweeping data within the MS4 area ▪ Use data to optimize sweeping routes and notify the public during MS4 sweeping efforts.
J. Development Regulations for Private Stormwater Infrastructure & Inspections	Moderate	Establish an internal system that identifies and catalogues private stormwater systems and inspection schedules.	MS4 Permit (A.3.e.v.) ISWMP BMP PC-4	▪ Identify and create a plan to provide appropriate LOS necessary to meet permit compliance ▪ Monitor and evaluate implementation of emergent activities ▪
K. Other MS4 Compliance	Moderate	Maintain compliance with all aspects of the MS4 Permit.	MS4 Permit	▪ Maintain LOS ▪ Monitor effectiveness of current compliance activities ▪ Evaluate needs under new Permit in 2026

Several categories will experience an increase in inventory as the City's stormwater system expands. The future workload is therefore also expected to increase corresponding to inventory growth. Current LOS may trend up or down as inventories increase and can be mitigated by additional full-time equivalent (FTE) for the stormwater utility and/or introducing processes that prioritize efficiency.

Categories not classified as having a high LOS currently have the potential for more proactive activities and practices. In several of the categories, the City wishes to improve upon the current LOS. Increasing LOS can be measured through introducing new actions or improving upon key performance metrics, often the frequency of actions specific to each category.

The City's stormwater infrastructure inventory is projected to grow, and regulatory requirements are also expected to increase. Under these conditions, the utility's financial and staffing capacity will directly impact levels of service for all categories. There are four recommended next steps following the LOS analysis:

- **Adopt the 2025 Stormwater Master Plan.** The SMP will guide future capital investments and policy decisions and should be considered when setting LOS goals.
- **Establish LOS goals and related resource needs and cost of service.** Using the analysis and recommendations in the white paper, summarized in Table 18, the City should establish LOS benchmarks for its service categories.
- **Engage internal stakeholders in budget planning.** Conversations with internal stakeholders (field staff and managers of the stormwater utility and departments that interface with the stormwater system) are needed to assess current and future budgetary needs.

- **Conduct a stormwater utility rate analysis**. A rate analysis is needed to determine the resources needed to achieve target levels of service and implement the capital projects.

6.3. Climate Change

To begin to address the question about whether the City should update its stormwater technical standards or policies to adjust to changes in precipitation patterns, the firm Haley & Aldrich developed a presentation for City staff based on local and national climate research. (Appendix A).

Research indicates that the following impacts due to climate change may be expected in Bend:

- Increased overall annual precipitation by 2100 (6% greater)
- Increased severity and intensity of storm events
- Decline in winter snowpack, reducing the amount of stored water during the melt season
- Increased severity and duration of drought, measured by decreased frequency of seasonal precipitation

6.3.1. Current Precipitation Depths

Bend uses the COSM for stormwater standards. The water quality design storm is the 6-month 24-hour storm, and the flow control storm is the 25-year 24-hour storm.

The design storm precipitation depths are based on NOAA Atlas 2, which was last updated in 1973 based on data from the 1960s. The use of outdated precipitation depths could lead to stormwater system designs that provide a lower level of service than intended and may play a role in the City's numerous local or nuisance flooding issues, identified in Section 3 of this plan.

In the absence of updated data over the past couple of decades, many municipalities in the northwest have updated design storms on their own using local data or other approaches. ODOT and City of Salem use data from ODOT, which updated NOAA Atlas 2 data for Oregon in 2008 based on historic rainfall. However, ODOT's data is already over 15 years old. City of Eugene uses locally collected data; its flood control design storms are based on different specific historical storms and vary by basin. Seattle developed design storms to replace Atlas 2 that were based on specific historical storms recorded by the City's large network of rain gauges.

In coordination with other agencies, Bend has access to data from three currently operational weather stations in Bend and one in Madras.

6.3.2. Historic Rainfall vs Projected Rainfall with Climate Change

Recent studies and climate models indicate storms are expected to become more severe in central Oregon. The University of Washington Climate Impacts Group has created a dynamic downscaled model of global climate change data. This model projects changes in extreme precipitation under different representative concentration pathways (RCP) or climate change scenarios. RCP 8.5 is considered the "business as usual" scenario in which the carbon emission patterns of today are continued into the future. A visualization of possible changes in extreme precipitation for Bend between the 2030s to the 2080s are shown in Figure 17 and Figure 18. In the charts, the blue dots represent the outputs of various climate models, and the red diamonds represent the average of the models.

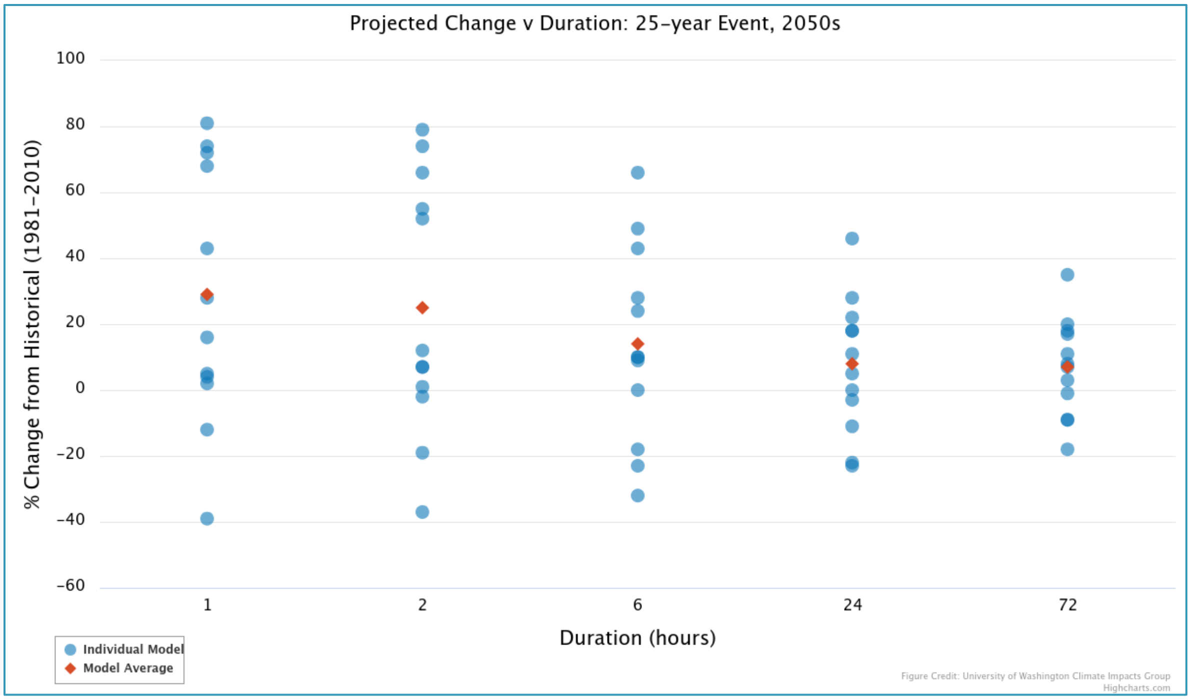


Figure Credit: University of Washington Climate Impacts Group
Highcharts.com

Figure 17 Projected Change in Precipitation for the 25-Year Event by Duration in Bend (Morgan, et. al, 2021)

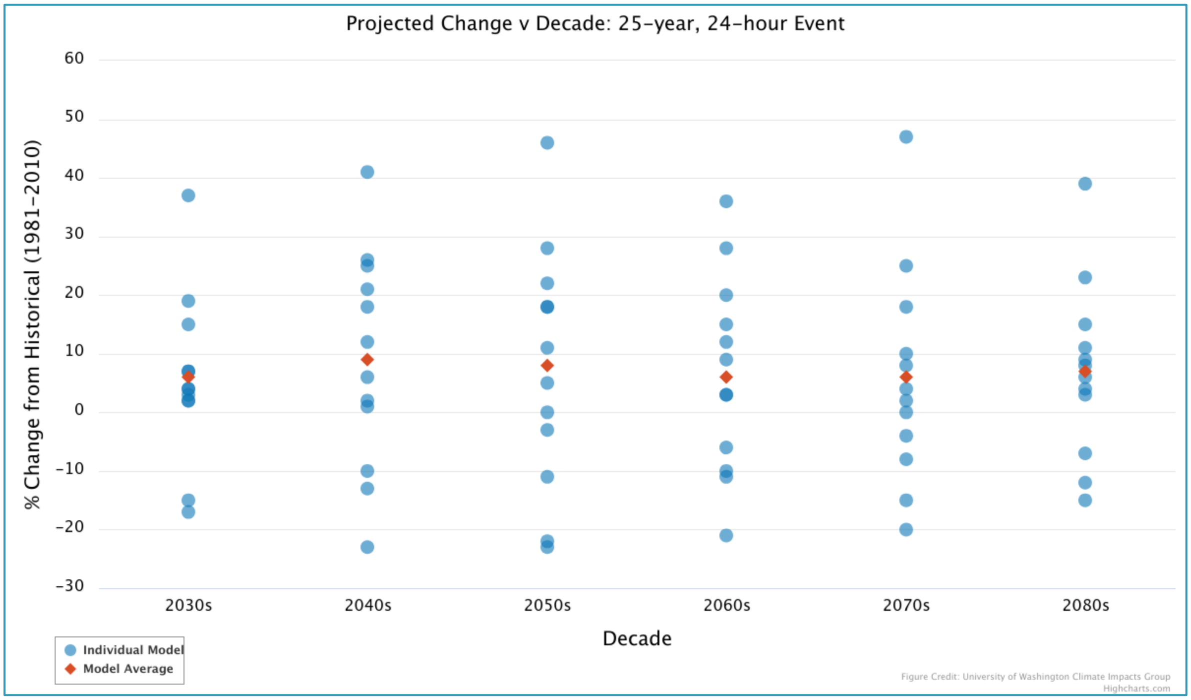


Figure Credit: University of Washington Climate Impacts Group
Highcharts.com

Figure 18 Projected Change in Precipitation for the 25-Year Event by Decade in Bend (Morgan, et. al, 2021)

6.3.3. Stormwater System Challenges

Shifting precipitation regimes due to climate change will impact Bend's stormwater system. Through discussion with stakeholders, two of six identified issues associated with precipitation were prioritized:

- Inappropriately sized design storms for existing conditions
- Increasing intensity and frequency of storm events

A lack of both updated national data and recent local precipitation data was identified as a gap hindering the City's ability to address these priorities. Fortunately, NOAA Atlas 15 is expected in 2027 and will provide an updated national dataset that covers Central Oregon. The first volume will be updated with historical and present-day data, covering the entirety of the United States. The second volume will build on that by generating adjustment factors for the present-day data based on climate models.

6.3.4. Recommendations

Primary recommendations include:

1. Developing a strong baseline of observed precipitation records by increasing weather data collection locations.
2. Adopt a watchful waiting stance for developing new design guidelines. Updating design guidelines based on the most updated data and climate projections requires time, expertise, and resources.
3. Change flow control facility requirements based on other factors when a complete update based on climate projections is not yet possible. Options include: upsizing flow control BMP volumes by a factor, scaling design storms by a factor, or designing BMPs for a larger storm event – like using the 50- or 100-year storm rather than the 25-year storm.
4. Help the community understand why they should care and how the parts of the community they love will be affected by a changing climate and increases in stormwater intensity (i.e. the river, their homes). Getting the community on board can help move processes along and hopefully make them more willing to put resources toward stormwater management and climate change.
5. Considering developing an internal policy for stormwater system design which encourages the Engineering Department to use conservative assumptions and calculations when sizing stormwater conveyance, treatment, and disposal systems, resulting in erring on the size of greater collection and conveyance capacity.

6.4. New Stormwater Management Techniques

In the 15 years since the COSM was last updated, stormwater management practices and techniques have evolved. Innovative proprietary and non-proprietary facilities that are easier to install in challenging locations or that improve pollutant removal capacity have been tested and used elsewhere in the Pacific Northwest. Of particular interest to Bend are stormwater management techniques that can introduce water quality protection in front of existing drillholes with minimal disturbance, provide multiple benefits such as greenery or aesthetics, or manage runoff in areas with welded tuff soils or shallow groundwater.

Use of new stormwater management techniques for City capital improvements and private development projects may be hindered by lack of familiarity among staff and the community, lack of provisions for their use in Title 16, Grading, Erosion Control, Stormwater, Illicit Discharge, Tree Protection, and Wells, lack of standards for selection, siting, design, performance, and maintenance in either the COSM or City of Bend Design Standards Part II, and absence of a standard drawing or standard detail approved by the City Engineer.

6.4.1. Specialized Water Quality Manhole

The Drillhole Water Quality Retrofit Program recommends the use of a specialized water quality manhole that uses both a snout and a baffle wall to improve pollutant removal. The design differs from the City's standard water quality manhole standard detail and the water quality manhole illustrated in the COSM. The specialized design is effective and inexpensive and may be a good option for introducing water quality treatment in front of drillholes with minimal disturbance. The design is non-proprietary. Adoption of this specialized manhole for use in front of existing drillholes should be vetted with the City's Engineering and Operations stakeholders. Because this structure is not being recommended for general use on new projects as a water quality manhole, it would not be necessary to update the Design Standards or Standard Drawings.

6.4.2. Stormwater Trees

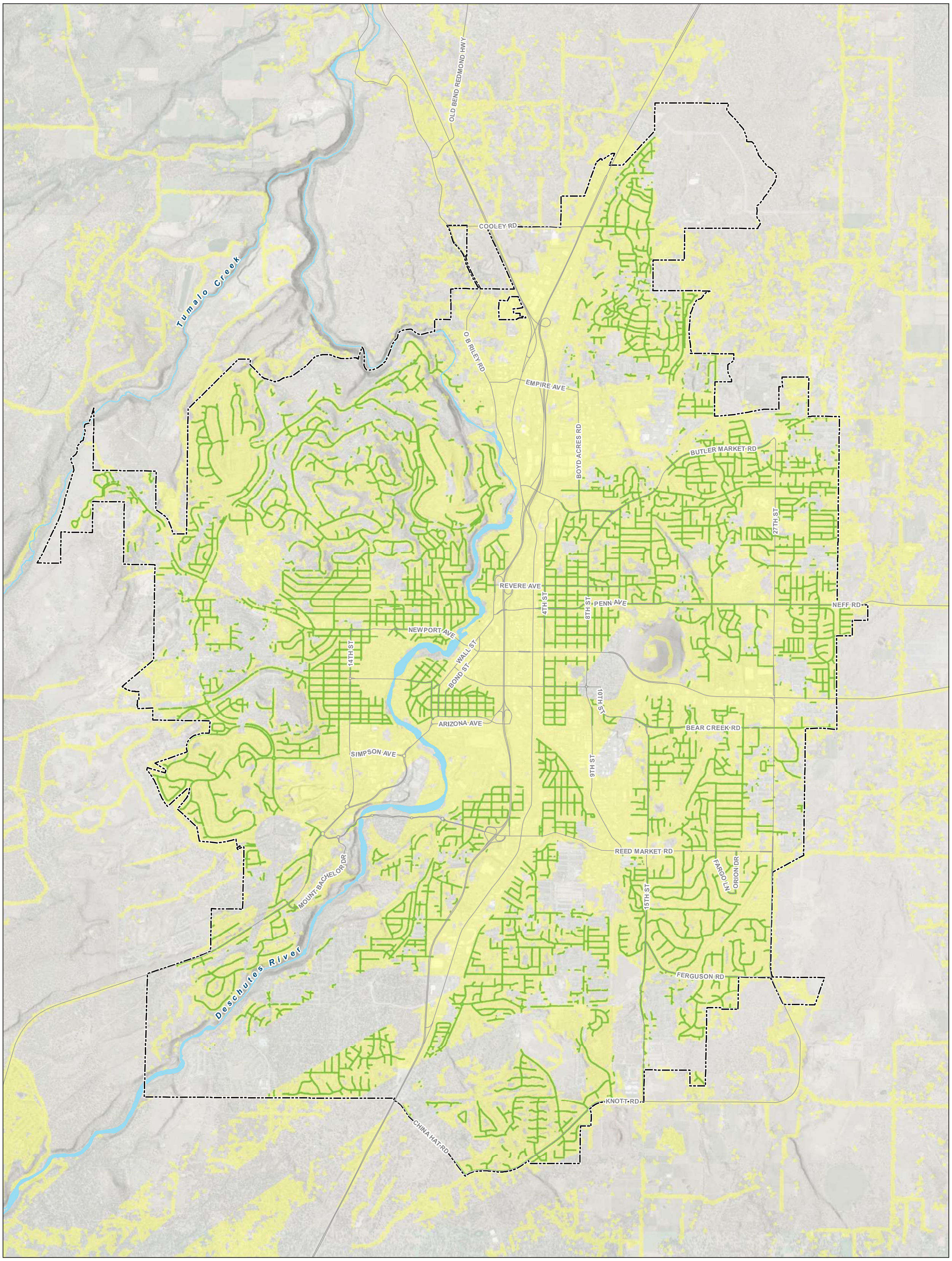
Gresham, Oregon and some cities in Europe have begun using versions of a stormwater tree to manage and treat runoff. Some CIP projects recommended in this plan assume the use of a non-proprietary stormwater tree practice to manage and mitigate stormwater runoff along public streets. The Stormwater Trees fact sheet (Appendix B) describes the technique. Stormwater trees are not currently included in the COSM or Bend's Standards and Specifications for stormwater control or treatment. Use on existing City streets to provide stormwater management where a stormwater system is currently lacking is the recommended use in the SMP. After the City gains experience siting, designing, constructing, and maintaining these facilities, the City may wish to consider adopting the stormwater tree as an approved stormwater facility for development sites by adding it to its Design Standards and Standard Drawings and/or by working with regional partners to update the COSM.

6.4.3. Deep Drywell Siting

Deep (or modified) drywells are an emerging stormwater management practice in the Pacific Northwest that may allow the use of infiltration where welded tuff near the surface typically prevents infiltration through drywells or surface infiltration facilities such as swales. Because deep drywells rely on drilled shafts of various depths, and Bend's aquifer varies in depth, the City should take additional precautions to protect groundwater resources when using or allowing their use. A preliminary analysis (Appendix A) has identified locations where deep drywells up to 100-foot may be sited with no additional investigation into water quality protection. Secondary locations, where these facilities are likely to be safe, but site-specific studies should be provided, are also identified (Figure 19). To allow and consistently regulate the use of deep drywells, the City should update its Standards and Specifications.

6.5. Required Regulatory Updates and Future Permits

The City should respond to new and additional requirements in the next NPDES Phase II Permit. The current permit was issued in 2021 and will expire in 2026. The extent of potential regulatory changes in the next permit is not known at this time. The City's WCFP Permit expired in 2013 and was reissued in July 2025 during preparation of this plan. The new permit did not include major changes from the previous one.



LEGEND

🟩 **Green Light** - Impervious surfaces, residential land use; local, collector, minor arterial, resource, and service roads; outside of two-year time-of-travel zones and >500 ft from water wells; and outside of areas with perched groundwater

🟨 **Yellow Light** - Impervious areas that are outside of the two-year ToT and greater than 100 feet from all water wells

All Other Features

City Boundary

Major Road

Watercourse

Waterbody

FIGURE 19

Deep Drywell Siting Criteria Map

City of Bend Modified Drywell Siting Criteria
and Drillhole Decommissioning Framework

Date: July 24, 2025
Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

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Water Solutions, Inc.

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Section 7. Outreach and Engagement

The Stormwater Master Plan update was managed by the Engineering Department and will be implemented primarily by the Water Services Department and the Engineering Department, with support from the Community Development Department related to new development standards and programs. Other departments or divisions are internal stakeholders, managing work that may be coordinated with implementation of the capital programs or policy recommendations. The project team consulted internal stakeholders for input and feedback on targeted issues and recommendations. External stakeholders were engaged throughout the plan development, and the general public was informed through the Stormwater Master Plan Update web page.

7.1. Internal Stakeholders

The project team met with the internal stakeholder to discuss a variety of topics as follows:

- Community Development Department, Growth Management Division to discuss the relationship of regional stormwater facilities to economic development in the Central Core and to address equity questions (December 2024)
- Community Development Department, Private Development Engineering Division and Building Safety Division to review on-site stormwater management issues in the field for the drainage and density policy review (May 2025)
- Enterprise Asset Data Division to discuss data requirements for stormwater capital improvement program GIS records (July 2025)

7.2. External Stakeholders and General Public

A variety of external stakeholders were invited to engage repeatedly throughout the plan development. They include Bend Park and Recreation District (BPRD), and the members of the Water Advisory Group (WAG). Additionally, the project team engaged with Central Oregon Builders Association (COBA), the City of Redmond, and local engineering firms on specific topics through round table discussions. BPRD is a recognized stakeholder because several of Bend's outfall pipes pass through parks adjacent to the Deschutes River and because the Engineering Department and BPRD are coordinating together on a project in Columbia Park which will improve access to the river and realign one of the City's stormwater outfalls. WAG, formerly Utilities Public Advisory Group (UPAG), is a group of community stakeholders invited by the Water Services Department to provide input to staff on programs and policies for stormwater management and other water system topics. It is made up of individuals who have experience or expertise, professional or lived, in areas that relate to the protection and management of water resources represent the following interests:

- Landscape design and construction
- Property development and consulting engineers
- Environmental community
- Citizens/neighborhood organizations
- Business/Chamber of Commerce
- State water/environmental regulator

Table 19 Stakeholder Involvement Dates and Topics

Date	Stakeholder	Topic
March 2024	UPAG	Introduction to Stormwater Master Plan update project
April 2024	BPRD	Meeting at Columbia Park to review project concept and existing stormwater infrastructure on site
May 2024	UPAG	Interactive workshop to discuss values and priorities for the SMP
August 2024	UPAG	Modified drywell siting, prioritization of existing drillholes for groundwater quality protection, concepts for capital project prioritization criteria
September 2024	UPAG	Follow-up to capital project prioritization criteria and introduction to the outfall retrofit needs assessment
October 2024	UPAG	Climate change and stormwater, follow-up from feedback on previous topics
January 2025	WAG	Introduction to the drainage and density policy topic
February 2025	WAG	Updates to rating criteria, results of CIP prioritization, discussion of other stormwater capital programs
March 2025	BPRD	Discuss possible synergy between stormwater projects and Parks
March 2025	Local Engineering Round Table	Discussion hosted by AKS Engineering including several local engineering firms to discuss drainage and density policy topic
April 2025	WAG	Follow-up to drainage and density policy topic
April 2025	COBA	Stormwater Master Plan overview and drainage and density policy topics
May 2025	City of Redmond	Overview of City of Redmond’s approach to stormwater management focused on private development
May 2025	WAG	Recap, review final CIP recommendations, and introduce policy recommendations
September 2025	WAG	Recap and presentation of DRAFT Stormwater Master Plan

The general public has had the opportunity to be informed via the Stormwater Master Plan Update web page, which includes the project purpose, schedule, and background, as well links to the draft CIP map with ranks and the DRAFT Stormwater Master Plan.

Materials used for outreach to external stakeholders and the public are collected in Appendix F.

Section 8. Implementation Plan

The SMP proposes a balance between addressing immediate concerns and preparing for the future. This implementation plan will help the City sequence its efforts over the next 20 years and adapt to changing circumstances and priorities.

8.1. Stormwater Program Goals

Completion of infrastructure master plans, including this update to the SMP, is a stated goal of City Council for 2025 to 2027. Implementation of the SMP will help Bend address public concerns with drainage, stakeholder priorities for public safety and environmental stewardship, and City Council's goals.

8.1.1. Public Drainage Concerns

Several intense rainstorms with severe localized flooding have occurred in the last decade, drawing increasing public attention to private property damage and traffic safety resulting from lack of collection and/or conveyance capacity in the City's storm systems. These intense storms include, but are not limited to, two over Pilot Butte in August 2025 as this plan was reaching its conclusion. Addressing severe localized flooding is a priority for staff and affected members of the public and could serve to reduce the City's liability.

8.1.2. Staff and Stakeholder Goals

Both City staff and stakeholders have emphasized public safety as a priority that can be served by attending equally to both drainage problems that impact pedestrians or traffic safety or private property and to water quality protection.

Stakeholders have emphasized environmental stewardship and projects that serve multiple purposes.

Compliance with the City's two stormwater permits is a priority for staff and stakeholders and is the driver of several of the recommendations.

8.1.3. City Council Goals

The following elements of the 2025-2027 City Council Work Plan are pertinent to the SMP:

- Prioritizing policies that support affordable, attainable housing, and livability contribute to Council's "Safety + Belonging" principle.
- Prioritizing environmental resilience to ensure a thriving and livable Bend contributes to Council's "Environment and Climate" guiding principle and honors the original stewards of the land.
- Adopting development code and entitlement process improvements that remove barriers and speed up missing middle-income, affordable housing, and infill development serve Council's Housing objectives.
- Several objectives of the Transportation & Infrastructure goal are pertinent:
  - Enhancing safety for all modes of travel.
  - Developing projects and funding solutions to improve safety, reliability, maintenance, and capital needs, aligning revenue options with planning and performance metrics and goals.
  - Ensuring stormwater systems are aligned with the needs of a growing city and understanding capacity for growth.
  - Finishing the Stormwater Master Plan, prioritizing infill development.

- Leveraging public-private partnerships that catalyze investment in the Bend Central District.
- Improving permitting processes and reducing review times to support housing and economic development.

The SMP addresses each of these principles or goals through capital improvements and policy recommendations. See Table 21 (on page 79) for the recommended stormwater program priorities and their relationship to City Council's goals.

8.2. Summary of Recommended Solutions and Costs

The SMP recommends implementation of stormwater capital improvements that have been planned, designed, or started construction since the 2014 SMP. Most of these projects address drainage issues. It recommends planning for 11 new stormwater capital improvement projects (CIPs) to address larger-scale drainage and water quality issues and three programmatic solutions to systematically address smaller-scale water quality and storm system condition issues over time (Figure 20).

The SMP estimates the cost of capital improvements in 2025 dollars. The planning-level estimates include the full cost of implementing each individual CIP, from design through construction, as well as approximate costs for implementing programmatic solutions.

The 20-year cost table (Table 20, on page 77 below) spreads the estimates over a 20-year horizon in phases correlating to the City's capital planning cycle: years one through five, years six through ten, and the remaining years 11 through 20. The 20-year cost table also includes stormwater CIPs that were in progress or planned for implementation prior to the completion of the SMP and that appear in the capital improvement budget or planning documents such as the Midtown Crossings Stormwater Report.

The SMP also recommends policy initiatives. To address drainage and density, the SMP explores how the City could enforce stormwater standards more rigorously while allowing greater flexibility for centralizing stormwater management facilities. To address the pressures on available staffing and equipment resources resulting from growing storm system inventory and increasing regulation, the SMP recommends establishing and communicating about levels of service for the various stormwater services provided by the City and recommends more uniform and rigorous tracking of service metrics. Over time, these service expectations and metrics will assist in evaluating the costs and benefits of different levels of staffing and revenues. Finally, the SMP recommends the City take a watchful waiting stance to address the uncertainties of climate change, while pursuing an update to the outdated national precipitation data used to size stormwater facilities.

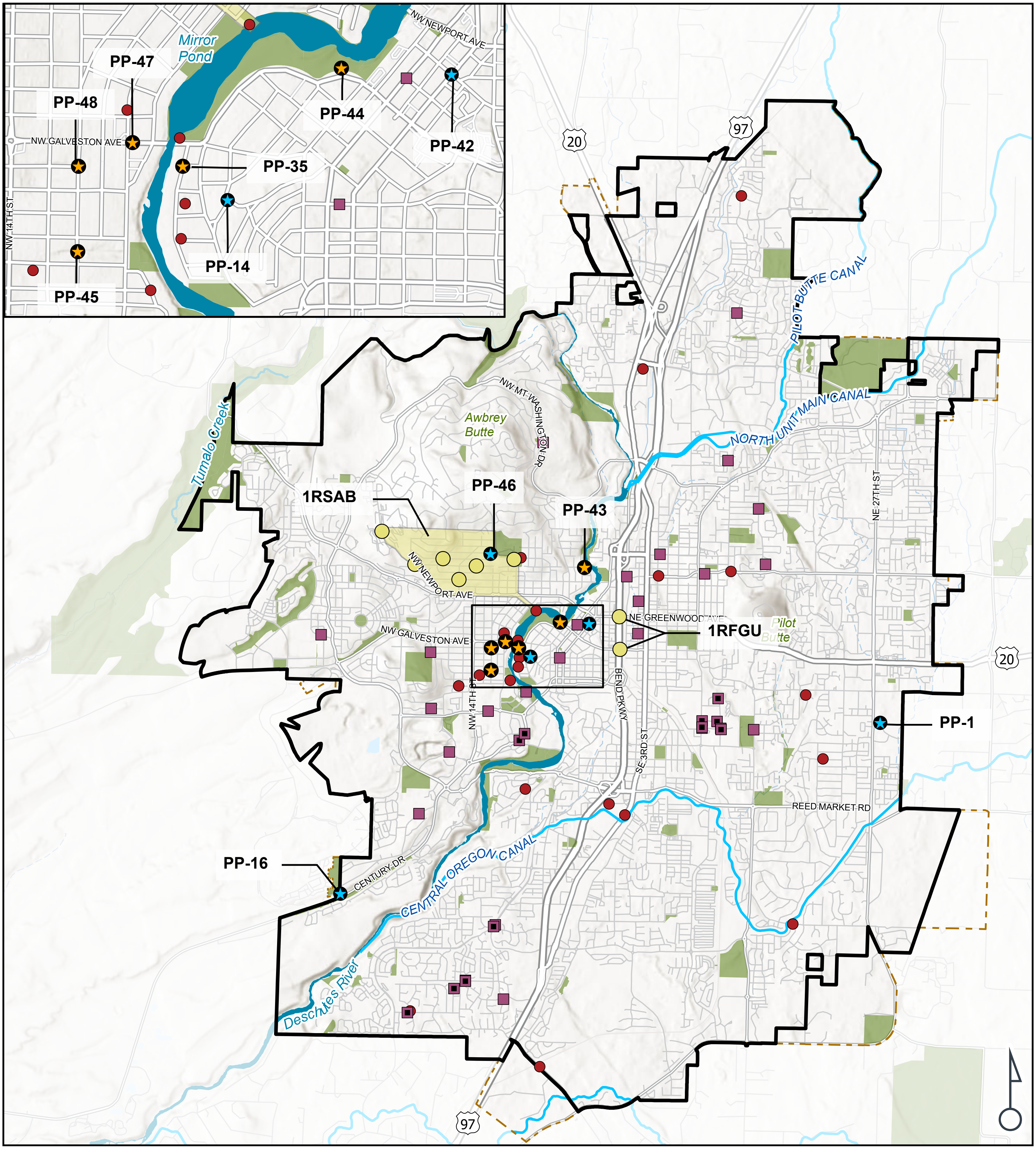

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FIGURE 20

STORMWATER MASTER PLAN PROJECTS & PROGRAMS

BEND STORMWATER MASTER PLAN

BEND, OREGON

Data Sources: City of Bend, Deschutes County, USGS, Google Maps.
Date: 10/28/2025
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

LEGEND

- ▭ Bend City Limits
- ┅ Urban Growth Boundary
- ― Streams
- ― Canals
- ★ CIP - Drainage
- ★ CIP - Outfall Retrofit
- ● CIP In Progress
- ● Major Maintenance Program
- ▣ Drillhole Water Quality Retrofit Program
- ■ Failing UIC Drainage Improvements Program

CITY OF BEND

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8.3. Recommended Stormwater Program Priorities

To address growing stormwater program demands amid stable funding, the SMP outlines strategic priorities that reflect City Council's goals and incorporate input from stakeholders gathered during the plan's development. Table 21 (on page 79 below) serves as a guiding framework for implementing these priorities.

Table 20 Recommended Stormwater Capital Improvements 20-Year Costs and Prioritization

Rank	ID	Project Name	Total Cost*	Information Source	Notes	Years 1-5[†]	Years 6-10	Years 11-20
Existing CIPs – Individual Projects								
1A[‡]	1SSW3	SW Sewer Basin Improvements Ph 3	$400,000	2025-27 Proposed Biennial Budget	Costs included in this table begin in 2026-27. Estimated completion in 2026-27.	$500,000		
1A	1RSAB	South Awbrey Butte Drainage Improvements	$12,500,000	2025-27 Proposed Biennial Budget	Costs included in this table begin in 2026-27. PP-2, PP-3, PP-4, PP-5, PP-6, PP-7 are all part of the drainage improvements; Estimated completion date of 2029	$15,450,000		
1A	1RFGU	Franklin Stormwater Improvements, Ph 1	$620,000	Midtown Crossing Stormwater Report	PP-51; Estimated completion date of 2026; Franklin is included in the budget with Greenwood, though they are separate project locations	$1,216,000		
1A	1RFGU	Greenwood Stormwater Improvements, Ph 1	$1,000,000	Midtown Crossing Stormwater Report	PP-39; Greenwood is included in the budget with Franklin, though they are separate project locations; Estimated completion date of 2026	$1,824,000		
					Existing CIPs Subtotal	*$18,990,000*	*$0*	*$0*
Planned CIPs – Individual Projects								
1B[‡]	1RFGU, Ph. 2	Franklin Stormwater Improvements, Ph 2	$850,000	Midtown Crossing Stormwater Report	Date of Implementation TBD; Franklin is included in the budget with Greenwood, though they are separate project locations		§	
1B	1RFGU, Ph. 2	Greenwood Stormwater Improvements, Ph 2	$3,800,000	Midtown Crossing Stormwater Report	Date of Implementation TBD; Greenwood is included in the budget with Franklin, though they are separate project locations		§	
1	PP-35	Riverfront Street Stormwater Improvements	$880,000	CIP Fact Sheet	Date of implementation TBD. Note that the 2025-27 Proposed Biennial Budget has a placeholder for Outfall Improvements (1ROTI) with expenditures beginning in 2028-29.		$880,000	
2	PP-42	Downtown Pedestrian Safety Drainage Improvements	$770,000	CIP Fact Sheet	Date of implementation TBD.		$385,000	$385,000
3	PP-44	Drake Park Stormwater Quality Improvements	$4,140,000	CIP Fact Sheet	Date of implementation TBD. Note that the 2025-27 Proposed Biennial Budget has a placeholder for Outfall Improvements (1ROTI) with expenditures beginning in 2028-29.		$2,070,000	$2,070,000
4	PP-14	Congress Street Drainage Improvements	$1,320,000	CIP Fact Sheet	Date of implementation TBD.			$1,320,000
5	PP-46	Vicksburg Avenue Drainage Improvements	$490,000	CIP Fact Sheet	Date of implementation TBD.		$490,000	
6	PP-47	Galveston Avenue Stormwater Quality Improvements	$5,820,000	CIP Fact Sheet	Date of implementation TBD. Note that the 2025-27 Proposed Biennial Budget has a placeholder for Outfall Improvements (1ROTI) with expenditures beginning in 2028-29.		$5,820,000	
7	PP-48	Fresno Avenue Stormwater Improvements	$4,230,000	CIP Fact Sheet	Date of implementation TBD. Note that the 2025-27 Proposed Biennial Budget has a placeholder for Outfall Improvements (1ROTI) with expenditures beginning in 2028-29.			$4,230,000
8	PP-45	12th Street Stormwater Quality Improvements	$1,040,000	CIP Fact Sheet	Date of implementation TBD. Note that the 2025-27 Proposed Biennial Budget has a placeholder for Outfall Improvements (1ROTI) with expenditures beginning in 2028-29.			$1,040,000
9	PP-1	Dove Lane Drainage Improvements	$390,000	CIP Fact Sheet	Date of implementation TBD.			$390,000
10	PP-43	Saginaw Avenue Stormwater Quality Improvements	$2,620,000	CIP Fact Sheet	Date of implementation TBD. Note that the 2025-27 Proposed Biennial Budget has a placeholder for Outfall Improvements (1ROTI) with expenditures beginning in 2028-29.			$2,620,000
11	PP-16	Campbell Rd Drainage Improvements	$130,000	CIP Fact Sheet	Date of implementation TBD.			$130,000
					Planned CIPs Subtotal	*$0*	*$9,645,000*	*$12,185,000*
					Individual CIPs Total	**$18,990,000**	**$9,645,000**	**$12,185,000**

Table 20 continues on next page

Table E-2 Recommended Stormwater Capital Improvements 20-Year Costs and Prioritization

Rank	ID	Project Name	Total Cost*	Information Source	Notes	Years 1-5†	Years 6-10	Years 11-20
Programmatic Solutions								
n/a	1RDHD	Drillhole Water Quality Retrofit Program	$5,700,000	Program Fact Sheet and 2025-27 Biennial Budget	Total costs include the priority locations documented in the fact sheet for a five-year implementation schedule and subsequent lower-priority projects implemented at a slower pace in future years.	$750,000	$3,375,000	$ 1,575,000
n/a	TBD	Failing UIC Drainage Improvement Program	$5,340,000	Program Fact Sheet	10-year implementation schedule to begin after completion of the high priority projects in the 1RDHD program. This program will be rolled into Stormwater Major Maintenance after the priority issues completed.		$2,670,000	$2,670,000
n/a	1RCAP	Stormwater Major Maintenance Program	Annual allocation	Annual allocation	Currently "Stormwater Capital Repair and Replacement" (1RCAP) in 2025-27 Proposed Biennial Budget. Assume continuation of this program at a set annual level of $1.5 million from years 6 to 20.	$6,620,000	$4,830,000	$13,155,000
					Programmatic Solutions Total	**$7,370,000**	**$10,875,000**	**$17,400,000**
					Total by Planning Horizon	**$26,360,000**	**$20,520,000**	**$29,585,000**
					Grand Total	**$76,465,000**		

** All costs are in 2025 dollars*

† Year 1 is the fiscal year 2025-2026

‡ Ranks 1A and 1B are given to projects that were not ranked by the SMP project team but are considered high-priority because they are either ongoing or budgeted capital improvements (1A) or contained in an existing master plan or infrastructure improvement plan that is being implemented by the City (1B)

§ City of Bend is determining if this work will be addressed through a City-funded CIP or through private development

Table 21 Recommended Stormwater Program Priorities

Program or Policy Recommendation	Description		Priority	Driver	Goal(s) Served
Implement the CIP Program – Drainage Projects	A stormwater capital improvement project is a standalone project to manage runoff which may have a design requiring complicated engineering, or creates a storm system where one does not exist, or has a high construction cost estimate.	A drainage project is designed to reduce the severity and frequency of flooding on streets and sidewalks after rain. Flooding on private property due to uncontrolled runoff from City streets may also be addressed.	High*	Service	▪ Enhance safety for all modes of travel ▪ Ensure stormwater systems are aligned with the needs of a growing city and understand capacity for growth ▪ Improve safety, reliability, maintenance, and capital needs
Implement the CIP Program – Outfall Retrofit Projects		An outfall retrofit project is designed to protect water quality by preventing untreated stormwater from flowing into the Deschutes River from existing outfalls. These projects remove urban pollutants and reduce sediment in runoff before it reaches the river.	High*	Service and Compliance	▪ Protecting and sustaining the environment ▪ Meets requirements of the City's National Pollutant Discharge Elimination System (NPDES) municipal stormwater permit issued by the State of Oregon under the federal Clean Water Act
Implement the Drillhole Water Quality Retrofit Program	The program is to protect the quality of groundwater resources by adding pre-treatment to existing drillholes that may be at risk of discharging pollutants to the aquifer. The program prioritizes drillholes that are within the 2-year time of travel of wells that are used as public drinking water wells.		High	Compliance	▪ Protecting and sustaining the environment ▪ Meets requirements of the WPCF Permit
Implement the Failing Underground Injection Control (UIC) Drainage Improvements Program	The program is to reduce nuisance flooding on streets and sidewalks by replacing UICs – drywells and drillholes – that no longer function or by adding new UICs to an underperforming system. Drywells or deep drywells may be used, depending on site conditions.		Medium	Service	▪ Enhance safety for all modes of travel ▪ Ensure stormwater systems are aligned with the needs of a growing city and understand capacity for growth ▪ Improve safety, reliability, maintenance, and capital needs
Implement the Major Maintenance Program	The program is to maintain condition or improve access to the existing stormwater system, or to manage small drainage issues on a public street, sidewalk, or private property when caused by runoff from a City street. Projects may repair, replace or add a small number or less complex structures (e.g. new inlets). Construction costs are estimated to be less than $1 million.		Medium	Service	▪ Enhance safety for all modes of travel ▪ Improve safety, reliability, maintenance, and capital needs
Drainage and Density policy: Advertise existing options for alternative stormwater management tools in development	The Drainage and Density white paper explores how Bend can better serve development by improving processes, increasing tools available, and exploring policy changes related to managing stormwater on development sites.	This is a short-term recommendation of the Drainage and Density white paper which will make permitting stormwater systems on some private development sites easier and more effective.	High	Service	▪ Improve permitting processes and reduce review times to support housing and economic development ▪ Prioritize policies that support affordable, attainable housing, and livability ▪ Adopt development code and entitlement process improvements that remove barriers and speed up missing middle-income, affordable housing and infill development.
Drainage and Density policy: Study and offer new options for alternative stormwater management tools in development, particularly for infill development		This is a long-term recommendation of the Drainage and Density white paper which will make permitting stormwater systems on some private development sites easier and more effective.	Medium	Service	▪ Improve permitting processes and reduce review times to support housing and economic development ▪ Finish the Stormwater Master Plan, prioritizing infill development ▪ Prioritize policies that support affordable, attainable housing, and livability ▪ Adopt development code and entitlement process improvements that remove barriers and speed up missing middle-income, affordable housing and infill development.
Drainage and Density policy: Prepare a separate regional stormwater plan to serve the Central Core District		This is a short-term recommendation of the Drainage and Density white paper which would remove barriers to redevelopment in the Bend Central Core.	TBD by City	Service	▪ Leverage public-private partnerships that catalyze investment in the Bend Central District ▪ Prioritize policies that support affordable, attainable housing, and livability

Table 21 continues on next page

Table 21 Recommended Stormwater Program Priorities

Program or Policy Recommendation	Description		Priority	Driver	Goal(s) Served
Level of Service (LOS) policy: Establish stormwater operations LOS goals and metrics	The LOS white paper explores Bend's policies, or lack thereof, for setting stormwater system LOS.	This is a short-term recommendation of the LOS white paper which would support a long-term goal of tracking metrics for stormwater operations, regulation, and capital improvements.	Medium	Service and Compliance	▪ Ensure stormwater system is aligned with the needs of a growing city and understand capacity for growth
LOS policy: Update stormwater tracking to address LOS metrics		This is a long-term recommendation of the LOS white paper which would provide standardized feedback on stormwater program achievement to support adapting policies, processes, and resource allocations to growth.	Low	Service and Compliance	▪ Ensure stormwater system is aligned with the needs of a growing city and understand capacity for growth
Climate change policy: Collect more precipitation and flow data to support assessment of design standards	The Climate Change presentation reviews data underpinning Bend's stormwater design standards and reviews the current state of the practice for predicting future precipitation patterns in central Oregon.	This is a long-term recommendation which would provide local data to supplement global and regionally downscaled climate model predictions when assessing design standards for stormwater control.	Medium	Service	▪ Ensure stormwater system is aligned with the needs of a growing city and understand capacity for growth ▪ Prioritizing environmental resilience
Climate change policy: Develop a watchful waiting approach to incorporating climate change projections into design standards for private development.		This is a long-term recommendation following the climate change literature review which would allow the City to target the long-term goal of ensuring capacity for growth while addressing more emergent drainage and water quality issues in the meantime.	Low	Service	▪ Ensure stormwater system is aligned with the needs of a growing city and understand capacity for growth ▪ Prioritizing environmental resilience
Climate change policy: Develop an internal policy for stormwater system design which encourages Engineering to use conservative assumptions and calculations when sizing stormwater conveyance, treatment, and disposal systems, to err on the size of providing greater collection and conveyance capacity.		This is a long-term recommendation following the climate change literature review which would allow the City to target the long-term goal of ensuring capacity for growth while addressing more emergent drainage and water quality issues in the meantime.	Low	Service	▪ Ensure stormwater system is aligned with the needs of a growing city and understand capacity for growth ▪ Prioritizing environmental resilience

** High priority describes overall priority for the Stormwater Capital Improvement Program. On the other hand, individual CIPs have been ranked so that each has a unique priority when compared to other CIPs (see Table 20).*

8.4. Funding

The stormwater utility receives its funding from the Stormwater Fund, which collects revenue from the stormwater utility fee paid by property owners. The stormwater utility issued long-term debt for the first time in FY 2021 for capital projects. The SMP recommends capital investment of more than $76 million over the next 20 years to address drainage issues, protect groundwater and surface water quality, and meet permit requirements for operating storm sewers and UICs. The costs of day-to-day stormwater operations and regulation of stormwater systems on private property have not been estimated in this plan; however, budgets for system operations, maintenance, and regulation can be expected to grow with increasing inventory of storm system assets, increasing growth in private development, and increasing regulation of the City.

Using cost inputs from the SMP, the City will study the cost of providing stormwater capital improvements and ongoing stormwater services to the community and assess how to align stormwater utility fees with City costs. See Appendix G for a preliminary financial analysis preceding the full study.

8.5. Adaptive Management

The SMP addresses numerous current stormwater issues and provides recommendations for some of the highest priority actions and policy considerations. During preparation of this plan, several questions and concerns arose which could not be addressed within the scope or schedule for preparing the plan. Some of the documented issues that have not been addressed in this plan include:

- Managing annexations from Deschutes County with no storm infrastructure. Deschutes County's stormwater regulations differ from Bend's. Urbanization on lands with little to no private or public storm infrastructure can lead to nuisance flooding and localized drainage concerns when properties annex to the city.
- Studying options for managing drainage, or lack thereof, in frozen conditions, or rain on ice conditions. Bend's climate produces frozen conditions that can block inlets to stormwater systems, leading to nuisance flooding and localized drainage concerns in the winter. There may be operational or design changes that could reduce flooding on streets related to frozen conditions.
- Managing the City's numerous outfalls that cross Bend Park and Recreation District (BPRD) property without easements for maintenance. Over the long term, the City needs to work with its partner, BPRD, to formalize permission to maintain outfall pipes that run under parks. Pipes need to be inspected, maintained, and improved to avoid surface impacts such as sink holes from breaks, to ensure capacity, and to improve quality of runoff discharging to the river.
- Assessing whether engineering design standards for low impact development stormwater facilities such as vegetated planters cause or contribute to maintainability issues that have been observed by staff.

The City should continue to adaptively manage its stormwater utility by periodically assessing the relative priority of this plan's recommendations, reviewing whether issues not addressed within this plan have increased in priority, collecting and prioritizing drainage complaints, and keeping abreast of changes to state and local priorities which may impact how the City plans for and manages stormwater.

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APPENDICES

Provided Separately

APPENDICES

Appendix A:

Memoranda, Reports, and Studies

Otak

Memorandum

To: Austin Somhegyi
From: Trista Kobluskie
Copies: Lori Faha, Brittany Barker, Elisabeth O’Keefe
Date: October 1, 2024
Subject: Bend Stormwater Master Plan Discovery Phase Summary
Project No.: 20359.000

Introduction

The City of Bend is updating its 2014 Stormwater Master Plan. The Stormwater Master Plan (SMP) Update will provide direction for the City’s stormwater utility system upgrades, system repair and replacement, operations and maintenance, and stormwater policy considerations. The plan will assess needs over the next 20 years.

This memorandum summarizes pertinent federal, state, and local regulations, summarizes the data collection phase of the master planning project, documents the identified known stormwater system issues, and recommends topics for further investigation for inclusion in the Stormwater Master Plan, such as a capital plan, programmatic solutions, and policy topics.

All maps are provided in Exhibit A.

Regulations

The City’s stormwater drainage system and related development and environmental activities are regulated by a suite of federal and state laws. City of Bend responds with codes, standards, policies, and plans as described below. These provide important context for the planning process and recommendations which will be documented in the Stormwater Master Plan.

NPDES MS4 Permit

The federal Clean Water Act of 1972 (CWA) created the National Pollutant Discharge Elimination System (NPDES) permit program to address sources of pollution in rivers, creeks, and streams. The program requires certain municipalities sizes to apply for and obtain a municipal NPDES permit for storm systems that discharge to rivers, streams, and other surface water bodies. In Oregon, these permits are administered by the Oregon Department of Environmental Quality (DEQ). These municipal NPDES permits, known as Municipal Separate Storm Sewer System (MS4) permits, are separated into two types based on jurisdictional sizes. Larger jurisdictions are managed under individual Phase I permits, while smaller jurisdictions are managed under general Phase II permits.

Bend applied for an individual MS4 Phase II permit in 2007 and is currently the only individual Phase II permittee in Oregon. The goal of receiving an individual permit was to respond to and manage unique drainage and regulatory conditions. Bend's MS4 Phase II permit was renewed in 2021 with an effective date of January 1, 2022, and will expire in 2026. Permits are issued for five-year periods. The MS4 permitted area ultimately drains to the Deschutes River.

The MS4 Permit guides many of Bend's stormwater management program's goals, policies, and day-to-day operations, and permit compliance represents a significant investment for Bend.

TMDL/303(d)

The CWA describes a program of Total Maximum Daily Loads (TMDLs) to protect water quality when other measures have failed. A TMDL establishes the limit of each pollutant that can be discharged to a water body in order for the water body to achieve or maintain water quality standards.

Under the CWA, DEQ is responsible for identifying waters that do not meet water quality standards (known as the 303(d) list). Water quality standards are intended to protect human health, aquatic life, and uses of waters for fishing, swimming, and other activities. DEQ is also responsible for calculating the allowable pollutant loads and developing water quality management plans, which allocate pollutant limits among dischargers and describe how a TMDL will be implemented.

As of 2024, there are no EPA approved TMDLs for the Deschutes River. The DEQ listed the Deschutes River as impaired on the 303(d) list and is in the process of developing TMDLs. The DEQ 2022 Integrated Report listed the following impairments for the Deschutes River near Bend:

- North Unit Diversion Dam to Whychus Creek – impaired for Flow Modification and Year-Round Temperature
- Spring River to North Unit Diversion Dam – impaired for Flow Modification, Habitat Modification, Turbidity, pH, Year-Round Temperature, and Sedimentation

The MS4 Permit requires Bend to evaluate whether stormwater discharges from Bend's MS4 system are likely to cause or contribute to these impairments, whether Bend is effective in addressing those pollutants, and if any changes or modifications are required.

WPCF Permit

The federal Safe Drinking Water Act (SDWA) regulates underground discharges in order to protect drinking water resources. These discharges are categorized by type of material being discharged; discharges related to stormwater are classified as Class V Underground Injection Controls (UICs). In Oregon, the DEQ is authorized to regulate Underground Injection Control (UIC) systems through Water Pollution Control Facilities (WPCF) permits to jurisdictions and property owners. Similar to the MS4 Permit, the WPCF Permits require jurisdictions to manage and operate public UICs in ways that are protective of water resources.

The DEQ issued Bend's first WPCF Permit in 2013 and re-issued the WPCF Permit in 2023. WPCF Permits are issued for ten years. The WPCF Permit requires Bend to identify UICs that may be out of compliance with groundwater quality protectiveness standards and develop a process to bring them into compliance. Bend's approximately 7,000 UICs consist of 6,000 drywells/sumps, which were designed to infiltrate stormwater, and 1,000 drill holes, which provide stormwater management but were not designed to do so.

Integrated Stormwater Management Plan

Bend's MS4 and WPCF Permits have similar requirements for managing public stormwater systems, including developing a management plan. Bend submitted an Integrated Stormwater Management Plan (ISMP) to DEQ in 2022 to meet the management plan requirements of both permits. The ISMP includes details on each of the best management practices required by each permit. Many of the best management practices required by each permit are similar, such as conducting public outreach and education, illicit discharge detection and elimination, construction site stormwater activities, post-construction stormwater management for new and redevelopment, and municipal operations and maintenance.

Statewide Planning Goals and Priorities

Oregon Administrative Rules 660 Division 15 establishes several Statewide Land Use Planning Goals. Goal 5 describes the protection of natural resources, including wetlands and riparian corridors. Statewide Planning Goal 6 describes the protection of air, water quality, and land resources quality, and Goal 7 describes protection of areas subject to natural disasters and hazards. Goal 11 describes the steps needed to plan utility infrastructure along with the growth of development (Oregon Department of Land Conservation and Development, 2019). These goals are addressed through the local jurisdictions' comprehensive plans and Bend's community development rules and standards.

Recent updates to Goal 10, Housing, along with other legislation has increased production goals for affordable housing, increased the type and variety of housing density possible within urban areas, and is requiring cities to evaluate how and where to increase housing density.

The Oregon legislature adopted climate-related pollution reduction goals in 2007. The Oregon Department of Land Conservation and Development (DLCD) adopted the Climate-Friendly and Equitable Community (CFEC) requirements to reduce climate pollution in 2022 and 2023. The DLCD adopted transportation planning rules that require certain jurisdictions to evaluate and update their standards and codes to create more walkable communities, which should reduce the volume of transportation-related emissions. The CFEC also includes requirements for annual reporting.

Bend Development Code Title 16

The Bend Community Development Department manages the application, plan review, permit issuance, construction inspection, and acceptance process for private development, including any development of public improvements required as a condition of development. The Community Development Department reviews against adopted standards to support statewide and local goals, such increasing the rate of completed housing production. The Engineering Division provides review of privately funded public improvements, such as stormwater infrastructure in the public right of way, and calculation of system development charges.

Title 16 of Bend municipal code includes the adopted requirements for grading, erosion control, stormwater, illicit discharge, tree protection, and well drilling. This title provides authority for Bend to establish minimum standards for new development and redevelopment on property or in the right of way. Bend has adopted the Central Oregon Stormwater Manual (COSM) as the design manual for stormwater in addition to Bend-specific Standards and Specifications (Bend City Code 16.05.040). The COSM was last updated in 2010, and Bend's Standards and Specifications were last updated in 2024.

Central Oregon Stormwater Manual

The Central Oregon Intergovernmental Council (COIC) supported jurisdictions in Central Oregon in collaborating to develop a regional stormwater manual. The COSM provides minimum standards for stormwater/drainage applicability, plan review, and guidance for stormwater management from design through construction. Jurisdictions subject to Phase II MS4 requirements can choose to adopt the COSM for use within their local development process. The COSM was completed in 2010 and include guidance for stormwater management systems that discharge to surface water or through soil systems to groundwater. The COSM will be updated in 2025 pursuant to the City's NPDES MS4 permit.

Sensitive Areas and Infiltration

The City establishes a Waterway Overlay Zone in Article V of Chapter 2.7, Special Planned Districts, Refinement Plans, Areas Plans and Master Plans, to preserve and enhance the Deschutes River and Tumalo Creek stream corridors within the urban growth boundary.

The City encourages use of infiltration to manage stormwater and provides tools to assist in implementing infiltration facilities on development project sites, including soil maps showing where infiltration may be favorable, maps and guidance for horizontal distance from drinking water wells, and maps of groundwater depths. These tools were last updated in 2020, and some are being updated in 2024 during the production of this memorandum. The latest available versions as of publication of the Stormwater Master Plan will be attached to the SMP as an Appendix. The SMP will provide recommendations for siting criteria and spill control requirements for deep drywells, which reach depths of up to 100 feet below ground.

Bend Climate Friendly Areas

Bend's response to CFEC has included changes to local codes and standards, in addition to the required annual reporting. Bend identified 10 potential Climate Friendly Areas (CFA) where additional public and private investment could result in walkable communities (Bend, 2023). Additional changes to code and standards will likely be necessary after the CFAs are finalized. Creating walkable communities will also help Bend meet housing unit targets and goals.

Core Area Redevelopment Programs and Plans

Bend has identified three areas where tax increment financing may be used to reinvest or rebuild parts of the City that have deteriorated: Core Area, Juniper Ridge, and Murphy Crossing. The City plans for much of the future housing and employment growth to be contained within the Core Area. Several infrastructure improvement projects are planned for the Core Area, to improve utility services, improve public safety, and improve connection to downtown Bend. The City plans to partner with and offer support to private and non-profit entities to improve both housing and business development opportunities in the Core Area; support options identified in the Tax Increment Finance Plan include, but are not limited to, off-site infrastructure improvements which could involve stormwater drainage and facilities (Ordinance No. 2379, 2020).

SMP Discovery Stage Process

The discovery phase began with a review of existing information pertaining to the stormwater infrastructure and stream systems within the planning area. This information includes stormwater reports, stormwater infrastructure plans, records of flooding and drainage issues, City's staff's individual informal records of issues, and community plans. Additionally, City of Bend staff provided several known issues derived from city resident correspondence. Exhibit B contains a comprehensive annotated list of documents provided by the client and reviewed by Otak staff.

The existing information review was supplemented by meetings with City of Bend staff to collect additional background knowledge and discuss known issue locations for the stormwater infrastructure and stream corridors in the planning area. These meetings consisted of a virtual kickoff meeting on February 8, 2024, virtual workshops on April 2, 2024 and July 9, 2024, an in-person workshop March 7, 2024, and site visits to known issue locations on April 18, 2024 and April 19, 2024.

Collect and Categorize Issues

The information about issues in the storm system collected during the discovery phase was compiled and classified in an ESRI geodatabase. The geodatabase was composed of a collection of geographic points that identify the location of known issues. The schema for the geodatabase is provided in Exhibit C.

Identifying known issues was the first step in the process of studying the storm system and developing solutions. Each known issue was given a unique identification number in the geodatabase. Additional fields provided descriptive information about the issue, such as the full name of the issue, a long description of the nature of the issue, as well as a field for any supplemental notes from site visits. A group of fields were included to indicate if the known issue was primarily related to drainage, condition, maintainability, erosion, groundwater quality, or surface water quality. Table 1 shows the number of issues that fall into each category.

Table 1 Count of Known Issues by Type

Type of Issue	Count	Description
Drainage	51	Drainage issues include ponding and flooding on streets and private properties where the drainage system is inadequate, damaged, or is not present
Water Quality-Groundwater	18	Groundwater quality issues are identified where underground injection controls such as drillholes and drywells may pose a contamination risk to groundwater because they are located over the aquifer or do not have a spill control structure
Condition	7	Condition issues are identified when the drainage system or stormwater facility is in a damaged condition
Water Quality-Surface Water	7	Surface water quality issues are identified where outfalls to the Deschutes River have been prioritized for retrofit by analyzing pollutant characteristics of the drainage area
Maintainability	5	Maintainability issues are identified where the drainage system or stormwater facilities is difficult or dangerous for City staff to maintain due to location, design, or condition
Erosion	1	Erosion issues are identified where stormwater flows over denuded or sparsely vegetated landscaped or natural areas and deposits eroded soils into streets, catch basins, UICs, or other elements of the drainage system
Total	**89**	

Figure 1 Count of Known Issues by Primary Type

About half of the Known Issues have a secondary issue type which contributes to the problem. The most frequent combination is a groundwater quality issue paired with an infrastructure condition issue. Most of these are drillholes that may pose a risk to water quality because they are located over the aquifer and have been damaged by long-term sediment build-up which impacts their function.

Table 2 Frequency of Primary and Secondary Issue Type Combinations

Primary Issue Type	Secondary Issue Type								Grand Total
	No Secondary Issue Type	Condition	Erosion	Drainage	Water Quality-Groundwater	Maintainability	Sedimentation	Water Quality-Surface Water	
Drainage	35	2	10		2	1	1		51
Water Quality-Groundwater		17						1	18
Water Quality-Surface Water	7								7
Condition	4			2		1			7
Maintainability	3	2							5
Erosion				1					1
Grand Total	**49**	**21**	**10**	**3**	**2**	**2**	**1**	**1**	**89**

To further describe some of the known issues, City of Bend staff selected approximately a dozen sites to visit over two days in April 2024. The Otak project manager and two project engineers accompanied staff to locations exemplifying issues related to drainage, erosion, water quality, and maintenance/easement access as well as typical examples of City and private stormwater infrastructure. Field notes and photographs are included as Exhibit D.

Early Studies

Additionally, three studies were conducted in conjunction with the Stormwater Master Plan data collection phase: a study to suggest siting criteria for modified (deep) drywells and locations of drillholes that pose the highest risk to groundwater, a study to identify the City's outfalls to the Deschutes River that are most in need of retrofit, and research into impacts of climate change on the stormwater system. These studies have identified additional potential capital improvement projects and will help inform the decision-making process as recommendations for the master plan take shape.

Solutions

In subsequent planning steps, Otak will screen all known issues and propose a solution concept for most known issues. A solution could be a large capital project, a program, or a policy update.

Known issues that are candidates for large capital improvement projects (CIPs) will be studied and further developed in a subsequent planning step. The final list of potential projects will be rated and ranked to select CIPs.

Programs are groups of similar small and medium projects that are tackled gradually over time with fixed yearly funding. Most of the known issues will be grouped into programs that will enable the City of Bend staff to address stormwater needs that require attention but do not rise to the scale or priority level of a capital project. Some programs have already been defined in the City of Bend Stormwater Master Plan 2014. In addition to these, Otak will propose to develop a handful of new programs to address common problems among the known issues. Known issues that are program candidates will be identified in the Known Issues Geodatabase by a text field called "Program" and by a numeric field called "Program ID."

A complete list of known issues in the geodatabase is provided in Exhibit E. To support the known issue identification and solutions analysis, various supporting data were collected and mapped, including a vicinity map, natural resources, and the collected known issues (Exhibit A).

Exhibit A

Maps

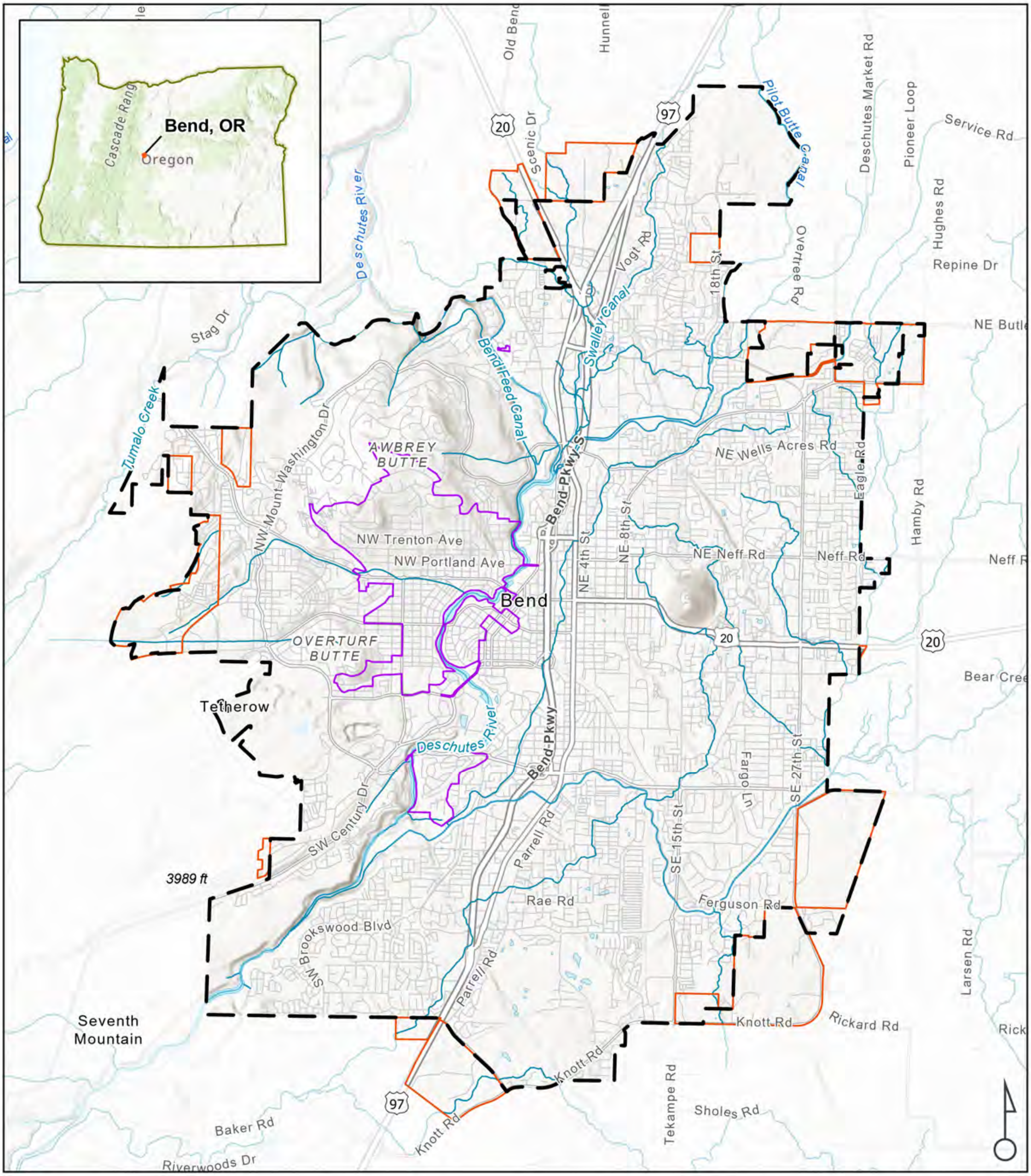


FIGURE 1
VICINITY MAP
BEND STORMWATER MASTER PLAN
BEND, OREGON

Data Sources: City of Bend, USGS, Google Maps.
Date: 9/13/2024
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

LEGEND

- City Limits
- UGB Expansion Areas
- MS4 Basin Delineation
- Streams

Mile
0 0.5 1

O:\PROJECT\20300\20359\04 CAD\GIS\APRX\20359 BEND OUTFALL STUDY\20359 BEND OUTFALL STUDY JR\20359 BEND OUTFALL STUDY JR.APRX

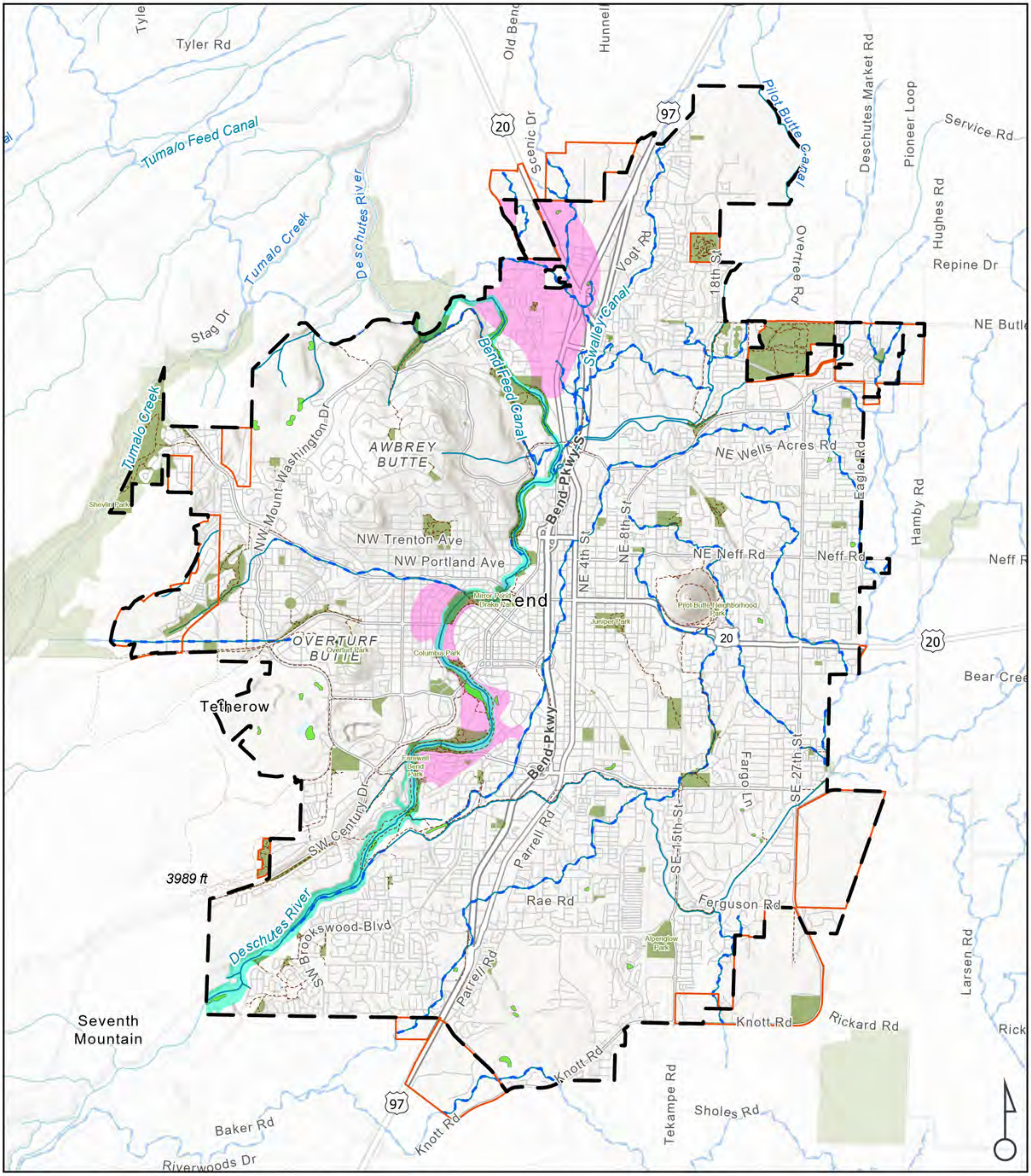


FIGURE 2

NATURAL RESOURCES

BEND STORMWATER MASTER PLAN

BEND, OREGON

Data Sources: City of Bend, USGS, Google Maps.
Date: 9/13/2024
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

LEGEND

- City Limits
- UGB Expansion Areas
- Streams
- Canal/Ditch
- Paths & Trails
- Parks
- Local Wetlands Inventory
- Waterway Overlay Zone
- Perched Aquifer

0 0.5 1 Mile

O:\PROJECT\20300\20359\04 CAD\GIS\APRX\20359 BEND OUTFALL STUDY\20359 BEND OUTFALL STUDY JR\20359 BEND OUTFALL STUDY JR.APRX

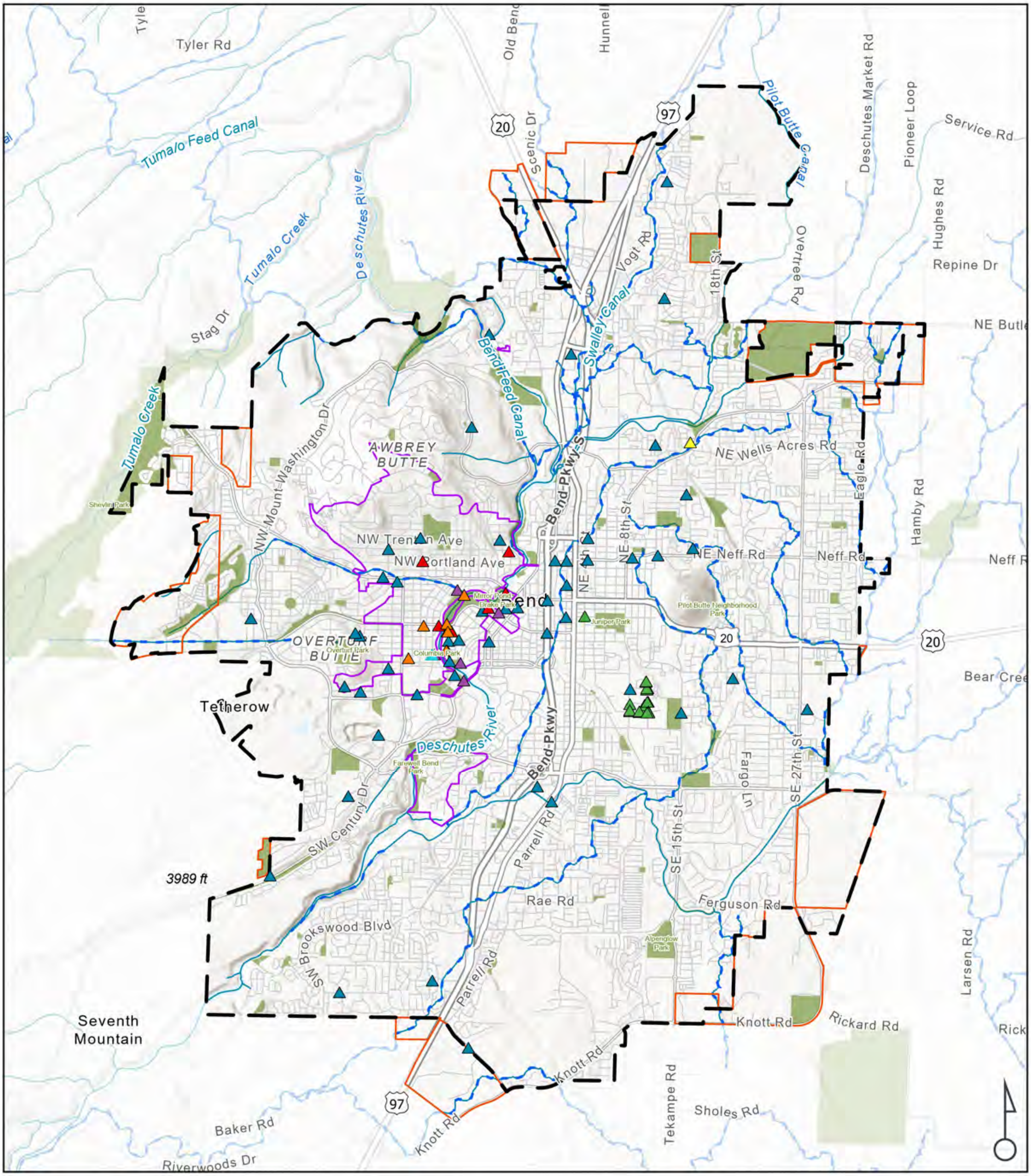


FIGURE 3

STORMWATER KNOWN ISSUES

BEND STORMWATER MASTER PLAN

BEND, OREGON

Data Sources: City of Bend, USGS, Google Maps.
Date: 9/13/2024
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

LEGEND

- City Limits
- UGB Expansion Areas
- MS4 Basin Delineation
- Streams
- Canal/Ditch
- 🟩 Parks

Stormwater Known Issue

- ▲ Drainage
- ▲ Water Quality-Surface Water
- ▲ Water Quality-Groundwater
- ▲ Maintainability
- ▲ Condition
- ▲ Erosion
- ▲ Sedimentation

BEND Otak

O:\PROJECT\20300\20359\04 CAD\GIS\APRX\20359 BEND OUTFALL STUDY\20359 BEND OUTFALL STUDY JR\20359 BEND OUTFALL STUDY JR.APRX

Exhibit B

Annotated Bibliography

Otak

City of Bend Stormwater Master Plan
Annotated Bibliography
September 27, 2024

Title	Date	Author	Annotation
Ambient River Water Quality Monitoring: 2008-2020 for City of Bend	2021-10-01	Environmental Science Associates	From 2004 to 2020, Bend monitored water quality at 12 sampling locations in the Deschutes River and one location along Tumalo Creek. Study objectives were to understand seasonal and annual variations in water quality, meet NPDES permit requirements, provide data to support listing or de-listing waters from the 303(d) list and to aid in establishing TMDLs, and provide information about sediment issues in Mirror Pond. The report summarizes monitoring studies conducted between 2004 and 2017 and builds upon them by analyzing the data collection between 2018 and 2020. The study may indicate the following issues remain or are present: temperature in the Deschutes River, pH in both Deschutes River and Tumalo Creek, dissolved oxygen during spawning periods, specific conductance in both. Recommendations for additional monitoring parameters and frequences are given.
CCTV Reports (2023)	2023-07-13	City of Bend	Otak collected notes from an in-person presentation and reviewed informal City staff notes on maps of several outfalls and their drainage systems which the City inspected by closed circuit television in 2023. The notes were used to document known pipe condition issues.
Central Oregon Stormwater Manual	2010-08-01	Central Oregon Intergovernmental Council	Adopted by Bend and other communities in Deschutes and Crook Counties, the COSM gives thresholds for stormwater management applied to development sites and requirements for submittals, site characterization, water quality treatment, flow control, conveyances, erosion and sedimentation control, source control, and operation and maintenance of stormwater systems, as well as recommendations for use of site design and low impact development techniques.
Climate Friendly Areas Study	2023-12-01	City of Bend	Prepared by City of Bend with assistance from consultants 3J Consulting and ECONorthwest, the Climate Friendly Areas Study was prepared in response to the State of Oregon's Climate Friendly and Equitable Communities rule. The study identifies ten candidates for a designated "Climate Friendly Area", defined as an area where residents can live, work, and meet most of their daily needs without the use of a vehicle. The study results are pertinent to the investigation of density in Bend and how stormwater standards impact ability to densify.
Core Area Tax Increment Finance Plan, Ordinance No. 2379	2020-08-19	City of Bend	This document describes the types of support City of Bend may provide in the effort to redevelop the Core Area. The plan is pertinent to the investigation of density in Bend and how stormwater standards impact ability to densify.

City of Bend Stormwater Master Plan
Annotated Bibliography
September 27, 2024

Title	Date	Author	Annotation
Emerging Pollutant Evaluation for Individual Underground Injection Control Permit Renewals	2022-09-28	GSI Water Solutions	Evaluates risk to groundwater drinking sources from emerging pollutants injected into groundwater via underground injection controls of stormwater. It identifies seven emerging pollutants as posing the highest risk to degrade groundwater: PFAS, diuron, fipronil, atrazine, simazine, 2,4-D, and 4-nonylphenol. The emerging pollutant that potentially poses the highest risk of degrading groundwater quality is PFAS because it is highly mobile, highly persistent, and highly toxic to humans.
Groundwater Protectiveness Demonstration Update for Per- and Polyfluoroalkyl Substances (PFAS), City of Bend, Oregon	2024-04-10	GSI Water Solutions	The memorandum summarizes an update to the City of Bend's 2011 Groundwater Protectiveness Demonstration based on modeling the environmental fate of per- and polyalkyl substances (PFAS) and simazine in stormwater discharges from UICs. These new and emerging pollutants of concern have been identified as concerns to groundwater since 2011, and the United States has adopted a maximum contaminant levels in drinking water, which may be applied to stormwater discharging to UICs. The study findings are being used by the City to update vertical and horizontal setbacks of UICs.
Integrated Stormwater Management Program Document 2023	2023-11-01	City of Bend	Documents the City's plans to manage stormwater to comply with federal/state permits for drinking water and surface water protection. The documented actions should minimize pollutants that reach the groundwater or Deschutes River via stormwater. The regulations, permits, and compliance actions provide important context and boundaries for the Stormwater Master Plan.
MS4 Phase II Individual Permit issued to City of Bend, Permit No. 102901	2021-12-15	Oregon DEQ	Issued by Oregon DEQ, the Phase II permit authorizes City of Bend to discharge stormwater runoff through outfalls to surface waters such as the Deschutes River by conforming to permit conditions. The permit requires maintenance and operation of the City's stormwater system, regulation of development to provide stormwater management, regulation of discharges into the City's system, and other requirements. The 2022 MS4 Permit includes significant changes related to water quality treatment requirements for new and redevelopment. The permit provides important context and boundaries for the Stormwater Master Plan.
Pollutant Fate and Transport Model Results in Support of City of Bend UIC WPCF Permit - Groundwater Protectiveness Demonstration and Proposed EDLs Technical Memorandum	2011-09-21	GSI Water Solutions	The groundwater protectiveness study was prepared to support City of Bend's initial application for a UIP WPCF Permit from Oregon DEQ in 2011. The study modeled expected groundwater recharge from UICs and studied the protectiveness of UICs discharging in the vicinity of drinking water wells by modeling discharge of eight pollutants. City of Bend used the study results to set requirements for separation of UICs from water wells in code.

City of Bend Stormwater Master Plan
Annotated Bibliography
September 27, 2024

Title	Date	Author	Annotation
Priority Issues - Stormwater Flooding Reports Levels 1-3	2021-2024	City of Bend	This set of selected work orders about high consequence or high frequency drainage complaints and responses dating between approximately 2021 and 2024 was provided by City Utilities Maintenance staff and has been sorted into priorities 1, 2, and 3. These are entered as known issues in the stormwater master plan geodatabase. These documents are unpublished work product from City of Bend.
South Awbrey Butte Drainage Study Alternative Analysis	2017-05-15	Brian Wilkinson/ HDR Engineering	The study identified existing drainage issues on the south side of Awbrey Butte, approximately a 500 acre area, to document their impacts, and propose alternatives.
South Awbrey Butte Drainage Study: Final Improvement Plan	2017-10-17	HDR Engineering	Longstanding drainage issues on the south side Awbrey Butte extending from College Way to 9th Street and from Newport Avenue to the summit inconvenience residents, pose public health hazards to the driving public, and require disproportionate City resources to manage. The Final Improvement Plan lists the prioritized stormwater recommendations. As of 2024, the recommendations along Newport Avenue have been implemented along with a major road corridor improvement. Other project recommendations may be included in the Stormwater Master Plan.
Stormwater Infiltration Evaluation Update	2020-10-01	GSI Water Solutions	The report updates tools the City uses on a planning level to guiding siting, maintenance, and retrofit of UIC facilities such as drywells and drillholes. Updates include, drainage area maps, drainage area characteristics, an aging evaluation of UICs, updated water well location database, and potential perched groundwater map. The SMP will make use of the updated drainage area maps and aging evaluation in particular to inform recommendations.
Stormwater Master Plan (2014)	2014-07-01	URS	The 2014 Stormwater Master Plan is a source of information about geology, geography, and the City's stormwater management system, as well as a source of information about past issues and projects. Remaining issues from this plan - if still relevant - are carried over in the current plan.
Summary of Supporting Information for the City of Bend Stormwater Design Standards Update	2022-09-30	Brown and Caldwell	The memorandum summarizes a stormwater gap analysis of the Central Oregon Stormwater Manual (COSM) to the MS4 permit, source control and site planning research, and pervious pavement research conducted by Brown & Caldwell. The memo identifies gaps in the COSM related to thresholds for providing stormwater management, need to prioritize infiltration and green infrastructure, and need to develop a numeric stormwater retention requirement.

City of Bend Stormwater Master Plan
Annotated Bibliography
September 27, 2024

Title	Date	Author	Annotation
System-Wide Assessment: Individual WPCF Permit for Class V Underground Injection Control Systems, Permit No. 103052	2023-03-27	GSI Water Solutions	The 2023 assessment is an update to the 2012 assessment and was prepared to comply with the City's UIC WPCF Permit from Oregon DEQ. UICs are a key stormwater management tool for the City, which owns approximately 6,500. The outcome is to inventory and assess risk to groundwater from existing municipal UICs.
UIC Lifespan Analysis	2011-08-05	GSI Water Solutions	The 2011 UIC lifespan analysis reported on UIC lifespan in the cities of Bend and Redmond, Oregon. Infiltration tests were conducted at 130 UICs. The study concludes that infiltration capacity of drywells in Bend declines by 8 gpm/yr and the capacity of both drywells and drillholes declines by 7 gpm/yr in Redmond.
Water Management and Conservation Plan	2021-09-01	GSI Water Solutions	The City operates a public drinking water system that draws from the Bend Municipal Watershed (BMW), and groundwater from the Deschutes Regional Aquifer. The dual water sources are valuable. Effective water management and implementation of conservation measures can reduce water consumption, delay the need to develop additional water supplies, and reduce the volume of new water needed. Two private water utilities also serve areas within the City limits and UGB. Surface water provides approximately half of the City's annual water supply; groundwater provides the other half. The report describes measures to ensure adequate supply and conserve drinking water.
Water Pollution Control Facilities Permit For Class V Stormwater Underground Injection Control Systems, Permit No. WPCF-DOM-UIC-103052	2013-05-14	Oregon DEQ	Effective from May 14, 2013 to April 30, 2023 and administratively extended (current as of September 2024), the UIC WPCF permit authorizes the City to discharge stormwater to groundwater through drill holes, drywells, and other types of UICs. It applies to the approximate 6,500 UICs operated by the City. The permit is issued by Oregon DEQ to implement the Federal Safe Drinking Water Act requirements for UICs.

Appendix C

Geodatabase Schema

Bend Stormwater Master Plan
Geodatabase Schema
September 30, 2024

Feature Class	Geometry	Attributes:							
Known Issues	point	Field	KI_ID	FullName	IssueType_Primary	IssueType_Secondary	InfoSource	LongDesc	Last_Occur_Yr
"Known_Issue_P"		Alias	*Known Issue ID*	*Full Name*	*Issue Primary*	*Issue Secondary*	*Information Source*	*Long description*	*Last Year of Issue Occurrer*
		Format	Text, 15	Text, 100	Text, 36 - Domain	Text, 36 - Domain	Text, 50	Text, 3000	Text, 4
Represents known issues points collected during the discovery phase of the Stormwater Master Plan (SMP) planning process that began in 2024. Includes issues from past planning processes that are still active and unsolved.		Content	Unique ID for the known issue. All known issues are recorded as point features. Example KI-01.	Full name of the issue	Documents the primary issue, including such values as domain values should be: "Drainage", "Water Quality - Surface Water", "Water Quality - Groundwater", "Maintainability", "Condition"	Documents the secondary issue, including such values as Domain values should be: "Drainage", "Water Quality - Surface Water", "Water Quality - Groundwater", "Maintainability", "Condition"	Category of source (i.e. interview, previous study, existing data)	A long description of the issue and the nature of the issue.	A 4 digit text field for last year of known issue occurrence.
Existing Projects	point	Field	City_Proj_ID	Proj_Name	Proj_Desc	Proj_Location	Proj_Type	Completion	Proj_Sourc
"Existing_Projects_P"		Alias	*City Project ID*	*City Project Name*	*Project Description*	*Project Location*	*Project Type*	*Completion*	*Project Source*
		Format	Text, 24	Text, 70	Text, 1500	Text, 80	Text, 50	Text, 9	Text, 50
Represents projects and project concepts advanced by the City of Bend to address stormwater known issues prior to the Stormwater Master Plan (SMP) planning process that began in 2024. Includes only projects that have not gone to construction as of 2024.		Content	Unique ID given to the project by the City in its CIP or previous planning documents.	Full name of the project	Description of the project from CIP or previous planning document.	Brief description of address or intersection.	Project category.	Year of planned or actual implementation of project. If spanning more than one year, choose year when major work will be complete.	Source of information about the project, usually a prior planning effort
Potential Projects	point	Field	PP_ID	Proj_Name	Proj_Description	Proj_Rank	Category	CIP_ID	ProgramID
"Potential_Projects_P"		Alias	*Potential Project ID*	*Project Name*	*Project Description*	*Project Rank*	*Category*	*CIP_ID*	*Program ID*
		Format	Text, 10	Text, 255	Text, 3000	Long Int	Text, 64	Long Int	Short Int
Represents preliminary project concepts to address known issues. May include existing project concepts developed under different planning efforts if they need concepts and costs further developed under the SMP.		Content	Unique ID for the potential project. All potential projects developed by Otak during the SMP planning process are documented as point features. Example "PP-1."	Name of the potential project	A long description of the project concept	Rank of the potential project after scoring. Not all projects are scored and ranked.	General project type (Water Quality, Quantity, Conveyance Capacity, Maintenance/ Replacement)	Unique ID for the CIP number given to the potential projects. Only given to those potential projects that advance onto the SMP CIP or have already been assigned a CIP number by City of Bend under a different capital planning process.	Potential projects are often sorted and grouped into operational programs. ID number of the program.

Bend Stormwater Master Plan
Geodatabase Schema
September 30, 2024

Feature Class	Geometry	Attributes:							
Known Issues	point	Field	Frequency	Issue_Sev	Status	Issue_Owner	Program	ProgramID	PP_ID
"Known_Issue_P"		Alias	*Issue Frequency*	*Issue Severity*	Status	Issue Ownership	*Program*	*Program ID*	*Potential Project ID*
		Format	Text, 50	Text, 50	Text, 24 - Domain	Text, 48 - Domain	Text, 128	Short Int	Text, 32
Represents known issues points collected during the discovery phase of the Stormwater Master Plan (SMP) planning process that began in 2024. Includes issues from past planning processes that are still active and unsolved.		Content	A text description of known issue frequency.	A text description of known issue severity.	Documents the status of the known issue, including such values as active, solved, solution in progress, unconfirmed, and inconsequential	Documents whether known issue is the responsibility of the client (using value "City") or is the responsibility of a private party, another public agency, or unknown responsibility.	Issues are often sorted and grouped into operational programs. Name of the program.	Issues are often sorted and grouped into operational programs. ID number of the program.	Issues that can be solved with a capital construction project are documented in the "Potential Projects" point feature class. PP_ID is the unique identifier given to the corresponding project in the Potential Projects feature class, and it acts as a secondary key in this, the "Known Issues" feature class.
Existing Projects	point	Field	Proj_Owner	Proj_Status	Otak_Notes	CreatedUser	CreatedDate	LastEditedUser	LastEditedDate
"Existing_Projects_P"		Alias	*Project Owner*	*Project Status*	*Otak Notes*	*Created User*	*Created Date*	*Last Edited User*	*Last Edited Date*
		Format	Text, 50	Text, 24	Text, 1500	Automated	Automated	Automated	Automated
Represents projects and project concepts advanced by the City of Bend to address stormwater known issues prior to the Stormwater Master Plan (SMP) planning process that began in 2024. Includes only projects that have not gone to construction as of 2024.		Content	Brief description of project owner; often is the City department that is advancing the project.	A text description of the project's status.	Freeform notes field for Otak	Person/Agency who created the point - automated	XX/XX/XXXX - automated	Person/Agency who updated the point - automated	XX/XX/XXXX - automated
Potential Projects	point	Field	Program	KI_ID_01	KI_ID_02	KI_ID_03	KI_ID_04	KI_ID_05	Solution_Type
"Potential_Projects_P"		Alias	*Program*	*KI_ID_01*	*KI_ID_02*	*KI_ID_03*	*KI_ID_04*	*KI_ID_05*	*Solution Type*
		Format	Text, 64	Long Int	Long Int	Long Int	Long Int	Long Int	Text, 10, Domain List
Represents preliminary project concepts to address known issues. May include existing project concepts developed under different planning efforts if they need concepts and costs further developed under the SMP.		Content	Potential projects are often sorted and grouped into operational programs. Name of the program.	Unique ID of the first Known Issue associated with the potential project	Unique ID of the second Known Issue associated with the potential project	Unique ID of the third Known Issue associated with the potential project	Unique ID of the fourth Known Issue associated with the potential project	Unique ID of the fifth Known Issue associated with the potential project	Domain: Solution Type, List: Project, Program, Study, Other

Bend Stormwater Master Plan
Geodatabase Schema
September 30, 2024

Feature Class	**Geometry**	**Attributes:**							
Known Issues	point	Field	CIP_ID	City_Priority	FileLocationLink	CreatedUser	CreatedDate	LastEditedUser	LastEditedDate
"Known_Issue_P"		Alias	*CIP ID*	*City Priority*	*File Location Link*	*Created User*	*Created Date*	*Last Edited User*	*Last Edited Date*
		Format	Short Int	Short Int	Text, 120	Automated	Automated	Automated	Automated
Represents known issues points collected during the discovery phase of the Stormwater Master Plan (SMP) planning process that began in 2024. Includes issues from past planning processes that are still active and unsolved.		Content	Potential Projects which have been selected as capital improvement projects (CIP) in the plan are given a unique CIP_ID in the "Potential Projects" point feature class. CIP_ID acts as a secondary key in this, the "Known Issues" feature class.	City Utilities Operations staff prioritized a subset of the known issues provided to the consultant from one to three. This field documents the priority for the known issues that were given one by City Utilities Operations staff.	A hyperlink to the location of any corresponding files or resources on the Otak network drive.	Person/Agency who created the point - automated	XX/XX/XXXX - automated	Person/Agency who updated the point - automated	XX/XX/XXXX - automated

Existing Projects	point	Field
"Existing_Projects_P"		Alias
		Format
Represents projects and project concepts advanced by the City of Bend to address stormwater known issues prior to the Stormwater Master Plan (SMP) planning process that began in 2024. Includes only projects that have not gone to construction as of 2024.		Content

Potential Projects	point	Field	ProjStatus	Otak_Notes	CreatedUser	CreatedDate	LastEditedUser	LastEditedDate
"Potential_Projects_P"		Alias	*Project Status*	*Otak Notes*	*Created User*	*Created Date*	*Last Edited User*	*Last Edited Date*
		Format	Text, 64	Text, 500	Automated	Automated	Automated	Automated
Represents preliminary project concepts to address known issues. May include existing project concepts developed under different planning efforts if they need concepts and costs further developed under the SMP.		Content	Project status with respect to either implementation or the SMP planning process.	Freeform notes field for Otak	Person/Agency who created the point - automated	XX/XX/XXXX - automated	Person/Agency who updated the point - automated	XX/XX/XXXX - automated

Exhibit D

Field Notes

April 18-19, 2024

Bend Stormwater Master Plan
Site Visit to Archie Briggs Road, Mt. Washington, and Sylvan Park (driving through only)
April 18, 2024
TMK

No photos taken at these locations

Archie Briggs low point drainage issues – drive through (this is northern side of Awbrey Butte)

- The area lacks drainage
- From here the river starts into the canyon
- Developments are 5 acre – ish conversions of farm
- Across river a private property on north side of Archie Briggs sits below road grade and gets flooded

Mt. Washington

- On Mt. Washington, are the culverts outfalls? Lori is defining the culverts leading to typically dry ravines as culverts, not as outfalls to surface waters
- Mt. Washington is a major arterial. There are one-off drywells. The pink tuff soil is visible in the road cuts

Sylvan Park

- Sylvan Park is at the top of Awbrey Butte
- BPRD split from City of Bend in the 1970s.
- Stormwater infrastructure in Parks were not formally transferred to BPRD and easements for City maintenance and inspection were not established.

Bend Stormwater Master Plan
Site Visit to Central Oregon Community College along College Way (driving through only)
April 18, 2024
TMK

Agenda: Awbrey Butte Drive Around: take Mt Washington around Awbrey Butte to College Way to discuss north/south butte drainage issues. Stop at Sylvan Park at top of butte. College Way has a lot of private runoff to public ROW.

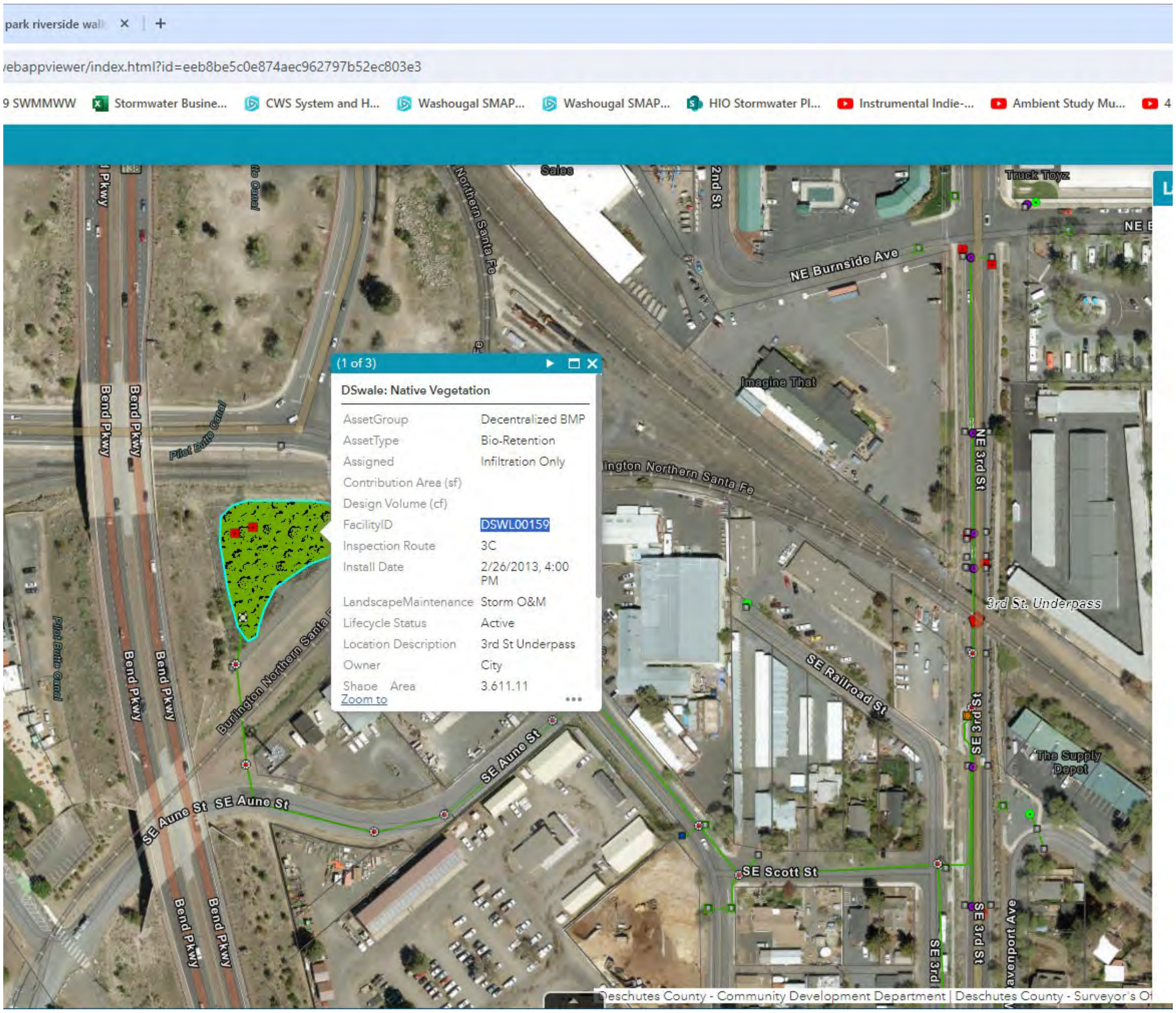
Notes

- No photos taken
- Central Oregon Community College (COCC) has a lot of drainage issues. Grades are steep and contribute sediment to the ROW.
- Could the City partner with the college to control sediment?
- City’s Awbrey Butte Waterline Project will also add drywells, but there will be a risk of clogging from sediment.

Bend Stormwater Master Plan
Site Visit to Central Core (driving through only)
April 18, 2024
TMK

Notes:

- No photos taken.
- The older commercial developments look run down. Some amount of open poverty seen on streets.
- City has a plan for redevelopment into mixed use. Zero lot line development allowed, so not much room for on-site stormwater.
- A pedestrian bridge over the Parkway has been funded
- Regional stormwater solutions would be helpful to spur redevelopment. Stormwater tree wells, green streets could also work.
- 3rd Street Underpass, which used to flood, has 2 stormwater pump stations that pump to the "Colorado Swale".



(1 of 3)

DSwale: Native Vegetation

AssetGroup	Decentralized BMP
AssetType	Bio-Retention
Assigned	Infiltration Only
Contribution Area (sf)	
Design Volume (cf)	
FacilityID	DSWL00159
Inspection Route	3C
Install Date	2/26/2013, 4:00 PM
LandscapeMaintenance	Storm O&M
Lifecycle Status	Active
Location Description	3rd St Underpass
Owner	City
Shape Area	3.611.11

Zoom to

Bend Stormwater Master Plan
Site Visit to Newport Outfall
April 18, 2024
TMK, PK

Agenda: Newport Corridor Project: project elements, walking tour, outfall to mirror pond

Notes

- The new Newport outfall is the only modern outfall in the city
- There is flow monitoring. Big event on June 3, 2022
- Staff commented on the LID facilities.
    - Curb cuts are "useless" because of the sand. The LIDs need forebays that can be cleaned.
    - Planters need mulch – they are bare soil.
    - Design standards for LID facilities are missing or sparse or not well conceived for the on-the-ground realities
- The Contech StormFilter vault at NW Nashville and NW Columbia – staff likes this system
    - O/W separator is integrated
- The StormFilter vault at NW Nashville & Federal – staff does NOT like this system
    - Very difficult access
    - *Lori suggested this location as a retrofit project*
- The StormFilter vault with the diamond doors has no pretreatment and receives runoff from a large basin. The manhole has no sump
    - *Lori suggested this location as a retrofit project*
- When Otak suggested replacing media with ZPG to remove phosphorus or possibly PFAS, Lori said City is more concerned with sediment.
- Regarding StormFilters:
    - The (public) City currently has 135 cartridges (total), and they receive inspections about every 6 months.
    - From Troy: It's about $25,000 for the manufacturing and shipping of a full replacement set of 135 – this does not include labor for installation.

Bend Site Visit April 18, 2024
Newport Outfall Site
Photographs by Karina Nordahl, Trista Kobluskie, Phil Kenyon

File Name	Location
Alternative_Access_Hatch_Lid.jpg	Alternative_Access_Hatch_Lid
Alternative_Access_Hatch_Lid_2.jpg	Alternative_Access_Hatch_Lid_2
Alternative_Access_Hatch_Lid_3.jpg	Alternative_Access_Hatch_Lid_3
IMG_0227	Newport Ave, near maxwell system
IMG_0228	Newport Ave, near maxwell system
IMG_0229	Newport Ave stormwater outfall, newly constructed
IMG_0230	Newport Ave stormwater outfall, newly constructed
IMG_0231	Stormfilter catchbasins, newly constructed
IMG_0232	Stormfilter catchbasins, newly constructed
IMG_0233	Stormfilter vault, very difficult to access (near school)
IMG_0234	Stormfilter vault, manhole access (near school)
IMG_0235	Stormfilter vault, hatch acess (near vault)
IMG_0236	Stormfilter vault, manhole access (near school)
IMG_1771	Newport Outfall
IMG_1772	Newport Outfall
IMG_1773	Newport Outfall
IMG_1774	StormFilters upstream of Newport Outfall
IMG_1775	StormFilters upstream of Newport Outfall
IMG_1776	StormFilters upstream of Newport Outfall
IMG_1777	StormFilters upstream of Newport Outfall
IMG_1778	StormFilters upstream of Newport Outfall
IMG_1779	StormFilters upstream of Newport Outfall
IMG_1780	StormFilters upstream of Newport Outfall
IMG_1781	StormFilters upstream of Newport Outfall
IMG_1782	StormFilters upstream of Newport Outfall
Newport_Ave_Stormfilter_vault.jpg	Newport_Ave_Stormfilter_vault
Newport_Ave_Stormfilter_vault_2.jpg	Newport_Ave_Stormfilter_vault_2
Newport_Outfall_New.jpg	Newport_Outfall_New
Newport_Outfall_Old.jpg	Newport_Outfall_Old
Newport_Outfall_Old_2.jpg	Newport_Outfall_Old_2
Newport_Outfall_Towards_River.jpg	Newport_Outfall_Towards_River
Planter_Near_Newport_Outfall.jpg	Planter_Near_Newport_Outfall
Planter_on_corner_Showing_Curb_Damage.jpg	Planter_on_corner_Showing_Curb_Damage
Planter_on_corner_Showing_Curb_Damage_2.jpg	Planter_on_corner_Showing_Curb_Damage_2
Roadside_Planters_Curb_Cut_Inlets.jpg	Roadside_Planters_Curb_Cut_Inlets
Roadside_Planters_Overflow_Rock_Planter.jpg	Roadside_Planters_Overflow_Rock_Planter

Alternative_Access_Hatch_L...

Alternative_Access_Hatch_Lid

Alternative_Access_Hatch_L...

IMG_0227

IMG_0228

IMG_0229

IMG_0230

IMG_0231

IMG_0232

April 18-19, 2024 - Newport Outfall Site

IMG_0233

IMG_0234

IMG_0235

IMG_0236

IMG_1771

IMG_1772

IMG_1773

IMG_1774

IMG_1775

April 18-19, 2024 - Newport Outfall Site

IMG_1776

IMG_1777

IMG_1778

IMG_1779

IMG_1780

IMG_1781

IMG_1782

Newport_Ave_Stormfilter_va...

Newport_Ave_Stormfilter_vault

April 18-19, 2024 - Newport Outfall Site

Newport_Outfall_New

Newport_Outfall_Old_2

Newport_Outfall_Old

Newport_Outfall_Towards_River

Planter_Near_Newport_Outfall

Planter_on_corner_Showing_Curb_Damag...

Roadside_Planters_Curb_Cut_Inlets

Planter_on_corner_Showing_Curb_Damage

Roadside_Planters_Overflow_Rock_Planter

April 18-19, 2024 - Newport Outfall Site

Roadside_Planters_Overflow_Rock_Planter

Bend Stormwater Master Plan
Site Visit to Deep Drywell (Maxwell)
April 18, 2024
TMK, PK

Agenda: Maxwell deep drywell on NW 15th

Notes:

- The City has one Maxwell deep drywell – the site visit team went to visit it. This was installed in 2023. It has a 300 gpm infiltration cap.
- The original failing drywell is still the inlet and is still allowed to inject, when the failing drywell gets full, it routes to the Maxwell in the street.
- The Maxwell wasn't part of the Newport project
- 50-ft vertical rock gallery
- It cost the City about $70,000 to install, but there was already an existing pretreatment structure upstream for it to support it, and the City's utility dept did the connections from the existing system to the new system. For comparison, their drywells are around $35,000 each, and sedimentation manholes are around $10,000-$12,000.
- Discussion of why the Maxwell is more space efficient than traditional drywell
- The City has a number of drywell filters. Some sort of screen, described as a torpedo-shaped sump. Hard to imagine, and difficult to see from above.
    - City staff were willing to send us a photo of some that they had in the shop.
- Staff discussed uncertainties in sizing UICs. The crane/drill usually has already left the construction project before an infiltration test can be done.
    - Aubrey Butte has some private Maxwells, they're around 95ft deep each. However, there are some clay lenses which limit their infiltration caps.

Private runoff to ROW – no photos

- One of the big issues that the City is dealing with is that they are experiencing extra discharges into the ROW from private properties. What can happen is that as the private systems (which are less-frequently maintained than the public systems) begin to screen off and stop functioning, runoff that should be handled on the private properties instead overflows or bypasses into the ROW, placing additional burden on the public system.
- Team discussed a hardware store on Newport where parking lot drains to ROW.
- The old private systems do not have maintenance agreements. City is unaware if some private UICs are failing and overflow to ROW and cannot inspect.
- Staff has noticed a correlation in the heat map to areas with older private drainage.

Bend Site Visit April 18, 2024
Maxwell Site
Photographs by Karina Nordahl, Trista Kobluskie, Phil Kenyon

File Name	Location
Drywell_near_Newport.jpg	Site of installed "Maxwell" Deep Drywell
Drywell_Near_Newport_2.jpg	Site of installed "Maxwell" Deep Drywell
Drywell_Near_Newport_3-Maxwell_in_Road.jpg	Site of installed "Maxwell" Deep Drywell
Drywell_Near_Newport_With_Torpedo_Filter.jpg	Site of installed "Maxwell" Deep Drywell
IMG_0227	Newport Ave, near maxwell system
IMG_0228	Newport Ave, near maxwell system
IMG_1765	Site of installed "Maxwell" Deep Drywell
IMG_1766	Site of installed "Maxwell" Deep Drywell
IMG_1767	Site of installed "Maxwell" Deep Drywell
IMG_1768	Site of installed "Maxwell" Deep Drywell
IMG_1769	Site of installed "Maxwell" Deep Drywell
IMG_1770	Site of installed "Maxwell" Deep Drywell

Drywell_Near_Newport_2

Drywell_Near_Newport_3-Maxwell_in_Road

Drywell_Near_Newport_With_Torpedo_Filter

Drywell_near_Newport

IMG_0227

IMG_0228

IMG_1765

IMG_1766

IMG_1767

IMG_1768

IMG_1769

IMG_1770

April 18-19, 2024 - Maxwell Site

Bend Stormwater Master Plan
Site Visit to Columbia Park
April 18, 2024
TMK

Agenda: Columbia Park (good opportunity to try and collaborate with BPRD): discuss river outfall & BPRD project

Notes:

- Met with Ian Isaacson, Landscape Architect for BPRD, and Nick McAteer, Assistant Civil Engineer for Bend Utilities
- The stormwater conflicts are often a remnant of when Parks was part of city organization
- A city outfall is located in the project area in Columbia Park where BPRD is planning to improve accessibility to the river
- Project includes:
  - Paving the gravel train down to the water using permeable pavement
  - Hardening the riverbank where access is needed
  - Restoring the riverbank including revegetation (with native landscaping?) in vicinity of project
  - Hopes to reduce erosion to river while improving access
  - Move outfall to discharge downstream of improved access
- The City and BPRD have signed an IGA for the city to contribute to project design to move the outfall
- The project is grant funded
- Nick would like to reroute the whole pipe away from the play area and closer to the property line rather than just rerouting the end of the pipe near the trail. Trista is unclear what design is being advanced.
- There is a water quality swale, which does not appear to have pipe inlets. It may have been constructed in 2013 when the park was renovated. It is a private facility (BPRD).
- Idea to have an easement acquisition program in the SMP.

Other BPRD sites / projects

- Farewell Bend Park has City WQ facilities
- Miller's Landing Park
  - the location of the outfall here is unknown. The homeowner can see muddy water seeping from the riverbank, but it appears the outfall pipe may have been covered up by private building or private landscaping at some point.
  - There is another project to increase access to river, reduce erosion, hardening access, and revegetating other slopes. They have a WQ Certification from DEQ and doing the joint applications for DSL

Also saw undeveloped City ROW abutting NW Columbia St. across from Park. Steep drop off from Columbia to property below. Drainage infrastructure appears to be in private property back yard. City or property owner appears to have placed an asphalt berm on downslope side of sidewalk to prevent sheet flow onto the property.

Bend Site Visit April 18, 2024
Columbia Park
Photographs by Karina Nordahl, Trista Kobluskie, Phil Kenyon

File Name	Location
Columbia_Park_Open_Space_Inlet.jpg	Columbia_Park_Open_Space_Inlet
Columbia_Park_Open_Space_Inlet_2.jpg	Columbia_Park_Open_Space_Inlet
Columbia_Park_Open_Space_Inlet_3.jpg	Columbia_Park_Open_Space_Inlet
Columbia_Park_Outfall.jpg	Outfall
IMG_0237	Existing outfall at Columbia Park
IMG_0238	Low point along storm system coming into Columbia Park
IMG_0239	Road along Columbia Park
IMG_0240	Road along Columbia Park
IMG_0241	Road along Columbia Park
IMG_1784	Signage and Trail near river, Columbia Park
IMG_1785	Signage and Trail near river, Columbia Park
IMG_1786	Signage and Trail near river, Columbia Park
IMG_1787	Signage and Trail near river, Columbia Park
IMG_1788	Swale in Columbia Park
IMG_1789	Swale in Columbia Park
IMG_1790	Across the street from park - unoccupied ROW 10-15 ft below road
IMG_1791	Across the street from park - unoccupied ROW 10-15 ft below road
IMG_1792	Across the street from park - unoccupied ROW 10-15 ft below road

Columbia_Park_Open_Space_Inlet_2

Columbia_Park_Open_Space_Inlet_3

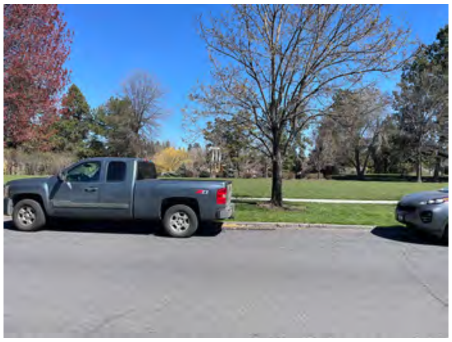
Columbia_Park_Open_Space_Inlet

Columbia_Park_Outfall

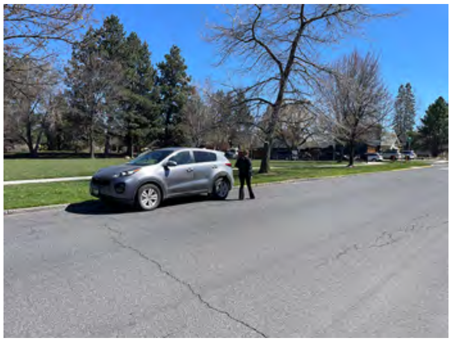
IMG_0237

IMG_0238

IMG_0239



IMG_0240



IMG_0241

IMG_1784

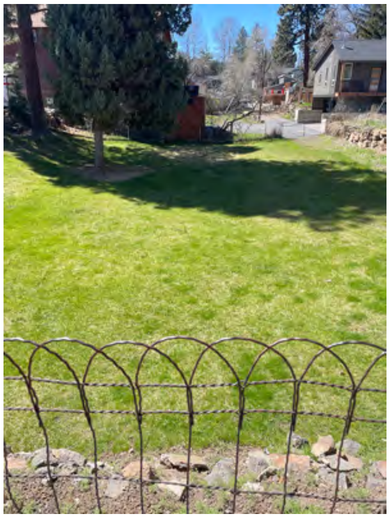
IMG_1785

IMG_1786

IMG_1787

IMG_1788

IMG_1789



IMG_1790

IMG_1791

IMG_1792

April 18-19, 2024 - Columbia Park

Bend Stormwater Master Plan
Site Visit to Drake Park and Old Bend
April 18, 2024
TMK, PK

Agenda: Drake park near downtown: discuss long stormwater main runs from downtown to outfall. Discuss storm network and issues in historic neighborhood.

Notes:

- At corner of NW Congress St and NW Louisiana Ave saw an example of sediment from sanding rock building up on street, getting caught in ADA ramps. The ADA ramps also shoot water right into private property.
- The neighborhood has very little storm infrastructure but a few outfalls to Mirror Pond/ Deschutes River
- BPRD constructed the boardwalk on the Deschutes from Drake Park to Pacific Park with minimal permitting from City. Would there have been an opportunity to collaborate more?
- Collaborate with BPRD on how to treat the river, planting restoration, natural resources protection, converting riverside lawn to native plantings
- East outfall of Drake Park:
    - The is roughly the most important outfall in the City. It receives runoff from the downtown area, and is in a very prominent public park, and outfalls into the river.
    - At present, there is insufficient pretreatment for this area, and there is also a serious problem with lack of access to the storm structure. While we were there, the maintenance folk lifted part of a street-seating area for a local restaurant to look at the catch basin underneath.
- One of the primary concerns for groundwater is PFOS (from Teflon, Goretex, etc.) – this is not a major concern for the surface waters at this time, mostly because the River is not used for drinking water whereas the groundwater wells need much clearance from the UIC’s.
- For the UIC in Drake Park, discussed the new groundwater protectiveness standard. It is location based and is variable. The variability is about PFOS. The separation might be between 50-100 feet vertical and horizontal.
    - It might require removal of existing drill holes that are too close to groundwater
- Walked along NW Franklin Ave.
    - There are long runs of pipe with few structures
    - Some structures are blocked by outdoor seating in the parking lane
    - This is a priority for staff. Maintenance is very difficult.

Bend Site Visit April 18, 2024
Drake Park and Old Bend
Photographs by Karina Nordahl, Trista Kobluskie, Phil Kenyon

File Name	Location
Congress_Louisiana_Overland_Flow_Downstream.jpg	Sediment & Flooding issue location
Congress_Louisiana_Overland_Flow_Issue.jpg	Sediment & Flooding issue location
Congress_Louisiana_Overland_Flow_Issue_ADA_Ramp.jpg	Sediment & Flooding issue location
Downtown_Access_Issue.jpg	Location of outdoor seating placed over maintenance hole
Downtown_Access_Issue_2.jpg	Location of outdoor seating placed over maintenance hole
Drake_Park_Access_Drillhole.jpg	Drillhole in Drake Park
Drake_Park_Outfall.jpg	Outfall in Drake Park
IMG_0242	Congress and Lousiana, issue with stormwater bypassing inlet and flooding yard
IMG_0243	Congress and Lousiana, issue with stormwater bypassing inlet and flooding yard
IMG_0244	Junction box will drill hole in Drake Park
IMG_0245	Junction box will drill hole in Drake Park
IMG_0246	Junction box will drill hole in Drake Park
IMG_1797	Congress and Lousiana, issue with stormwater bypassing inlet and flooding yard
IMG_1798	Congress and Lousiana, issue with stormwater bypassing inlet and flooding yard
IMG_1799	Congress and Lousiana, issue with stormwater bypassing inlet and flooding yard
IMG_1800	Drake Park
IMG_1801	Drillhole in Drake Park
IMG_1802	Drillhole in Drake Park
IMG_1803	Drillhole in Drake Park
IMG_1804	Drillhole in Drake Park
IMG_1805	Drillhole in Drake Park
IMG_1806	Location of outdoor seating placed over maintenance hole

Congress_Louisiana_Overland_Flow_Dow...

Congress_Louisiana_Overland_Flow_Issue...

Congress_Louisiana_Overland_Flow_Issue

Downtown_Access_Issue_2

Downtown_Access_Issue

Drake_Park_Access_Drillhole

Drake_Park_Outfall

IMG_0242

IMG_0243

April 18-19, 2024 - Drake Park and Old Bend

IMG_0244

IMG_0245

IMG_0246

IMG_1797

IMG_1798

IMG_1799

IMG_1800

IMG_1801

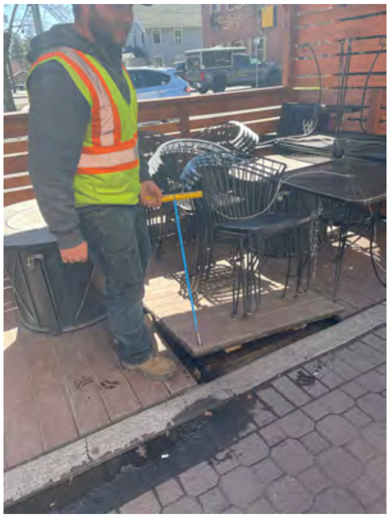
IMG_1802

April 18-19, 2024 - Drake Park and Old Bend

IMG_1803

IMG_1804

IMG_1805



IMG_1806

Bend Stormwater Master Plan
Site Visit to Cooley and Rockhurst Neighborhood
April 19, 2024
TMK, KRN

Agenda: Cooley and Rockhurst Neighborhood has no curbs in most places, erosion problems, and overwhelmed drywells

Notes

- Home on corner at a low spot – property gets inundated, shoulder of road is eroding onto the property, flooding has threatened home
- Hail can fill the drywells
- CB filled more than 30% triggers a cleaning
- Landscaping materials (bark, etc.) sometimes fill CBs and drywells
- Some swales are not irrigated. What is a reasonable plant cover for these?

Bend Site Visit April 19, 2024
Cooley Neighborhood
Photographs by Karina Nordahl, Trista Kobluskie, Phil Kenyon

File Name	Location
Drillhole_Pretreatment_Challenge.jpg	Drillhole_Pretreatment_Challenge
Drillhole_Pretreatment_Challenge_2.jpg	Drillhole_Pretreatment_Challenge
East_Bend_Drainage_Challenges.jpg	Drainage_Challenges
East_Bend_Drainage_Challenges_2.jpg	Drainage_Challenges
East_Bend_Erosion_Challenges.jpg	Erosion_Challenges
East_Bend_Irrigation_Channels.jpg	East_Bend_Irrigation_Channels
IMG_0251	House that gets flooded due to lack of curbing and stormwater infrasture
IMG_0252	House that gets flooded due to lack of curbing and stormwater infrasture
IMG_0253	Catchbasin with drill hole. Area has flooded when drill hole was overwhelmed
IMG_1814	House that gets flooded due to lack of curbing and stormwater infrasture
IMG_1815	Catchbasin with drill hole. Area has flooded when drill hole was overwhelmed
Typical_Rock_Mulch_Covering.jpg	Typical_Rock_Mulch_Covering

Drillhole_Pretreatment_Challenge_2

Drillhole_Pretreatment_Challenge

East_Bend_Drainage_Challenges_2

East_Bend_Drainage_Challenges

East_Bend_Erosion_Challenges

East_Bend_Irrigation_Channels

IMG_0251

IMG_0252

IMG_0253

IMG_1814

IMG_1815

Typical_Rock_Mulch_Covering

Bend Stormwater Master Plan
Site Visit to Miller's Landing Park and Vicinity
April 18, 2024
TMK

Notes

- Area is near river and has residential and commercial development
- Miller's Landing Park has vegetated ponds (private or City?) in newer developed park.
- The Whitewater Park is across the river and has lots of signage describing use of the river by native species
- Older drillholes in ROW

Bend Site Visit April 18, 2024
Miller's Landing and Whitewater Parks, Vicinty
Photographs by Karina Nordahl, Trista Kobluskie, Phil Kenyon

File Name	Location
Bend_Whitewater_Park.jpg	Bend Whitewater Park
Bend_Whitewater_Park_2.jpg	Bend Whitewater Park
Drillhole_with_Pretreatment_Riser_inside_Inlet.jpg	Older drillhole
IMG_0249	Bend Whitewater Park
IMG_0250	Bend Whitewater Park
IMG_0807	Stormwater pond at Miller's Landing Park
IMG_0808	Stormwater pond at Miller's Landing Park
IMG_0809	Bend Whitewater Park
IMG_0810	Bend Whitewater Park
IMG_0811	Older drillhole
IMG_0812	Older drillhole
IMG_0813	Older drillhole
Residential_Area_Near_River.jpg	Residential_Area_Near_River

Bend Stormwater Master Plan

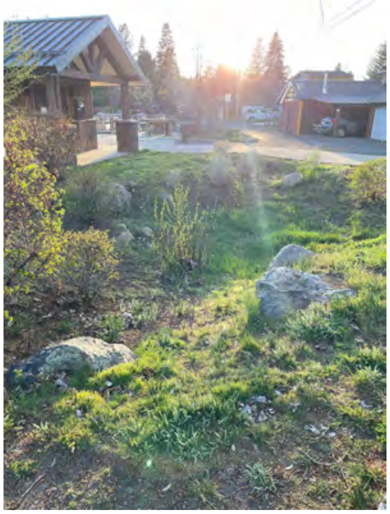

Bend_Whitewater_Park_2


Bend_Whitewater_Park


Drillhole_with_Pretreatment_Riser_inside_I...


IMG_0249


IMG_0250


IMG_1807


IMG_1808


IMG_1809


IMG_1810

April 18-19, 2024 - Miller's Landing and Whitewater Parks

IMG_1811

IMG_1812

IMG_1813

Residential_Area_Near_River

Bend Stormwater Master Plan
Site Visit to Overturf Dog Park
April 19, 2024
TMK, KRN, PK

Agenda: Overturf Dog Park – official and unofficial.

Notes

- Dog park on an undeveloped butte/hillside with lots of use in unofficial areas. The top of the butte is occupied by water storage tanks.
- Use has denuded the landscape, cut footpaths on slopes
- Lots of complaints downslope about fast runoff, inundating cul-de-sac and yards, threatening to flood homes
- Clear signs of erosion on hillside and maintenance road leading up to the park
- City Utilities staff have been placing erosion control measures
- Portions of the landscape have been temporarily fenced off to allow vegetation to recover; I am unclear if the fencing was placed by BPRD or City
- Intensity of rainstorms has exacerbated the erosion

Bend Site Visit April 19, 2024
Overturf Dog Park
Photographs by Trista Kobluskie, Phil Kenyon

File Name	Location
IMG_1826	Rocked ditch at Overturf
IMG_1827	Rocked ditch at Overturf
IMG_1828	Rocked ditch at Overturf
IMG_1829	Trail and signage
IMG_1830	Trail and signage
IMG_1831	Trail and signage
IMG_1832	Partially stabilized slope
IMG_1833	Trail and signage
IMG_1834	Trail and signage
Overturf_Park_Adjacent_Downhill_Area.jpg	Trail, signage, evidence of partial stabilization
Overturf_Park_Erosion_Challenge.jpg	Trail, signage, evidence of partial stabilization
Overturf_Park_Erosion_Challenge_2.jpg	Trail, signage, evidence of partial stabilization
Overturf_Park_Erosion_Challenge_3.jpg	Trail, signage, evidence of partial stabilization
Overturf_Park_Erosion_Challenge_4.jpg	Trail, signage, evidence of partial stabilization
Overturf_Park_Erosion_Challenge_5.jpg	Trail, signage, evidence of partial stabilization
Overturf_Park_Erosion_Challenge_6.jpg	Trail, signage, evidence of partial stabilization

IMG_1826

IMG_1827

IMG_1828

IMG_1829

IMG_1830

IMG_1831

IMG_1832

IMG_1833

IMG_1834

April 18-19, 2024 - Overturf Park

Overturf_Park_Adjacent_Downhill_Area

Overturf_Park_Erosion_Challenge_2

Overturf_Park_Erosion_Challenge_3

Overturf_Park_Erosion_Challenge_4

Overturf_Park_Erosion_Challenge_5

Overturf_Park_Erosion_Challenge_6

Overturf_Park_Erosion_Challenge

April 18-19, 2024 - Overturf Park

Bend Stormwater Master Plan
Site Visit to SE Bend SE Gateway/Ambassador Dr neighborhood off 15th by Alpenglow Park and SE Ironhorse & Lincoln neighborhood (off 15th, Reed Market)
April 19, 2024
TMK

Agenda: shows 2 kinds of developments, first with integrated swales & native plants but private streets, 2nd with standard curb-grass planter strip-sidewalk and a neighborhood scale regional stormwater pond

Notes

- Trista also has photos from the SE Gateway neighborhood taken in spring 2023, showing the integrated swales (not included in these notes)
- The neighborhood-scale stormwater ponds are considered “off-site,” in Bend terminology, not “on-site” even if they are on private (HOA) property/open space, serve private streets, and are privately maintained – confirm with City staff

Bend Site Visit April 19, 2024
Private Stormwater Facilities and Frontage, SE Bend
Photographs by Trista Kobluskie

File Name	Location
IMG_0254	Stormwater detention pond near SE Gateway/Ambassador Dr or SE Ironhourse & Lincoln.
IMG_1816	Private pond serving neighborhood
IMG_1817	Private pond serving neighborhood
IMG_1818	Private pond serving neighborhood
IMG_1819	Private pond serving neighborhood
IMG_1820	Private pond serving neighborhood
IMG_1821	Private pond serving neighborhood
IMG_1822	Private pond serving neighborhood
IMG_1823	Private pond serving neighborhood
IMG_1824	Example of dense housing type, frontage

IMG_0254

IMG_1816

IMG_1817

IMG_1818

IMG_1819

IMG_1820

IMG_1821

IMG_1822

IMG_1823

IMG_1824

Exhibit E

Known Issues

Bend Stormwater Master Plan
Known Issues
October 1, 2024

Known Issues ID	Full Name	Issue Primary	Issue Secondary	Information Source	Long Description	Last Year of Occurrence	Frequency	Severity	Status	Issue Ownership	Infrastructure Affected	Basin Size	City Priority
KI-1	1504 SW Overturf Drainage	Drainage	<Null>	Correspondence from Landowner	Cul-de-sac floods 2-3 feet at least once every spring/summer when pine needles and leaves clog storm drain. 1504 SW Overturf Ct.	2023	Annual	High	Active	City	Piped System	Unknown	N/A
KI-2	19th and Knoll Drainage	Drainage	<Null>	City of Bend Correspondence	Flooding occurs at 19th and Knoll. Runoff from Troon moves between houses, onto 19th, and ponds on private property surrounding the intersection at 19th and Knoll. Multiple residences affected. Utility Department is looking at this issue now. There is a house there now, but there wasn't previously; property may have been flooded before but not generated complaints because it was undeveloped. Property damage is a risk.	2023	Thunderstorms	High	Design	City	<Null>	Unknown	N/A
KI-3	Low point in the area. In 2013 the stormwater crew dug a trench in front of the property and filled	Drainage	<Null>	Infor Work Order 1261005	Low point in the area. In 2013 the stormwater crew dug a trench in front of the property and filled it with crushed basalt to help storm runoff infiltrate better. It helped, but the larger storm events still cause structure/property damage. Install stormwater infrastructure with conveyance system to protect private property (UIC, drywell, swale). This is an old county road with no infrastructure in place. The homeowner has done some mitigation work on his property to control runoff, but during the larger storm events water from the neighboring properties and right of way flow through the property. Despite recent efforts, flooding outside the house and garage is still occurring.	2020	Thunderstorms	High	Active	City and private	No Drainage System	4	1
KI-4	Stormwater Flooding Report 1515 NE 2nd St.	Drainage	<Null>	Infor Work Order 1415715	Drywell has completely failed causing water to puddle in roadway even with minimal precipitation. Install additional UIC's or maybe a regional pond in ROW. Notes from City staff indicate this issue will be resolved with the Olney Pedestrian and Bike Improvement Project.	2022	Seasonal	Moderate	Design	City	Drywell	15	1
KI-5	Stormwater Flooding Report 19 NW Mueller	Drainage	<Null>	Infor Work Order 735236	No drainage in low point of alley. Stormwater accumulates in the low point of the alley and flow onto 19 NW Mueller causing property damage. A 6-plex was going in and should have been controlling stormwater. Install UIC or deep drywell.	2023	Unknown	Moderate	Active	City	No Drainage System	10	1
KI-6	Stormwater Flooding Report 211-147-143 NW Congress	Drainage	<Null>	Infor Work Order 878124	Lack of drainage in this area. During rain events water tops the curb line and floods properties listed above. Damage to structures (interior) reported. Install storm system.	2022	Large thunder	High	Active	City	No Drainage System	Unknown	1
KI-7	Stormwater Flooding Report 717 NW Georgia	Drainage	<Null>	Infor Work Order 1433112	During large rain events water from Bond and Wall converge and overwhelm the drillholes and flood on private property. Property damage (exterior) has been reported. Performed infiltration test on all three drillholes and none of them work very well. Install new drainage/UICs.	2020	One Time	High	Active	City	Drillhole	Unknown	1
KI-8	Stormwater Flooding Report 1213 Vicksburg Ave	Drainage	<Null>	Infor Work Order 1419799	1213 Vicksburg is the low point for this drainage. Water flows through property causing structure damage (interior). Install storm system at the low point. Install additional storm systems up stream.	2022	All rains	High	Active	City	No Drainage System	Unknown	1

Bend Stormwater Master Plan
Known Issues
October 1, 2024

Known Issues ID	Full Name	Issue Primary	Issue Secondary	Information Source	Long Description	Last Year of Occurrence	Frequency	Severity	Status	Issue Ownership	Infrastructure Affected	Basin Size	City Priority
KI-9	Stormwater Flooding Report 1300 SE 3rd St	Drainage	<Null>	Infor Work Order 1261038	Water puddles on road and flows down into parking lot and main lobby of the Budget Inn causing property damage during larger rain events. City has installed water-bars and lowered the asphalt level to keep water in the right of way going to the drillhole, but it still floods during the larger events. There may be legal issues with this location. Property owner claims there is potential for water to enter the lower floor; City has not verified this. Property damage could occur when storm severity exceeds design capacity of infrastructure. Install additional drainage, UICs.	2020	Large thunder	High	Active	City	Drillhole	Unknown	1
KI-10	Stormwater Flooding Report 1648 NE Eastwood Dr	Drainage	<Null>	Infor Work Order 479871	Inadequate drainage to handle runoff. 1648 NE Eastwood is located at the low point in this basin. Water overwhelms the drill holes and floods onto property. Property damage (exterior) has been reported.	2024	Thunderstorms	High	Active	City	Drillhole	Unknown	1
KI-11	Stormwater Flooding Report 2310 NE Shepard Rd	Drainage	<Null>	Infor Work Order 1213903	Stormwater overwhelms existing system. During large rain events the water has flowed onto private property causing interior structure damage. Remove and replace existing drainage with City standard storm drains, sedimentation manholes and drywells. Connect all the drainage from NE Watson Dr on Shepard to NE Dempsey. Bypass/Overflow out existing storm line to the east at 2342 NE Shepard.	2020	Thunderstorms	High	Active	City	Drywell	Unknown	1
KI-12	Stormwater Flooding Report 63673 Boyd Acres Rd (Cooley Neighborhood)	Drainage	Erosion	Infor Work Order 1316400	This address is located at the lowest point in the area and receives storm water runoff from Wagontire, Cascade Village Dr (private road) and some from Boyd Acres. Flooding causes property erosion and structure damage. Install curb and gutter to convey water to storm drains connected to sed. manholes and a sized drywell gallery or drywells daisy chained together.	2021	All rains	High	Active	City and private	No Drainage System	18	1
KI-13	Stormwater Flooding Report 19410 Century Dr	Drainage	Erosion	Infor Work Order 141965	During large rain events water flows from West Campbell Rd and Tetherow overland through several properties and into the right of way. Property damage (exterior) has been reported. There are several homes that were built in the natural drainage and there is no stormwater infrastructure in the area. West Campbell Rd was re-graded to try and shed water to the opposite side, but water still flows through the properties. Runoff seems to originate in unincorporated Deschutes County, County ROW, private property in uninc. County, BPRD park in uninc. County, City ROW, and private property in City. Install UIC's, install regional swale, install erosion control measures.	2022	Large thunderstorms	High	Active	City, County, BPRD, and private	No Drainage System	Unknown	1

Bend Stormwater Master Plan
Known Issues
October 1, 2024

Known Issues ID	Full Name	Issue Primary	Issue Secondary	Information Source	Long Description	Last Year of Occurrence	Frequency	Severity	Status	Issue Ownership	Infrastructure Affected	Basin Size	City Priority
KI-14	Stormwater Flooding Report 633 NW York Dr	Drainage	<Null>	Infor Work Order 878656	Large puddle forms in the right of way and up over the curb during large rain/snow events. Serious traffic impacts have been reported. Large thunderstorm events cause flooding across roadway in the spring, summer and fall. In the winter when the ground is frozen it takes less water to cause issues at this location. Install additional UICs; install regional swale.	2024	All rains	High	Active	City	Drywell	Unknown	1
KI-15	Stormwater Flooding Report 63089 Nels Anderson Rd	Drainage	<Null>	Infor Work Order 1415715	Drill hole was decommissioned due to a diesel spill, and storm drain removed. Low point with no drainage. Install a storm system sed. manhole, storm drains, drywell or Install basin and connect to existing system.	2022	All rains	Moderate	Active	City	No Drainage System	2	1
KI-16	Stormwater Flooding Report 19650 SW Poplar	Drainage	<Null>	Infor Work Order 1515918	Stormwater flows to the northwest and puddles. Water accumulates and flows onto private property causing damage to structures (interior). Puddle will freeze and cause safety concerns. Install a storm system Sed. manhole, storm drains, drywell and maybe a drill hole.	2023	All rains	High	Active	City	<Null>	8	1
KI-17	Stormwater Flooding Report NW Summit/NW Mt. Washington	Drainage	<Null>	Infor Work Order 1219584	Water from NW Summit Dr flows down hill and overwhelms drywell on SW corner. Very slow draining drywell. This large drainage area has become a stormwater hotspot for flooding. Drywell has completely failed and water either builds up enough to flow across the intersection and down to the next drainage area or it evaporates. Serious traffic impacts have been reported. Install additional drainage/UIC's on Summit, rehab/replace existing drywell, install drillhole in existing drywell, swale.	2024	All rains	High	Active	City	Drywell	Unknown	1
KI-18	Stormwater Flooding Report 1936 SE Waco Dr	Drainage	<Null>	Infor Work Order 754965	This location has no stormwater infrastructure and floods in the winter when the ground is frozen. Serious traffic impacts have been reported. Install UIC's (drywell, drillhole).	2024	Frozen conditions only	High	Active	City	No Drainage System	Unknown	1
KI-19	Stormwater Flooding Report 858 NW Wall St	Drainage	<Null>	Infor Work Order 779132	The drywells in this area have completely failed and sit full of water year-round. Water builds up and floods into several businesses before it can flow south to the mainline to the river. Property damage (exterior). All downtown drainage is aging and needs to be addressed. This location floods more frequently than any other downtown location. Install new UIC's, extend pipeline to the river, install pre-treatment.	2022	Thunderstorms	High	Active	City	Drywell	Unknown	1
KI-20	Stormwater Flooding Report 1125 NE 2nd St	Drainage	<Null>	Infor Work Order 1082838	Water puddles in intersection during large rain events. Serious traffic impacts have been reported. Over the years this intersection has undergone several changes including the addition of swales and a new drywell system to try and help the failing drillholes. Still needs additional UIC's on South and East and West side. Install additional UIC's, install regional swale.	2020	Thunderstorms	High	Active	City	Drillhole	Unknown	2

Bend Stormwater Master Plan
Known Issues
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Known Issues ID	Full Name	Issue Primary	Issue Secondary	Information Source	Long Description	Last Year of Occurrence	Frequency	Severity	Status	Issue Ownership	Infrastructure Affected	Basin Size	City Priority
KI-21	Stormwater Flooding Report 1532 NE 9th st	Drainage	Water Quality-Groundwater	Infor Work Order 1087831	Runoff from Pilot Butte all drains downhill to this location. There is no drainage infrastructure between 9th and 13th on Penn. There was some swale work done on the shoulder at this intersection, but it still floods and runs down onto private property. Install additional UIC's on Penn, re-drill drillhole, install pre-treatment, connect drainage to swale on 8th and Penn.	2022	All rains	Moderate	Active	City	Drillhole	Unknown	2
KI-22	Stormwater Flooding Report 902 SE Textron	Drainage	<Null>	Infor Work Order 1141148	Water puddles on SE corner, drillhole infiltrates very slowly. The drillhole on the NE corner has been re-drilled and works, but water still puddles on the SE side of the intersection. Re-drill, install UICs. City recently reconditioned with drillhole which may have solved the issue.	2024	Unknown	Moderate	Solved, Monitor	City	Drillhole	Unknown	2
KI-23	Stormwater Flooding Report 1501 NE Neff Rd	Drainage	Erosion	Infor Work Order 1420496	This one drillhole serves a very large drainage basin and can be overwhelmed easily. During large rain events, erosion from Pilot Butte contributes a large amount of sediment. This drillhole has been re-drilled to 95ft and does infiltrate well now. The entire Penn/Neff corridor from 8th St. to NE Cliff Dr. needs additional stormwater infrastructure. This has been a known flooding area for years and was also previously identified in the 2014 masterplan. Install flanking catch basins to protect drillhole, install additional UIC's, install regional swale, install erosion control measures on Pilot Butte and vacant lot. The City recently redrilled the drillhole and the issue has not been reported since then.	2022	Thunderstorms	Moderate	Solved, Monitor	City	Drillhole	Unknown	2
KI-24	Stormwater Flooding Report 330 SE 15th st	Drainage	<Null>	Infor Work Order 694128	Water puddles in bike lane and road causing traffic to drive into on-coming lane. This drillhole is easily overwhelmed, but it does catch up it just takes a while. It cannot be re-drilled due to overhead powerlines. Install UIC, connect to drill hole on east side of the road.	2024	Seasonal	Moderate	Active	City	Drillhole	Unknown	2
KI-25	Stormwater Flooding Report 151 SW Shevlin Ln	Drainage	Water Quality-Groundwater	Infor Work Order 715133	Drywells at this location have wet feet. Floods across entire width of roadway. Serious traffic impacts reported. Install pretreatment and discharge to river.	2015	Large rainstorms	High	Active	City	Drywell	Unknown	2
KI-26	Stormwater Flooding Report 1212 SW Simpson	Drainage	<Null>	Infor Work Order	The two drywells at this location are failing. Stormwater floods across the entire roadway. Serious traffic impacts reported. Replace old storm system.	2020	Thunderstorms	High	Active	City	Drywell	Unknown	2
KI-27	Stormwater Flooding Report 1757 Forest Ridge Ave	Drainage	Erosion	Infor Work Order 1225892	During large rain events water from both sides of Forest Ridge overwhelm the drillhole (DDH009888) and floods private property. Exterior property damage reported. Install new drainage/UIC's. This drillhole was re-drilled in 2015 to 87ft but still only takes 44 gpm. This drillhole has since filled in due to loose pumice-soil.	2020	Thunderstorms	High	Active	City	Drillhole	Unknown	2
KI-28	Stormwater Flooding Report 60924 SW McMullin	Drainage	<Null>	Infor Work Order	Failed drill hole causing water to puddle in the roadway and flow onto private property. Exterior property damage reported. Install new storm system or connect to new storm system located 100' to the north.	2015	Seasonal	High	Active	City	Drillhole	Unknown	2

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KI-29	Stormwater Flooding Report 61553 Westridge Ave	Drainage	Erosion	Infor Work Order 780398	Drill hole has failed. Stormwater builds up and flows over driveway approach onto property causing erosion. Exterior property damage reported. Install new storm system.	2022	Thunderstorms	High	Active	City	Drillhole	Unknown	2
KI-30	Stormwater Flooding Report 63275 Wishing Well Ln	Drainage	<Null>	Infor Work Order 1310021	During large rain events the entire intersection floods over the curb onto private property. Exterior property damage reported. On 6/24/2021 we removed approximately 24 Vactor loads of water from this intersection. The drywells in this area do infiltrate but can be overwhelmed during large events. Install additional drainage/UIC's, install regional swale.	2021	Thunderstorms	High	Active	City	Drywell	Unknown	2
KI-31	Stormwater Flooding Report 1567 SW Chandler Ave	Drainage	<Null>	Infor Work Order 1419415	Water puddles across the road during large rain events. There are several drywells in this area that do infiltrate, but become overwhelmed during large rain events. Moderate traffic impacts reported. There is a lot of pumice soil in the area that does not drain well. Install additional UIC's, Install regional swale.	2022	Large rainstorms	Moderate	Active	City	Drywell	Unknown	2
KI-32	Stormwater Flooding Report NE 2nd St/NE Lafayette	Drainage	Erosion	Infor Work Order 770608	Old/minimal stormwater infrastructure. Some of the drill holes work, some do not. We have issues with the storm grates plugging at this location. Moderate traffic impacts reported. Install additional upstream storm systems and expand or replace storm system at the intersection.	2018	Seasonal	Moderate	Active	City	Drillhole	Unknown	2
KI-33	Stormwater Flooding Report Ne 4th St/NE Revere Ave	Drainage	<Null>	Infor Work Order 1082854	Stormwater runoff overwhelms drill holes and the swale causing water puddle in the roadway. Moderate traffic impacts reported. Install additional UIC's with pretreatment to handle runoff.	2023	Thunderstorms	Moderate	Active	City	Swale	Unknown	2
KI-34	Stormwater Flooding Report NE 4th at NE Olney Ave	Drainage	<Null>	Infor Work Order 715134	There is a failing drywell at this location that becomes overwhelmed during rain events. We have responded to this location for more than 20 years. New drainage has been added uphill of this intersection over the years which has reduced the amount of water this UIC receives. Response to this location is now less frequent. Add an additional UIC or connected drywell to the drywell that works 85' to the east.	2020	Thunderstorms	Moderate	Active	City	Drywell	Unknown	2
KI-35	Stormwater Flooding Report 537 NW Riverfront	Drainage	Condition	Infor Work Order 1419426	During peak river flows the outfall is completely submerged causing the system to back up during storms and flood the road and adjacent property. The stormwater maintenance crew has tried to dig around the outfall when the river is down, but the system still backs up. The pipe is completely submerged for half of the year, and the basins and connecting pipe in the area are rapidly aging and deteriorating. Moderate traffic impacts. Install UIC's, connect drainage to different outfall, install new outfall at higher elevation, install regional swale.	2022	Unknown	Moderate	Active	City	Piped System	Unknown	2
KI-36	Stormwater Flooding Report 1193 Ross Rd	Drainage	<Null>	Infor Work Order 1483252	Drywell is failing and easily overwhelmed. Serious traffic impacts reported. Install additional drainage, drywell or drill hole in drywell.	2023	Thunderstorms	High	Active	City	Drywell	2	2

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KI-37	Stormwater Flooding Report SE China Hat Rd-RR Tracks	Drainage	Erosion	Infor Work Order 356203	Floods across the entire road causing serious traffic problems. We installed a infiltration gallery in 2012 that helped with the flooding but this location still floods during large rain events. Install storm drains, sedimentation manholes and drywells.	2023	Thunderstorms	High	Active	City	<Null>	Unknown	2
KI-38	Stormwater Flooding Report 510 NW Sean Ct. (Overturf Park)	Drainage	Erosion	Infor Work Order 1024531	Runoff from Overturf Butte runs downhill onto private property and overwhelms the catch basin and drywell. The drywell does infiltrate slowly but is undersized for the area. The stormwater maintenance crew installed several erosion control measures on Overturf Butte including: straw wattles, check dams, and re-vegetation. This did help, but the larger storms still cause problems. BPRD owns Overturf Park, and COB owns the 30+ ac parcel encompassing the butte and water towers. Install additional UIC's, better control of runoff on Overturf Butte. City believes recent actions have reduced frequency and severity of this issue; monitor situation for recurrence.	2023	Thunderstorms	Low	Active	Unclear	Drywell	Unknown	2
KI-39	Stormwater Flooding Report 125 NE Franklin Ave.	Drainage	Erosion	Infor Work Order 1483259	There is 1 working drill hole servicing the underpass runoff and it is failing. Storm water puddles in roadway requiring underpass to be closed. There is a large amount of sediment erosion along the road and sidewalk that are contributing to the expedited failure of the drillhole (DDH010016). Serious traffic impacts reported. Install a storm system sed. manhole, storm drains, drywells or pump station. City already has a road project planned here, with some stormwater improvements.	2022	Large rainstorms	High	Design	City	Drillhole	Unknown	1
KI-40	Stormwater Flooding Report 5 NW Greenwood	Drainage	<Null>	Infor Work Order 1483284	There are 2 drill holes servicing the underpass runoff and they are inadequate in large rain events. Storm water puddles in roadway requiring underpass to be closed. Drillhole (DDH010018) in west bound lane was recently re-drilled to 100ft. Both drillholes still infiltrate poorly and ultimately all drainage needs to be upgraded. Install a storm system sed. manhole, storm drains, drywells, or pump station.	2022	Large rainstorms	High	Active	City	Drillhole	Unknown	N/A
KI-41	Blocked Outfall in Miller's Landing Park (SMP Online Comment 2)	Drainage	Condition	SMP Online Comment 2	Blocked/collapsed outfall, confirmed in 2023 CCTV inspection. Outfall located in Miller's Landing Park, BPRD property. The whole neighborhood has flooding problems between Tumalo Riverside lots of flooding on private property, a little in the ROW. Project is underway by Utilities Department to rehab the outfall.	2023	Ongoing	Low	Solved, Monitor	City, BPRD	Piped System	Unknown	N/A
KI-42	Damaged pipe in NW McKay Ave (SMP Online Comment 4)	Condition	<Null>	SMP Online Comment 4	2023 CCTV inspection discovered gas pipeline through the outfall pipe, which has a huge void behind it.	2023	Ongoing	High	Active	City	Piped System	Unknown	N/A
KI-43	Tear in pipe at NW Galveston Ave. (SMP Online Comment 5)	Condition	<Null>	SMP Online Comment 5	2023 CCTV inspection shows a tear in the pipe	2023	Ongoing	Low	Active	City	Piped System	Unknown	N/A

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KI-44	Damaged pipe south of NW Baltimore Ave (SMP Online Comment 6)	Condition	Drainage	SMP Online Comment 6	2023 CCTV inspection shows damaged pipe, possibly from boring, causing restriction to flow; shows rocks in pipe. Pipe is on private property. Easement status has not been studied.	2023	Ongoing	Low	Active	City	Piped System	Unknown	N/A
KI-45	Crushed pipe in NW McKay Ave (SMP Online Comment 7)	Condition	<Null>	SMP Online Comment 7	2023 CCTV inspection. Location of gas boring line, pipe bends 90 degrees. Can't find outfall because pipe is crushed. Evaluate whether this is the same issue as KI-42.	2023	Ongoing	Unknown	Active	City	Piped System	Unknown	N/A
KI-46	Flooded home and damaged pipe at NW Hixon Ave (SMP Online Comment 8)	Condition	Drainage	SMP Online Comment 8	2023 CCTV inspection shows pipe is corroded near outfall; the rest going through property is okay; outfall is underwater most of the year. Private riverfront home floods.	2023	Ongoing	Moderate	Active	City	Piped System	Unknown	N/A
KI-47	Inaccessible and damaged pipe, Drake Park (south) (SMP Online Comment 9)	Condition	<Null>	SMP Online Comment 9	2023 CCTIV inspection shows root intrusion; can't make it to the outfall; the pipe dives where the material changes; it is allowing soil in and will eventually form a void. In Drake Park near NW Tumalo Ave	2023	Ongoing	Low	Active	City, BPRD	Piped System	Unknown	N/A
KI-48	South Awbrey Butte Drainage Study	Drainage	Maintainability	South Awbrey Butte Alternatives Analysis	Drainage issues on Awbrey Butte and along Newport Avenue have persisted for decades and continue to inconvenience citizens and require a disproportionate amount of the City of Bend's (City) maintenance resources and funding. The South Awbrey Butte Drainage Study and Alternatives Analysis in 2017 identified 7 priority improvements to reduce flooding.	2023	Ongoing	High	Active	City	<Null>	Unknown	N/A
KI-49	Old Newport Ave. Outfall	Condition	Maintainability	Email from Lori Faha	Old outfall acting as overflow; need to discuss maintenance, possible replacement, or work on lining and outfall.	2024	Ongoing	Moderate	Active	BPRD	Piped System	Unknown	N/A
KI-50	Archie Briggs Rd Drainage Issues	Drainage	<Null>	Fieldwork, City of Bend	Archie Briggs has drainage issues at the low point. The area lacks drainage systems. From here the river starts into the canyon. Developments are 5 acre – ish conversions from farm. Private property on north side of Archie Briggs Rd and west side of river sits below road grade and gets flooded. Have recently installed asphalt berms and water is directed to river near bridge. The bridge will be upgraded. The berms seem to have solved the immediate problems (recent). But we could keep the issue as active, since there is no drainage system and no water quality.	2022	Unknown	Moderate	Active	City	No Drainage System	Unknown	N/A
KI-51	Central District Lacks Drainage Options for Redevelopment	Water Quality-Groundwater	Water Quality-Surface Water	Fieldwork, City of Bend	The City of Bend has a redevelopment plan for the Bend Central District, bounded by Greenwood Ave, 5th St, Franklin Ave, and 2nd St. The plan encourages redevelopment and allows zero lot line configurations, leaving little room for stormwater management. Can City provide a regional stormwater management solution?	N/A	N/A	N/A	Active	City, private	No Drainage System	Unknown	N/A

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KI-52	Lack of easement for stormwater outfall and pipe	Maintainability	<Null>	Fieldwork, City of Bend	The outfall at Columbia Park is an example of City infrastructure on Bend Park and Recreation District which exists without maintenance easements. This is a typical problem, stemming from the time that BPRD split from the City government. In this particular instance, BPRD is improving the trail adjacent to the river and is working with the City to relocate the outfall, and the two have signed an IGA.	N/A	N/A	N/A	In Progress	City, BPRD	Piped System	Unknown	N/A
KI-53	Lack of easement for City stormwater facilities and outfall in Miller's Landing Park.	Maintainability	<Null>	Fieldwork, City of Bend	The outfall and stormwater facilities at Miller's Landing Park are an example of City infrastructure on Bend Park and Recreation District which exists without maintenance easements. This is a typical problem, stemming from the time that BPRD split from the City government.	N/A	N/A	Low	Active	City, BPRD	Swale	Unknown	N/A
KI-54	Lack of access to stormwater main	Maintainability	Condition	Fieldwork, City of Bend	The stormwater main in NW Franklin Ave near NW Wall St. has long runs with no maintenance structure, and one manhole has been covered by a restaurant outdoor seating area. Staff maintain the manhole before business hours via a hatch in the seating area floor. The pipe may have caused a sinkhole in the street a couple of years ago.	Ongoing	Annual	Moderate	Active	City	Piped System	Unknown	N/A
KI-55	Sediment control at NW Congress and Louisiana	Drainage	Sedimentation	Fieldwork, City of Bend	Sediment from sanding builds up along Louisiana and clogs the ADA ramp. Runoff from Louisiana bypasses the inlet and enters the private property at the intersection.	2022	One Time	High	Active	City	No Drainage System	Unknown	N/A
KI-56	Private drainage impacting ROW on Newport Ave	Drainage	<Null>	Fieldwork, City of Bend	This location at Ace Hardware on NW Newport Ave. is an example of a location where a private parcel discharges stormwater runoff to the City ROW and causes increased flows to the system, which may or may not be accounted for in the system design. This particular issue was solved with Newport project, but the is thematic city-wide and could be addressed through policy.	Unknown	Unknown	Low	Solved	City, private	Piped System	Unknown	N/A
KI-57	Private drainage impacting public alley south of Newport Ave	Drainage	<Null>	Fieldwork, City of Bend	Before the Newport project, the public alley between Milwaukee and Newport used to receive runoff from Ace Hardware and from Overturf Butte. The runoff would overwhelm the existing drywell. The City has solved the issue by installing a deep drywell and by improving collection and conveyance in Newport with the Newport project. However, the theme of private runoff impacting public ROW is still relevant and can be found elsewhere in the City.	Unknown	Unknown	Unknown	Solved	City, private	Piped System	Unknown	N/A

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KI-58	LID design causing maintainability issues	Maintainability	Condition	Fieldwork, City of Bend	This site is one example of many where Operations staff feel that the design of LID facilities is causing difficulties with maintainability and condition of the facilities. Otak did not document every site where this is the case. Specific concerns include: curb cuts are not a good choice because of winter sanding, forebays are needed to capture sediment and facilitate cleaning, planters need mulch because the bare soil allows undesirable plants to grow, siting on corners or roundabouts makes maintenance difficult or dangerous	Ongoing	N/A	Low	Active	City	Swale	Unknown	N/A
KI-59	Stormwater Flooding Report, 576 NW Lindsay Ct. (Overturf Park)	Drainage	Erosion	Infor Work Order 1419952	Runoff from Overturf Butte runs downhill onto private property and overwhelms the catch basin and drywell. Damages exterior of private property. The drywell does infiltrate slowly but is undersized for the area. The stormwater maintenance crew installed several erosion control measures on Overturf Butte including: straw wattles, check dams, and re-vegetation. This did help, but the larger storms still cause problems. BPRD owns Overturf Park, and COB owns the 30+ ac parcel encompassing the butte and water towers. Install additional UIC's, better control of runoff on Overturf Butte. City's recent actions to control erosion have solved this issue.	2022	Unknown	High	Solved	Unclear	Drywell	Unknown	3
KI-60	Stormwater Flooding Report, 59 SW Hayes Ave	Drainage	<Null>	Infor Work Order	Historic flooding location. Water puddles in road before it can flow east to the catch basin and drywell. Creates moderate traffic impacts. Mike's Fence Center did some work on the property to control stormwater, and it has helped. But water still puddles in the driveway to the food bank. Suggested solution is to install additional catch basins and connect to drywell, install additional UICs, and install a regional swale. This may be an example of uncontrolled private runoff which affects the ROW.	Unknown	Infrequent	Moderate	Active	City	No Drainage System	Unknown	3
KI-61	Stormwater Flooding Report, 162 NW Utica Ave	Drainage	<Null>	Infor Work Order 787107	Stormwater flows onto and through property, causing exterior property damage. New drainage was previously installed to capture runoff from NW Vicksburg Ave. There are catch basins that convey water through up-basins from NW Utica down NW 2nd to the storm mainline on NW Saginaw ultimately flowing to the river. Suggested solution is to install a sediment manhole, storm drains, and drywell. City notes issue is solved as of 7/2024.	2017	Unknown	High	Solved, Monitor	City	No Drainage System	Unknown	3
KI-62	Stormwater Flooding Report, 1507 NE 1st St	Drainage	<Null>	Infor Work Order	Historic flooding location. Water from Olney and 1st converge causing flooding on private property (exterior damage). There is one drillhole which was re-drilled in 2017 and does infiltrate, yet it can become overwhelmed in larger storms. Water puddles on the north and south side of the intersection.	Unknown	Infrequent	High	Active	City	Drillhole	Unknown	3

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KI-63	Illicit discharge detected to outfall	Water Quality-Surface Water	<Null>	2023 Illicit Discharge Inspections	Trickle discharge detected during dry weather inspection. Could not sample due to trickle. Flow contained, not reaching River. Verified roof connection. Could be condensate from air conditioner.	2023	Unknown	Low	Solved, Monitor	City	Piped System	Unknown	N/A
KI-64	Location and status of outfall DOF000076 is unknown	Maintainability	<Null>	2023 Illicit Discharge Inspections	Outfall in McKay Park not found during 2023 dry weather illicit discharge screening inspections. City's GIS data lists the outfall as abandoned.	2023	Ongoing	Low	Active	City	Piped System	Unknown	N/A
KI-65	Quiet Canyon Loop Erosion and Flooding	Erosion	Drainage	April field visit agenda	Houses do not have gutters in this relatively recent development. Residential lot landscaping erodes during large storms. Flooding, mud, debris enter right of way.	2022	Unknown	Moderate	Active	City	Drillhole	Unknown	N/A
KI-66	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009485, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A
KI-67	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009498, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A
KI-68	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009510, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A
KI-69	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009513, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A
KI-70	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009514, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A
KI-71	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009520, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A
KI-72	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009550, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A
KI-73	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009624, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A
KI-74	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009625, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A

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KI-75	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009727, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A
KI-76	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009728, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A
KI-77	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009763, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A
KI-78	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009764, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A
KI-79	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009765, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A
KI-80	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009766, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A
KI-81	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009767, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A
KI-82	Drillhole Decommissioning Location – Priority Rank 1	Water Quality-Groundwater	Condition	Drillhole Decommissioning Framework memo by GSI, July 2024	Drillhole, with ID DDH009841, has been identified as a priority #1 location for water quality retrofit or decommissioning to protect groundwater and improve maintenance operations.	<Null>	<Null>	Moderate	Active	City	Drillhole	Unknown	N/A
KI-83	Flooding and ice at intersection	Drainage	<Null>	Utilities Public Advisory Group	The corners get quite flooded when the snow melts or heavy rains, and then turn into an ice rink in the evenings during winter.	Unknown	Unknown	Moderate	Active	City	<Null>	Unknown	N/A
KI-84	Outfall Retrofit Need Identified, Outfall Basin 266 & 14N	Water Quality-Surface Water	<Null>	Outfall Needs Assessment Memo, Otak, 2024	Outfall Basin 266 & 14N has been identified as the highest priority basin for outfall retrofit to improve surface water quality. This is the upper basin contributing to the Newport outfall.	N/A	N/A	Moderate	Active	City	Piped System	497	N/A
KI-85	Outfall Retrofit Need Identified, Outfall Basin 024	Water Quality-Surface Water	<Null>	Outfall Needs Assessment Memo, Otak, 2024	Outfall Basin 024 has been identified as the second priority basin for outfall retrofit to improve surface water quality.	N/A	N/A	Moderate	Active	City	Piped System	70	N/A
KI-86	Outfall Retrofit Need Identified, Outfall Basin 020	Water Quality-Surface Water	<Null>	Outfall Needs Assessment Memo, Otak, 2024	Outfall Basin 020 has been identified as the third priority basin for outfall retrofit to improve surface water quality.	N/A	N/A	Moderate	Active	City	Piped System	56	N/A

Bend Stormwater Master Plan
Known Issues
October 1, 2024

Known Issues ID	Full Name	Issue Primary	Issue Secondary	Information Source	Long Description	Last Year of Occurrence	Frequency	Severity	Status	Issue Ownership	Infrastructure Affected	Basin Size	City Priority
KI-87	Outfall Retrofit Need Identified, Outfall Basin 013	Water Quality-Surface Water	<Null>	Outfall Needs Assessment Memo, Otak, 2024	Outfall Basin 024 has been identified as the second priority basin for outfall retrofit to improve surface water quality.	N/A	N/A	Moderate	Active	City	Piped System	70	N/A
KI-88	Outfall Retrofit Need Identified, Outfall Basin 018	Water Quality-Surface Water	<Null>	Outfall Needs Assessment Memo, Otak, 2024	Outfall Basin 024 has been identified as a tie for fourth priority for outfall retrofit to improve surface water quality.	N/A	N/A	Moderate	Active	City	Piped System	24	N/A
KI-89	Outfall Retrofit Need Identified, Outfall Basin 128	Water Quality-Surface Water	<Null>	Outfall Needs Assessment Memo, Otak, 2024	Outfall Basin 024 has been identified as the sixth priority basin for outfall retrofit to improve surface water quality.	N/A	N/A	Moderate	Active	City	Piped System	13	N/A

Memorandum

To: Austin Somhegyi, City of Bend

From: Trista Kobluskie, Philip Kenyon, PE

Copies: Lori Faha, Elisabeth O’Keefe, File

Date: August 27, 2024

Subject: Outfall Retrofit Needs Assessment

Project No.: 20359

Introduction

The City of Bend is updating its Stormwater Master Plan (SMP) and is reviewing its existing stormwater outfalls to identify retrofit needs and opportunities. Stormwater in the City of Bend discharges predominantly into underground injection controls (UICs). However, the area around the Deschutes River north of Farewell Bend Park discharges to the river itself. Geographic Information System (GIS) records indicate that there are 31 outfalls owned by the City of Bend. An outfall is a point discharge from the City’s Municipal Separate Storm Sewer System (MS4) into the river. A majority of these outfalls are not located on City-owned property and are located either on Bend Park and Recreation Department (BRPD) properties or located on other private properties. This Outfall Retrofit Needs Assessment studies the characteristics of each outfall’s contributing basin with respect to its pollution source potential and incorporates information about the condition and accessibility of the stormwater pipes and outfalls.

Purpose

The purpose of this Outfall Retrofit Needs Assessment is to document the City’s stormwater quality retrofit objectives and to identify the outfalls most in need of retrofit when considering the objectives. Subsequent analyses will identify potential projects to retrofit the highest priority outfalls. The City’s MS4 permit requires the following: “The permittee must develop a Stormwater Quality Retrofit Strategy that addresses areas identified by the permittee as having an impact on water quality, and that are underserved, difficult to maintain in its current design, or lacking stormwater quality controls.

A. The stormwater retrofit strategy must be based on a permittee-defined set of stormwater quality retrofit objectives and a comprehensive evaluation of a range of retrofit control measures and its appropriate use. The permittee-defined objectives must prioritize progress toward improving water quality.

B. The permittee must submit a stormwater retrofit strategy document with permittee-defined objectives with the fourth annual report, due to the Oregon Department of Environmental Quality by November 1, 2025.

Stormwater Quality Retrofit Objectives

The City has identified the protection of the public, natural resources, water quality, and the preservation of existing City infrastructure as primary goals for their Master Plan. The stormwater quality retrofit objectives described below will support these goals.

Urban stormwater runoff is known to carry a variety of pollutants, including metals, oils, chemicals, bacteria, and nutrients. An emerging group of dissolved contaminants of concern are per- and-polyfluoroalky substances (PFAS). The City of Bend utilizes Magnesium Chloride (MgCl) for deicing operations during the winter months. The Deschutes River from Spring River to North Unit Diversion Dam (AU_ID = OR_SR_1707030104_05_102628) is listed as Category 5 Impaired for sedimentation, temperature (year round), turbidity, and pH, and is listed as Category 4 Impaired for flow modification and habitat modification. Sedimentation, turbidity and pH can all be influenced by urban stormwater.

The City staff has documented numerous instances of inlet clogging and movement of particulate material around and through the stormwater system in undesirable/unintended ways. These challenges can be referred as pretreatment challenges. Lack of pretreatment contributes to stormwater pollution in a couple of ways. First, when inlets are clogged with sediments, inlet capacity is reduced, leading to runoff flowing for longer distances over impervious surfaces and picking up more pollutants. Second, some sediments are conveyed through the piped system and discharged to the river along with pollutants that may adsorb to the particles. Typical pretreatment systems provide capture/removal of particulate matter and floatable materials.

The City staff has also documented both poor condition and maintenance access issues through camera inspection and maintenance records. Where condition or access issues have been documented, the need for retrofit is coupled with a need for repair or redesign of the pipe system.

The stormwater quality retrofit objectives are:

1. Reduce polluted discharges from largest contributing areas that do not already have treatment.
2. Prioritize removal of typical urban stormwater pollutants from higher intensity land uses.
3. Prioritize protecting the capacity and function of existing stormwater conveyance, treatment and infiltration facilities.
4. Prioritize retrofits for outfalls where repairs, rehabilitation, or realignment of pipes and structures is necessary to correct poor condition and/or lack of access to public infrastructure.

Needs Analysis

Otak has developed a framework for prioritizing outfall basins for retrofit in collaboration with the City of Bend by calculating a score identifying need for retrofit for each outfall basin. The score is calculated based on the following criteria: untreated area, pollutant load, sediment load, and maintenance access/pipe condition. Scoring for each criterion is explored below.

Untreated Areas

Reducing polluted discharges from the largest contributing areas that do not already have treatment has been identified as a water quality objective. There are 32 outfall drainage basins as shown in Figure 1. Three basins have multiple outfalls and are identified as such. One basin (labeled “TBD”) is delineated in the City’s stormwater inventory but has no associated point outfall identified with it in the inventory. The

City identified one very large basin draining to the Newport outfalls. Based on conversations with the City about the recent improvements along Newport Avenue, this large basin has been divided into two smaller basin polygons for the purposes of this assessment. The basins range in size from 0.2 acres to 497.4 acres. For the purposes of this assessment, areas within the MS4 basins draining to runoff treatment facilities or UICs are considered treated areas that are not in need of retrofit. Approximate treated areas are represented visually on Figure 1 and have been tabulated in Table 7.

Treated areas have been estimated at a planning level as follows:

- UICs: approximately 150 UICs have been identified within the boundaries of the outfall drainage basins. Each UIC is assumed to have 12,500 square feet of area draining to it based on a GIS analysis conducted by the City (City of Bend, 2024). Private stormwater swales: private stormwater swales are assumed to provide runoff treatment for the tax lots on which they are located.

- Public stormwater swales: public stormwater swales are assumed to have been sized using a 6% sizing factor, i.e., the swale area is 6% of the area that drains to it. While this rationale is not included in the COSM, it is a simplified approach used in low-infiltration (2 in/hr or less) areas in parts of north-western Oregon. Clean Water Services utilizes a 6% sizing factor (CWS, 2019).

- Contech StormFilter© cartridge vaults and catch basins: we collected drainage basin size for each StormFilter© vault by reviewing the drainage report.

After calculating treated area within a basin, the remaining basin area is considered untreated.

Untreated Area Scores

Outfall basins are scored from 0 to 3 according to the acreage of untreated area as shown in Table 1.

Table 1 Untreated Areas Scoring

Untreated Area (ac)	Score	Basins in this Category (each)
0-10	0	17
10-50	1	8
50-150	2	4
150+	3	2

Pollutant Load

Removal of typical urban stormwater pollutants has been identified as a water quality objective. Pollutant loads can be correlated to land uses and high-traffic roadways. A desktop GIS review of roadway classifications revealed that only moderate variation of roadway types is present within the outfalls study area, with the highest polluting roadways in the City (highways, etc.) being located outside of the area. However, roadways are spatially correlated with land uses such that higher-traffic count roads are adjacent to more intense land uses. Therefore, for this assessment both land use and roadway pollutant intensity are represented by the City's established zoning. Otak classified zoning into three intensities of pollutant generation, as follows:

- Low pollutant generating land uses include residential, urban reserve, professional offices, and most public facilities such as parks and schools (those with less than 80% impervious area). Zoning codes included in this category are RL, RS, RM, RM-10, RH, UAR, PO, and PF.

- Moderate pollutant generating land uses include mixed uses and commercial uses, as well as public facilities with more than 80% impervious area. A visual inspection of the public facilities within the outfall drainage basins shows two bridge areas as being more than 80% impervious. Zoning codes included in this category are ME, MR, MN, MU, CB, CC, CL, CG, and CN.

- High pollutant generating land uses include industrial and special planned districts. Zoning codes included in this category are IG, IL, and SM.

Pollutant Load Scores

Outfalls are scored from 0 to 3 for pollutant load based on the relative amounts of area in each land use category. Table 2 summarizes the scoring for this factor. The scoring is additive; an outfall basin is awarded a point for each criterion it meets.

Table 2 Pollutant Load Scoring

Description	Add Score	Basins Eligible for this Point (each)
Only "Low" Loading	0	20
Any amount of "High" Loading	Add 1	1
At least 1 acre of "Moderate" Loading	Add 1	10
More than 10 acres of "Moderate" Loading	Add 1	4
Maximum Score is 3		

The counts of basins by total score are listed below:

- Score 0: 20 basins
- Score 1: 7 basins
- Score 2: 4 basins
- Score 3: 0 basins

Sediment Load

Protecting the capacity and function of existing stormwater treatment and infiltration facilities has been identified as a water quality objective. Under existing conditions, the City has collected evidence through tracking drainage complaints and maintenance service calls that sediment in the collection and conveyance system from erosion and winter street maintenance threatens the capacity, function, and longevity of collection, conveyance, and runoff treatment systems within the outfalls basins.

Within the MS4 area, Awbrey Butte has slopes greater than 15%, which then flatten out as it approaches the river (slopes less than 5% slope). Although portions of Awbrey Butte have been developed under more recent and more protective stormwater standards, sediment is still deposited and transported to storm systems on the roads due to runoff flowing over bare or erodible soils and landscaping and sanding for winter traction (HDR, 2017). City staff reported that some of the main roads that lead up or down from Awbrey Butte transport significant sediment.

The City of Bend has soils that are predominantly friable and non-cohesive (GSI, 2020). Older parts of the City are lacking curb and gutter infrastructure. In some cases, low exposure curbs approximately three inches tall are present. In these locations, loose sediment readily moves across roadways, alleys, sidewalks, driveways, paths, etc. during storms. The City applies sand during the winter to provide traction during icy conditions. The steepest roads in the City receive the most sand.

The City's staff reported that most of their catch basins have sumps, but the depth of these sumps may vary. The City has also identified that some of the filter media cartridge treatment vaults lack pretreatment structures that would extend the service life of the cartridges by capturing trash and larger sediment particles prior to runoff entering the filter vault. Implementation of pretreatment vaults would lessen frequency of clogging of filters and bypassing of flows during storm events.

For the purposes of this assessment, site topography has been identified as an indicator of higher sediment loads.

Slopes have been separated into three categories: "Flat," "Moderate," and "Steep." Flat slopes are defined as less than 5% slopes, Moderate slopes are greater than or equal to 5% and less than or equal to 15% slopes, and Steep slopes are defined as greater than 15% slopes.

Sediment Load Scores

We calculated a "slope factor" in Excel for each outfall basin derived from the inverse of the relative proportions of each slope category normalized against basin size. Then we calculated a score for slope from the slope factor, where higher slope factors are associated with higher scores. Larger slope factors correspond to higher scores (Table 3).

Table 3 Sediment Load Scoring

Slope Factor	Score	Basins in this Category
0.00-0.25	0	7
0.25-0.40	1	15
0.40-0.55	2	4
0.55-1.00	3	5

Related Known Issues

The preliminary planning steps for the Stormwater Master Plan have identified numerous known issues within the outfall basins. Additional emphasis is given in this assessment where there are documented pipes or structures in poor condition based on closed-circuit television (CCTV) investigation, documented maintenance access issues, drainage issues, or documented sedimentation issues. See related known issues descriptions in the notes on Table 7.

Related Known Issues Scoring

The City has provided a list of drainage known issues with priority scores attached to them. A score of 3 (the highest score) is given to outfall identified by the City's maintenance team as being "Priority 1" or highest priority known issue. Of the remaining known issues within the MS4 permit area, the only "Priority 2" known issue was in the same basin as a "Priority 1" known issue and the only "Priority 3" known issue was listed as being already resolved as of July 2024. After review of each of the specific known issues in each basin, a score of 0, 1, or 2 was applied based on engineering judgement of severity of the known issues. A total of 8 outfall basins have related active known issues.

Scoring Input

The scoring input values were geo-processed and mapped for visualization (Figure 2, Figures attached).

Results

The outfalls are scored from 0 to 9 by adding scores for each of the four factors above. Increasing score corresponds to increasing need for retrofit.

The average score of the outfall basins using the above scoring criteria is a score of 3. The top seven highest scoring basins have scores of 4-9. At the low end of scoring, three basins received scores of 0. Figure 1 below provides a histogram of the outfall scoring.

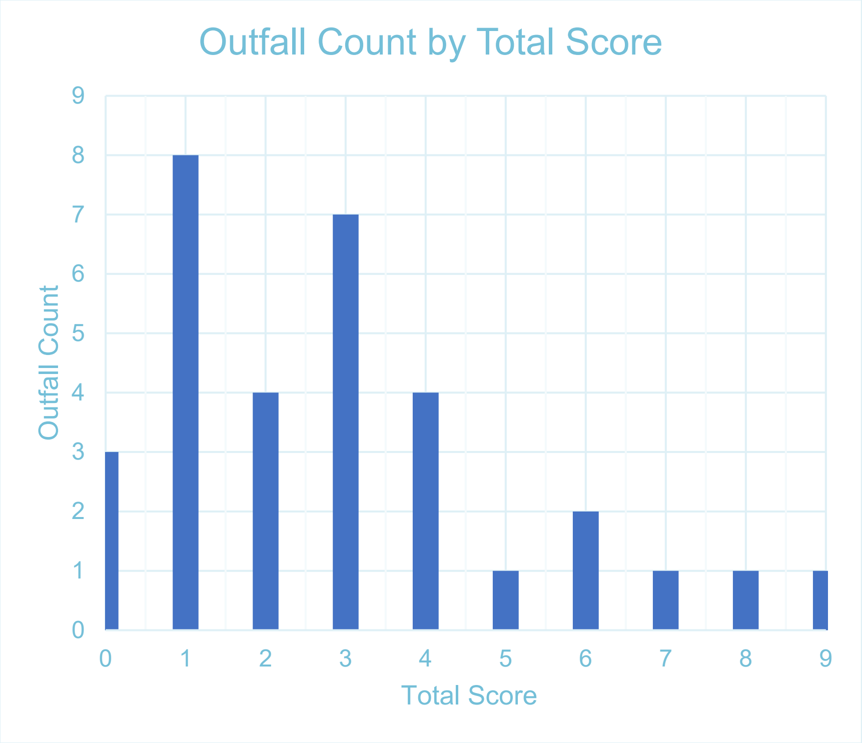

Figure 1 Outfall Retrofit Needs Score Distribution Chart

We ranked basins based on score. See Table 4 below for the outfalls in alphanumeric order, with high score / low rank denoting greatest need. There are many “tie” scores between outfalls. See Conclusions for recommendations to proceed.

Table 4 Outfall Basins' Scores and Ranks

Outfall ID	Untreated Score	Slope Score	Zoning Score	Known Issue Score	Total Score	Rank
DOF000012	0	1	0	0	1	22
DOF000013	3	3	0	0	6	4
DOF000016	0	0	0	0	0	30
DOF000017	1	0	0	0	1	22
DOF000018	1	0	2	3	6	4
DOF000019	1	1	0	2	4	7
DOF000020	2	1	2	2	7	3
DOF000022	1	1	0	1	3	11
DOF000024	2	3	1	2	8	2
DOF000034	0	1	0	0	1	22
DOF000039	2	2	0	0	4	7
DOF000040	0	1	0	0	1	22
DOF000065	0	0	1	0	1	22
DOF000066	0	1	1	0	2	18
DOF000070	0	0	0	0	0	30
DOF000108	0	1	0	0	1	22
DOF000109	0	0	0	0	0	30
DOF000110	0	1	0	0	1	22
DOF000125	0	2	1	0	3	11
DOF000127	1	1	2	0	4	7
DOF000128	1	1	0	3	5	6
DOF000130	1	1	0	0	2	18
DOF000131	2	1	1	0	4	7
DOF000192	0	2	0	0	2	18
DOF000193	0	1	0	2	3	11
DOF000200 & DOF000222 & DOF000223	0	0	1	0	1	22
DOF000207	0	3	0	0	3	11
DOF000220	0	3	0	0	3	11
DOF000221	0	2	1	0	3	11
DOF000266 & DOF000014S	2	1	0	0	3	11
DOF000266 & DOF000014N	3	3	0	3	9	1
TBD	1	1	0	0	2	18

Conclusions

Otak recommends that the highest six ranked basins be considered in the next stage of the master plan. The highest-ranking basin is very large (nearly 500 acres) and has numerous opportunities for potential retrofits. The basins recommended for further consideration are listed as ranked in Table 5.

Table 5 Priority Outfalls for Further Consideration

Outfall ID	Total Score	Rank
DOF000266 & DOF000014N	9	1
DOF000024	8	2
DOF000020	7	3
DOF000013	6	4
DOF000018	6	4
DOF000128	5	6

There is a four-way tie for the seventh-ranked outfalls, which the City could consider in an additional phase of outfall retrofits, as listed in Table 6.

Table 6 Secondary Outfalls for Further Consideration

Outfall ID	Total Score	Rank
DOF000019	4	7
DOF000039	4	7
DOF000127	4	7
DOF000131	4	7

Figure 3 (Figures attached) shows that the outfall basins ranking highest in need are mostly located west of the Deschutes river and tend to be larger basins. Large basins offer opportunities for larger “regional” facilities that simplify maintenance by centralizing captured pollutants. The “DFO000266 & DOF000014” basin has been split into north (N) and south (S) subbasins for this purpose. Even though these two subbasins outfall to the same location, there have been significant improvements to the south subbasin along Newport Avenue. There remain many opportunities in the South Awbrey Butte area to the north. The rating and ranking classified the large north basin as the highest priority basin. A challenge with regional facilities is often the space that they require (whether vegetated or underground), which can be prohibitively expensive where valuable real estate / easements must be purchased. Regional vegetated/above-ground facilities may be difficult to locate due to the land uses in the most highly ranked basins. However, stormwater pretreatment systems such as hydrodynamic separators may centralize pollutants for easier maintenance if they can be located within the existing right-of-way.

Table 7 **Outfall Rating and Ranking**

		Untreated Area			Slopes								Zoning							Related Known Issues		Total Score and Rank	
Outfall ID	**Basin Area**	**Untreated Area (acres)**	**Untreated Percentage**	**Untreated Score**	**Steep (acres)**	**Steep (percentage)**	**Moderate (acres)**	**Moderate (percentage)**	**Flat (acres)**	**Flat (percentage)**	**Slope Factor**	**Slope Score**	**High Load (acres)**	**High Load (percentage)**	**Medium Load (acres)**	**Medium Load (percentage)**	**Low Load (acres)**	**Low Load (percentage)**	**Zoning Score (See Notes Table)**	**Known Issues (See Notes Table)**	**Issues Score**	**Total Score**	**Rank**
DOF000012	3.7	3.7	100%	0	0.1	4%	0.7	18%	2.9	78%	0.36	1	0	0%	0.0	0%	3.7	100%	0		0	1	**22**
DOF000013	170.4	160.3	94%	3	16.9	10%	75.4	44%	78.1	46%	0.58	3	0	0%	0.0	0%	170.5	100%	0		0	6	**4**
DOF000016	7.9	7.9	100%	0	0.0	0%	0.7	8%	7.2	91%	0.16	0	0	0%	0.0	0%	7.9	100%	0		0	0	**30**
DOF000017	11.2	11.0	98%	1	0.0	0%	1.3	11%	9.9	88%	0.20	0	0	0%	0.0	0%	11.2	100%	0		0	1	**22**
DOF000018	24.2	20.5	85%	1	0.2	1%	2.4	10%	21.5	89%	0.20	0	0	0%	19.0	79%	5.2	21%	2	Yes	3	6	**4**
DOF000019	11.3	11.1	98%	1	0.1	1%	1.8	16%	9.3	83%	0.29	1	0	0%	0.0	0%	11.3	100%	0	Yes	2	4	**7**
DOF000020	56.0	52.7	94%	2	0.6	1%	9.6	17%	45.8	82%	0.30	1	0	0%	11.0	20%	45.0	80%	2	Yes	2	7	**3**
DOF000022	21.4	21.0	98%	1	0.3	2%	4.2	20%	16.8	79%	0.34	1	0	0%	0.0	0%	21.3	100%	0	Yes	1	3	**11**
DOF000024	70.4	65.9	94%	2	10.7	15%	21.7	31%	37.9	54%	0.59	3	0	0%	4.6	6%	65.9	94%	1	Yes	2	8	**2**
DOF000034	0.7	0.6	75%	0	0.0	0%	0.2	22%	0.6	77%	0.36	1	0	0%	0.0	0%	0.7	100%	0		0	1	**22**
DOF000039	97.1	91.7	94%	2	10.2	11%	18.0	19%	68.9	71%	0.45	2	0	0%	0.7	1%	96.4	99%	0		0	4	**7**
DOF000040	14.4	9.4	65%	0	0.3	2%	2.9	20%	11.2	78%	0.35	1	0	0%	0.0	0%	14.4	100%	0		0	1	**22**
DOF000065	9.2	8.9	97%	0	0.2	2%	1.0	11%	8.0	87%	0.24	0	0	0%	1.0	11%	8.2	89%	1		0	1	**22**
DOF000066	1.3	1.1	89%	0	0.1	5%	0.2	17%	1.0	77%	0.37	1	0	0%	1.3	100%	0.0	0%	1		0	2	**18**
DOF000070	1.4	1.4	100%	0	0.0	0%	0.1	6%	1.3	94%	0.12	0	0	0%	0.0	0%	1.4	100%	0		0	0	**30**
DOF000108	0.3	0.3	100%	0	0.0	11%	0.0	4%	0.3	82%	0.31	1	0	0%	0.1	43%	0.2	57%	0		0	1	**22**
DOF000109	0.4	0.4	100%	0	0.0	0%	0.0	6%	0.3	93%	0.14	0	0	0%	0.4	100%	0.0	0%	0		0	0	**30**
DOF000110	4.2	4.2	100%	0	0.1	2%	0.7	17%	3.4	81%	0.31	1	0	0%	0.0	0%	4.2	100%	0		0	1	**22**
DOF000125	0.8	0.6	79%	0	0.1	8%	0.2	27%	0.5	64%	0.51	2	0.3	34%	0.0	6%	0.4	59%	1		0	3	**11**
DOF000127	52.7	32.6	62%	1	1.7	3%	6.6	13%	44.5	84%	0.27	1	0	0%	45.5	86%	7.2	14%	2		0	4	**7**
DOF000128	12.7	12.7	100%	1	0.1	1%	2.0	16%	10.6	83%	0.28	1	0	0%	0.0	0%	12.7	100%	0	Yes	3	5	**6**
DOF000130	20.0	19.5	98%	1	0.6	3%	3.8	19%	15.6	78%	0.35	1	0	0%	0.0	0%	20.0	100%	0		0	2	**18**
DOF000131	67.4	63.6	94%	2	0.3	0%	10.2	15%	56.9	84%	0.26	1	0	0%	2.6	4%	64.8	96%	1		0	4	**7**
DOF000192	7.8	6.8	87%	0	0.9	11%	1.6	21%	5.3	68%	0.48	2	0	0%	0.0	0%	7.8	100%	0		0	2	**18**
DOF000193	7.8	7.5	96%	0	0.5	6%	1.3	16%	6.1	77%	0.37	1	0	0%	0.0	0%	7.8	100%	0	Yes	2	3	**11**
DOF000200 & DOF000222 & DOF000223	1.1	1.0	88%	0	0.0	0%	0.1	8%	1.0	91%	0.17	0	0	0%	1.0	89%	0.1	11%	1		0	1	**22**
DOF000207	0.2	0.2	100%	0	0.1	31%	0.0	29%	0.1	39%	0.67	3	0	0%	0.2	100%	0.0	0%	0		0	3	**11**
DOF000220	3.7	3.4	92%	0	0.3	7%	1.6	44%	1.8	48%	0.56	3	0	0%	0.0	0%	3.7	100%	0		0	3	**11**
DOF000221	1.6	1.3	85%	0	0.1	5%	0.4	24%	1.1	70%	0.45	2	0	0%	1.6	100%	0.0	0%	1		0	3	**11**
DOF000266 & DOF000014S	95.3	55.1	58%	2	2.1	2%	17.5	18%	75.8	79%	0.33	1	0	0%	16.1	17%	79.2	83%	0		0	3	**11**
DOF000266 & DOF000014N	497.4	486.5	98%	3	73.5	15%	278.6	56%	145.2	29%	0.58	3	0	0%	0.6	0%	496.9	100%	0	Yes	3	9	**1**
TBD	11.5	10.6	93%	1	0.3	3%	2.3	20%	8.9	77%	0.36	1	0	0%	0.0	0%	11.5	100%	0		0	2	**18**

Updated 8/27/2024

Related Known Issues Notes

Outfall ID	**Description**
DOF000018	Rationale: Score this as 3, City identified two "Priority 1" issues in the basin related to long pipe runs with limited access for maintenance.
DOF000019	Rationale: Score this as 2, City reported that this issue occurred at multiple places in the neighborhood, and this was concern for private property.
DOF000020	Rationale: Score this as 2, Tear in the pipe represents potential sinkhole concern.
DOF000022	Rationale: Score this as 1, CCTV shows root intrusion and a void but no outward indicators of an issue.
DOF000024	Rationale: Score this as 2, damage to pipe is a potential safety concern (though it is on private property), there are reported inlet clogging problems, and some flooding.
DOF000128	Rationale: Score as 3, there are multiple "Priority 1" issues identified by the City staff in this basin.
DOF000193	Rationale: Score as 2, gas line through a pipe with a "huge void" is a safety and utility concern.
DOF000266 & DOF000014 N	Rationale: Score as 3, Awbrey Butte is one of the highest priority stormwater issue locations in the City.

Zoning Notes

Outfall ID	**Description**
DOF000266 & DOF000014 S	Rationale: This basin ranks highly based on land use zone, however Newport Ave has had significant improvements to treat runoff, substantially attenuating the impact of the land use zoning. This basin has been scored "zero" for zoning.

References

GSI, 2020. *Stormwater Infiltration Evaluation Update*. October 2020. GSI Water Solutions, Inc.

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Central Oregon Intergovernmental Council, 2010. *Central Oregon Stormwater Manual.* Update August 2010.

CWS, 2019. *Design and Construction Standards, Chapter 4.* Clean Water Services. November 12, 2019.

City of Bend, 2024. *Groundwater Protectiveness Demonstration Update for Per- and Polyfluoralkyl Substances (PFAS), City of Bend, Oregon.* April 14, 2024.

Figures

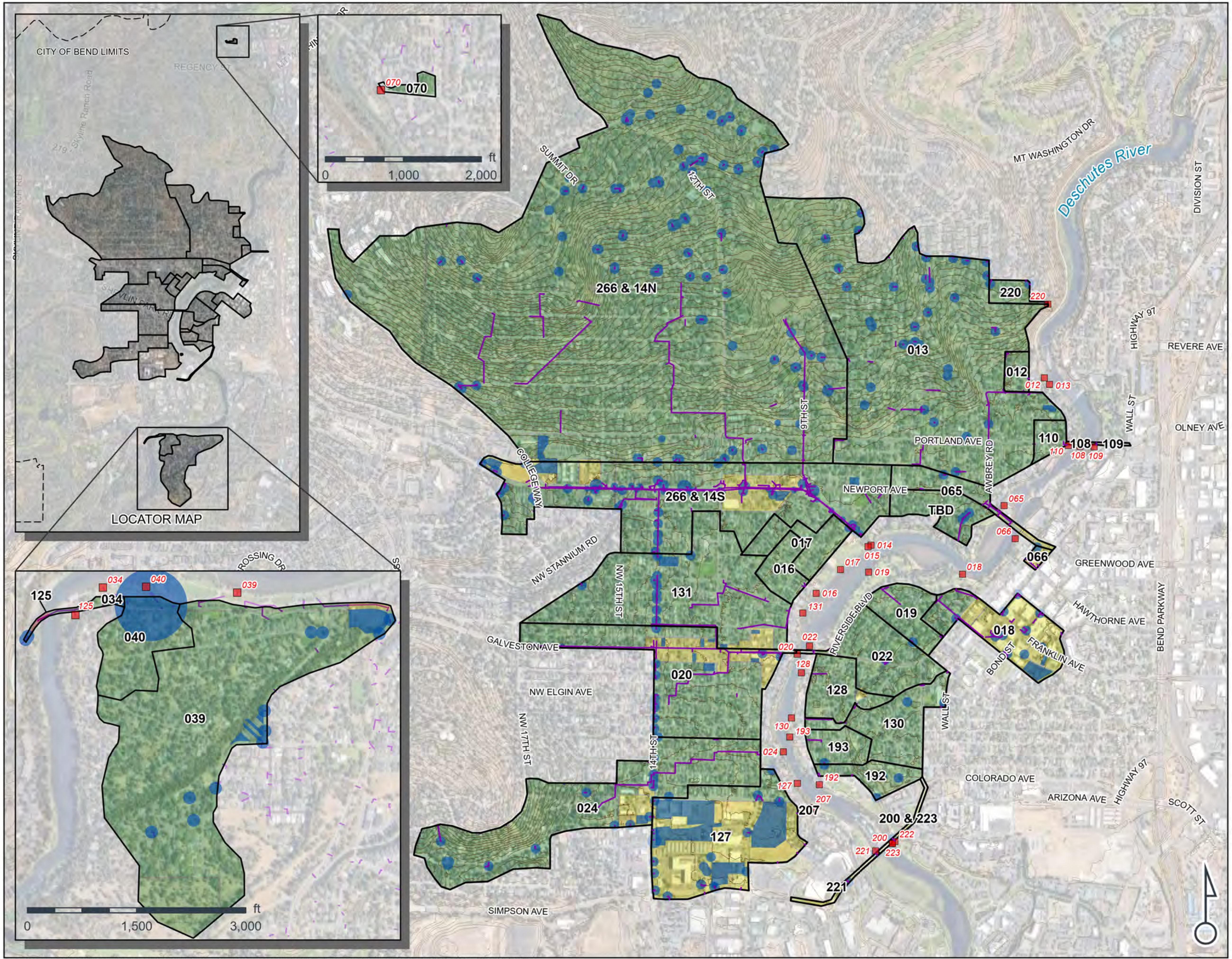


FIGURE 2

STORMWATER OUTFALL NEEDS ASSESSMENT INPUTS

BEND STORMWATER MASTER PLAN

BEND, OREGON

LEGEND

- 🟥 Outfalls
- — Storm Main
- ☐ Outfall Basin Delineation
- 🟦 Representative Treated Areas
- — Contours (10')

Zoning Type Pollutant Load

- 🟥 High
- 🟨 Moderate
- 🟩 Low

0 1,500 3,000 ft

Data Sources: City of Bend, USGS, Google Maps.
Date: 8/20/2024
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

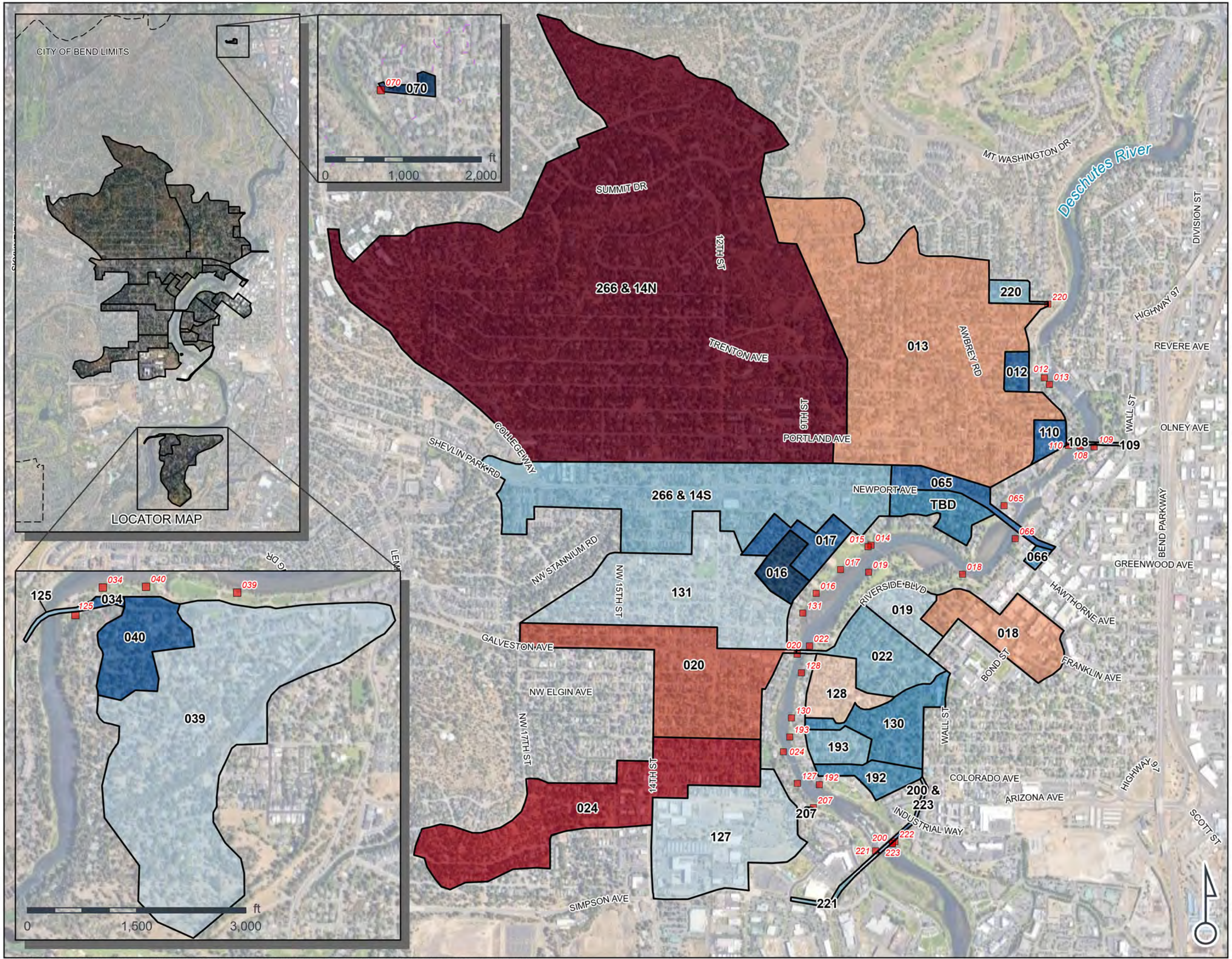
O:\PROJECT\20300\20359\04 CAD\GIS\APRX\20359 BEND OUTFALL STUDY\20359 BEND OUTFALL STUDY JR\20359 BEND OUTFALL STUDY JR.APRX

FIGURE 3

STORMWATER OUTFALL BASIN RANKING

BEND STORMWATER MASTER PLAN

BEND, OREGON



LEGEND

▭ Outfall Basin Delineation

■ Outfalls

Outfall Basin Ranking

Rank

- 🟥 1
- 🟥 2
- 🟧 3
- 🟧 4
- ▨ 6
- 🟦 7
- 🟦 11
- 🟦 18
- 🟦 22
- 🟦 30

0 1,500 3,000 ft

Data Sources: City of Bend, USGS, Google Maps.
Date: 8/27/2024
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

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GSI Water Solutions, Inc.

FINAL TECHNICAL MEMORANDUM

Modified Drywell Siting Criteria and Drillhole Decommissioning Framework, City of Bend, Oregon

To:	Trista Kobluskie, PE / Otak, Inc.
From:	Matt Kohlbecker, RG / GSI Water Solutions, Inc. Casey McGuire / GSI Water Solutions, Inc.
CC:	Elisabeth O'Keefe / City of Bend Lori Faha, PE / City of Bend
Date:	August 14, 2025
Attachments	**Figure 1** - Deep Drywell Design for Overflow at Awbrey Reservoir **Figure 2** - Areas that Meet Siting Criteria **Figure 3** - Land Use **Figure 4** - Traffic Volume **Figure 5a** - Risk Assigned to Water Well Locations – Distance from Water Wells **Figure 5b:** Risk Assigned to Water Well Locations – Risk to Public Water Wells **Figure 5c** - Risk Assigned to Water Well Locations - Perched Groundwater within the "North Bend Perched Area" or the "Old Mill District Perched Area **Figure 6** - Current Drill Hole Conditions **Figure 7** - Priority Ranking **Appendix A** – Drillhole Flooding Reports: Priority 1, Priority 2, and Priority 3 Locations **Appendix B** – Drillhole Prioritizations

1. Introduction

This technical memorandum (TM), prepared by GSI Water Solutions, Inc. (GSI) for Otak, Inc. (Otak), presents an evaluation of modified drywell suitability and a drillhole replacement prioritization to inform the City of Bend's (City) updated Stormwater Master Plan. The following sections provide an overview of Underground Injection Control (UIC) configurations, the purpose and objectives of this TM (Section 1.2), and the organization of this TM (Section 1.3).

1.1 Underground Injection Control Types and Configuration

The City uses about 6,500 UICs to manage stormwater runoff from public rights-of-way (GSI, 2023). According to the Oregon Administrative Rules, a UIC is a well, improved sinkhole, or other subsurface fluid distribution system that is used for the subsurface emplacement or discharge of fluids[1]. About 5,500 of the City's UICs are drywells, and about 1,000 of the City's UICs are drillholes. Drywells are typically 10 to 20 feet deep cylindrical structures constructed of 4-foot diameter concrete rings with weep holes. Drillholes are typically 6-inch diameter open boreholes completed with a steel surface casing (generally 10 to 20 feet) (GSI, 2023) that may be up to 100 feet deep (the maximum UIC depth allowable by state law for rule authorized UICs[2]). Recently, new construction techniques have been introduced in Oregon that allow for installation of drywells to up to 100 feet deep (modified drywells).

Drillholes are more common west of the Deschutes River where low-permeability volcanic ash layers are prevalent, and in older parts of the City. New drillholes have not been permitted in the City standards for several years due to maintenance issues, the lack of pretreatment, and due to the difficulty and expense of retrofitting.

1.2 Purpose and Objectives

The purpose of this TM is to provide the City with information about new-to-Oregon stormwater infiltration devices (i.e., modified drywells) and a prioritization framework for decommissioning of old stormwater infiltration devices (i.e., drillholes) to inform the City's 2024 Stormwater Master Plan update. The objectives of the TM are:

- Provide an overview of modified drywells, including advantages and disadvantages.
- Develop criteria for minimizing the risk of environmental contamination from modified drywells.
- Develop a prioritization framework for decommissioning drillholes.

1.3 Technical Memorandum Organization

The remainder of this TM is organized as follows:

- Section 2: Provides criteria for siting modified drywells
- Section 3: Outlines drillhole replacement and upgrade prioritization

2. Modified Drywell Siting Criteria

Conventional drywells, which comprise the City's approximately 5,500 drywells, are 4-foot diameter structures typically excavated with a hydraulic clam shell that have a maximum depth of approximately 40 feet in Oregon. Modified drywells have a similar diameter as conventional drywells but are excavated with large-diameter augers. Modified drywells are deeper than conventional drywells, generally up to 100 feet deep depending on local geology. The City's Stormwater Sedimentation Manhole, with proposed modifications for drywell design is shown in Figure 1. This design includes 150 gallons of spill control containment capacity.

Modified drywells have been used in the desert southwest since the 1970s; they have been installed at significant depths to bypass shallow, low-permeability caliche layers and rock. Recently, the City of Gresham, Oregon, constructed a modified drywell to bypass a shallow perched aquifer, and King County has managed stormwater runoff in dense residential neighborhoods by drilling 50 to 100 feet deep drywells to bypass shallow, low permeability glacial till and infiltrate stormwater into the underlying sands (Radford, 2016). The City of Bend has been receiving increased requests from developers to construct modified drywells.

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[1] OAR 340-044-0005(24)

[2] OAR 340-044-0018(3)(a)(G)

This section summarizes the advantages of modified drywells (Section 2.1), the disadvantages of modified drywells (Section 2.2), criteria for siting modified drywells to minimize the risk of environmental contamination (Section 2.3), and conclusions (Section 2.4).

2.1 Advantages of Modified Drywells

Advantages of modified drywells (when compared to drillholes or traditional drywells) include the following:

- **Footprint.** Modified drywells have a small footprint because the pretreatment device is installed within the same borehole as the drywell, making modified drywells a good option in urban areas where space is limited.
- **Bypass shallow, low-permeability soil layers**. Modified drywells can bypass shallow soils characterized by low infiltration rates (e.g., silt, clay, or volcanic ash), targeting deeper soils and sediments have higher infiltration rates.
- **Larger storage volume and improved treatment compared to a drillholes.** Because of their large-diameter, modified drywells can store a larger volume of water than a drillhole, thereby allowing the water to slowly exfiltrate from the drywell in low-permeability soil environments. In addition, unlike drillholes, proprietary modified drywells are equipped with pretreatment devices like a sedimentation manhole to allow for settling of stormwater solids, hydrocarbon-absorbent pillows, and intake screens/debris shields.
- **More head during infiltration.** Higher infiltration rates can be achieved at modified drywells because the drywell can accommodate additional mounding (i.e., head) during infiltration.

2.2 Disadvantages of Modified Drywells

Disadvantages of modified drywells (when compared to drillholes or traditional drywells) include the following:

- **Higher risk of causing groundwater contamination.** The highest risk to groundwater is from contaminants in stormwater that are toxic, common, mobile, and persistent (GSI, 2013). Pollutant fate and transport modeling by GSI (2011) showed that most common stormwater pollutants do not reach groundwater as long as there are five feet of vertical separation between the bottom of the drywell and groundwater. However, recent modeling by GSI (2024) showed that significantly larger vertical separation distances are needed to protect groundwater from emerging pollutants [i.e., per- and polyfluoroalky substances (PFAS) and simazine will reach groundwater unless there are about 53 feet and 37 feet of vertical separation, respectively]. Because modified drywells are deeper than conventional UICs, they minimize vertical separation distance and, therefore, increase the risk of groundwater pollution.
- **Difficult and expensive to clean in the case of a spill of hazardous material.** Traditionally, drywells are cleaned via pressure washing, scraping of the interior walls, and/or vacuuming with a vactor truck if a spill occurs. However, because vactor trucks are not effective on drywells that are more than 40 feet deep, removal of a spill of hazardous materials from a modified drywell cannot not be performed using traditional techniques. Options are drill or pump rigs and bailers to remove spilled material from deep drywells, which would significantly increase the cost of cleanup. In addition, remediation of spilled material that has infiltrated into soils surrounding the drywell would be significantly more expensive due to the increased depth.
- **Novelty and lack of performance data.** There is limited research on modified drywell performance in Oregon over time due to the relative newness in the Pacific Northwest. Geosyntec (2020) noted data gaps including Infiltration testing guidance prior to UIC citing and drywell lifecycle research, both of

which would be beneficial when planning a new UIC. However, it should be noted the City of Gresham's modified drywell has experienced no performance declines since it was constructed in the Spring of 2022.

- **Often more expensive than traditional UICs.**

2.3 Criteria to Minimize Risk of Environmental Contamination from Modified Drywells

This section provides criteria to minimize the risk of environmental contamination from modified drywells, including siting criteria (Section 2.2.1), construction practices (Section 2.2.2), spill mitigation (Section 2.2.3), pretreatment (Section 2.2.4), and operations and maintenance (Section 2.2.5).

2.3.1 Siting Criteria

Proper drywell siting minimizes the risk that a drywell will contaminate groundwater, and is especially important for modified drywells because groundwater contamination is significantly more expensive to clean up. As long as a 53-foot vertical separation distance between the base of the UIC and the seasonal high of groundwater are adhered to (based on the findings of GSI's 2024 Groundwater Protectiveness Demonstration Update), groundwater contamination from common stormwater pollutants should not be of concern. Contamination caused by spills of hazardous material poses the highest risk of groundwater contamination.

Drywell siting criteria are covered in Bend's standards (2023). Drywell siting should consider the local factors such as land use (which will affect the quality of the water discharging to the drywell), traffic volume, water well locations, groundwater depth, and geology. See Section 3 prioritization criteria for further information on these topics. There is a low risk that drywells meeting all of the following criteria will be impacted by a spill. Therefore, modified drywells may be sited in drainage basins that meet these criteria (see green-light areas in Figure 2):

- Residential land use
- Local, collector, minor arterial, resource, or service road street classifications,
- Outside of two-year time-of-travel zones from municipal supply wells and >500 feet from water wells, and
- Outside of areas with perched groundwater (i.e., the Old Mill District Perched Area and North Bend Perched Area).

Developers may request that modified drywells be used in areas that do not meet all these criteria. The City may consider approving modified drywell use in yellow-light areas identified in Figure 2, such areas as long as additional protective measures are incorporated into the drywell design (as shown in Figure 1). In no case should modified drywells be constructed within 500 feet of a water well or within the two-year time-of-travel zone of a municipal supply well.

The City of Gresham does not have formal siting criteria; however, the one modified drywell that has been installed so far was installed to meet the following protectiveness:

- Residential streets (< 1,000 trips per day),
- Outside of two-year time-of-travel zones from municipal supply wells, and
- Must have a shut off valve.

2.3.2 Construction

The following construction methods mitigate groundwater contamination, and should be common practice at a site where a modified drywell is being constructed:

- Drywell inlets should be sealed with two layers of UV protected geotextile material until nearby construction is complete, to prevent sediment ingress (ADEQ, 2018).
- Drywells should be covered by a solid manhole so that flow into the drywell is solely through the interceptor inlet, and the manhole should be bolted and labelled ‘stormwater only’ to prevent tampering (ADEQ, 2018).
- Manholes installed at modified drywells should be modeled on the Figure 1 to provide some level of additional spill protection.

2.3.3 Spill Mitigation

To mitigate the effect of spills, GSI recommends that Bend (similarly to what GSI previously recommended to the City of Gresham) have a spill response plan in place and automatic shut-off-valves that close when spills are detected. In addition, if the modified drywell is constructed of an infiltration pipe that runs inside the annular space between the sedimentation manhole and borehole wall, and then curves underneath the bottom of the sedimentation manhole, GSI recommends a cleanout be installed so that the infiltration pipe below the sedimentation manhole can be accessed by a bailer to clean material out of the drywell, or a brush to clean the drywell.

2.3.4 Pretreatment

Pretreatment options for stormwater discharges are described in DEQ’s Industrial Stormwater Best Management Practices Manual (Jurries and Ratliff, 2013).

Pretreatment recommendations for drywell type are described in Table 1, and should be considered for modified drywells. The best pretreatment option for a site will be determined by site characteristics and known potential pollutants at a site.

Table 1. Pretreatment Recommendations for Drywell Type.

Drywell Type	Pretreatment Goals	Types of BMPs Recommended	Additional Spill Control and Outreach Recommendations
Conventional	Manage rate of clogging[1], oil control, metals treatment	From Central Oregon Stormwater Manual (2010): ▪ Low impact development ▪ Infiltration swale ▪ Vegetated filter strips ▪ Oil/water separator ▪ Wetponds ▪ Extended detention dry ponds ▪ Evaporation ponds ▪ Grassy swales ▪ Sedimentation manholes ▪ Emerging technologies ▪ Treatment trains	N/A

Modified	"Conventional" goals, plus: ▪ Isolate and contain spills, and ▪ Capture trash ▪ Provide treatment of particulate-bound pollutants	From Geosyntec (2020): ▪ Oil absorbent pillows ▪ Debris screen ▪ Hydrodynamic separator ▪ TAPE Pretreatment GULD[2] Bioretention ▪ Media filter ▪ TAPE Basic GULD[3] (with sump element) ▪ Alternative pretreatment BMP selected based on clogging and water quality considerations (Subject to LEA approval)	From Geosyntec (2020): ▪ Conduct source control investigation and outreach for potential sources of human waste ▪ Closed bottom sump with elevated outlet, documentation of a spill response plan and adequately trained spill response team, or demonstration of low risk of spills in the drainage area ▪ Include an automatic shutoff valve

Notes

[1] Clogging is not a groundwater quality risk, however it affects the necessary maintenance intervals and lifecycle cost of a drywell and needs to be considered in selection of pretreatment BMPs.

[2] TAPE Pretreatment General Use Level Designation (GULD) BMPs are BMPs that meet 50% removal of TSS, when influent is between 100 and 200 mg/L.

[3] TAPE Basic GULD BMPs are BMPs that meet 80% removal of TSS when influent is between 100 and 200 mg/L.

2.3.5 Operations and Maintenance

Inspection and maintenance recommendations for modified drywells are outlined below. Records should be kept of all inspections, problems, and actions taken.

Inspections

Inspections should be conducted according to a schedule, ideally at least annually. The inspection should include but not be limited to the following (ADEQ, 2018):

- Ensure that no hazardous materials are being used or stored in the area.
- Check for staining, discoloration, or residue on the surrounding the area (i.e. oil stains on pavement), or odors, all of which could indicate potentially contaminating materials.
- Check settling chambers and interceptor compartments for debris and sediment (which should be removed under maintenance).
- Check chemical absorbents (where present) and replace if discolored and/or below the water surface.
- Track performance, ranging from documenting failure (e.g., performance) to testing modified drywells and comparing performance over time.

Maintenance

Maintenance of drywells should include cleaning filters and screens, replacement of chemical absorbents, and removal of sediment, debris, and trash:

- ADEQ (2018) recommends that debris and silt be removed at regularly scheduled times, i.e. at least annually, or at a minimum at the following times:
  - "In paved areas when the sediment level fills 10 percent of the effective settling capacity.
  - In landscaped areas when the sediment level fills 25 percent of the effective settling capacity.

- When ownership of the property changes.
- When material not resulting from storm water or urban surface runoff enters the drainage system interceptor or drywell settling chamber."

Regular street cleaning should also be conducted to reduce debris sources that could be mobilized by runoff to enter the UICs.

2.4 Advantages, Disadvantages, and Risk Minimization Conclusions

Table 2 below summarizes the modified drywell disadvantages (i.e., higher risk of causing groundwater contamination, difficult to clean, and lack of performance data) and options for minimizing the risk associated with each disadvantage.

Table 2. Modified Drywell Disadvantages and Mitigation Options.

Disadvantage	Risk Minimization Option		Option Details
Groundwater contamination	Siting		Establish siting criteria based on land use, perched groundwater areas, setbacks from water wells, and traffic volume
	Construction		Seal drywell inlets, secure manhole cover, sump
	Spill mitigation		Spill response plan, shut off valve
	Pretreatment		Require enhanced pretreatment (e.g., spill control manholes)
	Operations and Maintenance		Inspections at least annually, regular cleaning of drywell and street
Difficult/expensive to clean	Preventative measures (so cleaning not required)	Siting	Setbacks from potential sources of large sediment load associated with construction sites, or implement other best management practices
		Construction	Seal drywell inlets, secure manhole cover, sump
		Spill mitigation	Spill response plan, automatic shut off valve, install cleanout to access infiltration pipe
		Pretreatment	Require enhanced pretreatment (e.g., engineered media filters, vegetated strips, manufactured devices, and detention basins)
	Operations and Maintenance		Inspections at least annually, regular cleaning of drywell and street
Novelty and lack of performance data	Operations and Maintenance		Track and compile records of drywell failure and performance testing

3. Prioritization Framework for Drillhole Decommissioning

A drillhole is a 6" diameter open hole, typically completed with 20 feet of surface casing, that varies in depth from 10 feet to over 100 feet deep (City of Bend, 2012). Drillholes have not been allowed in the City's Standards and Specifications for several years, in part because they require frequent maintenance, are characterized by a lack of pretreatment, and they can be difficult and expensive to retrofit. This section provides a framework for prioritizing drillhole retrofits and/or replacements to meet the City's goal of efficiently managing stormwater by infiltration in a manner that is protective of groundwater quality.

3.1 Methods for Developing Framework to Prioritize Drillhole Decommissioning

GSI developed a framework for prioritizing drillhole decommissioning, in collaboration with the City of Bend, by calculating a risk score for each drillhole. The risk score was calculated for each drillhole location based on the following criteria: land use (Section 3.1.1), traffic volume (Section 3.1.2), risk to drinking water quality (Section 3.1.3), and current drillhole condition (Section 3.1.4). Each criterion was divided into different risk categories (e.g., high, medium or low), a score was assigned to each category, and a weighting was assigned to each score. Weighting was either applied as an “additive” (meaning the total risk score for a given drillhole is determined by summing the score for the criterion) or a “multiplier” (meaning the total risk score for a given drillhole is determined by multiplying the score for the criterion).

3.1.1 Land Use

Land use is correlated with pollutant load and likelihood of a hazardous material spill. Drillholes located in land use categories associated with higher pollutant loads and spill potential were prioritized for retrofit or replacement. Land use categories are shown in Table 3, and are classified into “high risk,” “moderate risk,” and “low risk” categories such that the highest risk is associated with the highest pollutant load and spill likelihood. The land use dataset is from the City of Bend Zoning Designations. Risk assigned to Land Use categories are shown on Figure 3.

Table 3. Risk Assigned to Land Use (City of North Bend, 2015; City of Bend, 2024).

Risk Category	City of Bend Zoning Designation	Definition	Score Assigned	Multiplier or Additive
High Risk	Industrial	Manufacturing and Production, industrial service, warehouse, transportation, freight, and distribution	3	Additive
Moderate Risk	Commercial	Retail, services, and offices	2	Additive
	Mixed-Use	Residential land use with retail/commercial/office and/or service uses in the same building or on the same site.		
	Public Facility (AND >50% impervious[1])	Public facilities, including Town Hall, recycling center, Community parks, sports complexes (and other outdoor recreation)		
	Urban Area	Urban Growth Area, i.e. area that may be developed in the future but not yet determined what land use it will be developed to.		
Low Risk	Public Facility (AND <50% impervious[1])	<80% developed to just capture community parks, sports complexes (and other outdoor recreation)	1	Additive
	Professional Office	"The Professional Office zone is intended to provide for professional offices in locations near arterial or collector streets and to provide a transition of uses between residential areas and other more intensive zones. Through design standards, the Professional Office zone is intended to create a mix of high density residential housing, office and service commercial developments that are pedestrian oriented and provide a positive contribution to the streetscape."		
	Residential	Low to high-density housing		

Note:

[1] The 50% impervious threshold was used to ensure the Deschutes Recycling center was captured. This site is within the 'public facilities' layer but is a higher risk than other facilities including parks that predominantly made up this layer so this impervious threshold was added to weed out this and other potentially contaminating sites.

3.1.2 Traffic Volume

Traffic volumes are correlated with pollutant load to a UIC, such that local streets are expected to have a lower number of trips per day and therefore a lower pollutant load than for example highways, which would have a higher pollutant load due to higher brake pad wear, deposition of hydrocarbon combustion byproducts, etc.

Drillholes located on highways, major arterials, and ramps were prioritized for retrofit or replacement. Data for this category came directly from the City, in a shapefile titled 'Road_Centerlines.' Risk categories that were assigned to Traffic Volume are outlined in Table 4 and displayed on Figure 4.

Table 4. Risk Assigned to Street Classifications and Associated Traffic Volumes.

Risk Category	Road classes within this category	Score Assigned	Multiplier or Additive
High Risk	Highways; Major Arterials; Ramps	3	Additive
Low – Moderate Risk	Local; Collector; Minor Arterial; Resource; Service	1	Additive

3.1.3 Risk to Drinking Water Quality

This risk posed by drillholes to drinking water quality was assessed by considering the distance between the drillhole and the nearest water well (i.e., whether a drillhole is located within the two-year time-of-travel zone or 500 feet of a water well) and the depth to groundwater. A time-of-travel zone is the volumetric extent of groundwater that is pumped by a drinking water well over a given time period. For example, the two-year time-of-travel zone represents the groundwater that is pumped by a drinking water well over two years. DEQ rules discourage construction of UICs within the two-year time-of-travel zone to minimize risk to groundwater quality. If a two-year time-of-travel zone has not been delineated for a well, then DEQ rules discourage construction of UICs within 500 feet of a water well. In addition to location relative to a water well, UICs pose a higher risk to drinking water quality in areas of shallow groundwater because there is not as much unsaturated soil to filter and remove pollutants from stormwater. Two areas of shallow groundwater have been identified in the City.

Water Well Locations

Drillholes that are located within a two-year time-of-travel zone or 500 feet of a water well were prioritized for retrofit or replacement. Water wells included in this category were municipal supply wells, irrigation wells, and domestic supply wells (GSI, 2022). Risk categories that were assigned are outlined in Table 5a and shown on Figure 5a. An extra high risk category was added with a large multiplier to ensure that any drillholes within 100 feet of a water well rose to the top of the prioritization list.

Table 5a. Risk Assigned to Water Well Locations.

Risk Category	Well Location	Score Assigned	Multiplier or Additive
Extra High Risk	<100 ft from water well	10	Multiplier
High Risk	<500 ft from water well	3	Additive
Low Risk	>500 ft from water well	1	Additive

An additional extra high risk category was added (Table 5b) with a large multiplier to ensure that any drillholes within Two-year time-of-travel of a public water well zones rose to the top of the prioritization list. This extra high risk category is shown in Figure 5b. There would be a very high impact if a public water well were to become contaminated due to the large population served.

Table 5b. Risk Assigned to Water Well Locations.

Risk Category	Well Location	Score Assigned	Multiplier or Additive
Extra High Risk	Two-year time-of-travel of a public water well zones	20	Multiplier

Groundwater depth

The depth to the regional groundwater table in Bend ranges from 300-750 feet bgs; however, areas of perched groundwater with groundwater depths of a few feet to 200 feet bgs have been identified within the City (GSI, 2024). These perched groundwater areas are primarily within two regions: the Old Mill District Perched Area and the North Bend Perched Area (Figure 5c). Based on the findings of GSI's 2024 Groundwater Protectiveness Demonstration Update, 53 ft vertical separation between the base of the UIC and the seasonal high of groundwater is required to protect groundwater from PFAS in stormwater (GSI, 2024). Because drillholes can be constructed to 100 feet deep, PFAS in stormwater discharges from drillholes has the potential to reach groundwater in these perched areas.

Drillholes located in areas of perched groundwater were prioritized for retrofit and/or replacement. These locations are shown in Figure 5c. Perched groundwater within the "North Bend Perched Area" or the "Old Mill

District Perched Area" has been applied as a multiplier due to the significant risk of introducing contamination to shallow groundwater posed by drillholes within these areas. Risk categories that were assigned to perched groundwater areas are shown in Table 6 and on Figure 5c.

Table 6. Perched Groundwater within the "North Bend Perched Area" or the "Old Mill District Perched Area."

Risk Category	Vertical Separation from Groundwater/Perched Groundwater	Score Assigned	Multiplier or Additive
Extra High Risk	Areas of perched groundwater **AND** <53 ft vertical separation from groundwater	2	Multiplier
High Risk	Areas of perched groundwater	1.5	
Low Risk	Outside of a perched groundwater area	1	

3.1.4 Current Drillhole Condition

For this section, GSI reviewed the 'Stormwater Master Plan Flooding Locations' spreadsheet as well as the 'Stormwater Flooding Report' for City-owned drillholes, provided by Travis Somers of the City of Bend Stormwater Utility Department via email in April 2024. The 'Stormwater Master Plan Flooding Locations' spreadsheet identified UICs (both drywells and drillholes) with known flooding issues that the City is aware of. These were organized by the City by order of priority to replace or repair, with Priority 1 being the highest priority to address. The Stormwater Flooding Reports detailed known information about each site, along with photos. These are included in Appendix A and locations are shown on Figure 6. Risk categories that were assigned to current drillhole conditions are shown in Table 7. A multiplier was applied to drillhole conditions to ensure drillholes that have been pre-prioritized for replacement would float to the top of this prioritization list.

Table 7. Risk assigned to Current Drillhole Conditions.

Risk Assigned	Category	Definition[3]	Score Assigned	Multiplier or Additive
High Risk	Level 1 Priority	Stormwater causes or is at risk of causing safety concerns. Stormwater causes property damage or has the risk of causing property damage. Frequent responses from the City are required.	3	Multiplier
Moderate Risk	Level 2 Priority	Stormwater infrastructure may be undersized or failing. Less frequent responses from the City are required, often after a more sustained rain event	2	
Low Risk	Level 3 Priority	Low priority locations. Some improvements completed at most of these sites to improve/control runoff. These locations should be evaluated overtime to decide if existing infrastructure is adequate, needs to be replaced, or additional controls are needed to increase capacity.	1	

3.2 Drillhole Decommissioning Prioritization Results

A score was assigned to each drillhole at the end of this scoring exercise. The results of the drillhole prioritization scoring assessment are shown on Figure 7. On this figure, drillhole rankings from 1 to 10 and >10 are displayed, with the drillhole ranked as number one being the drillhole that has the highest priority for replacement. The top five ranked drillhole prioritization results are shown in Table 8. The full drillhole scoring is shown in Appendix B.

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[3] Provided by Travis Somers at the City of Bend via email on March 21, 2024

Table 8. Drillhole Decommissioning Prioritization Results.

Priority Rank	Drillhole ID(s)
1	DDH009510, DDH009485, DDH009498, DDH009625, DDH009624, DDH009514, DDH009513, DDH009550, DDH009520, DDH009841, DDH009727, DDH009728, DDH009767, DDH009766, DDH009764, DDH009765, DDH009763, DDH002049, DDH009381, DDH009446, DDH009447, DDH009482, DDH010013
2	DDH009875, DDH009932
3	DDH009573, DDH009572, DDH009571, DDH009396, DDH009397, DDH009394, DDH009444, DDH009431, DDH002022, DDH009122, DDH009129, DDH009130, DDH009586, DDH009585, DDH009583, DDH009438, DDH009419, DDH009420, DDH009403, DDH009425, DDH002020, DDH009407, DDH009406, DDH009405, DDH009404, DDH009416, DDH009426, DDH009423, DDH009424, DDH009440, DDH009441, DDH009436, DDH009437, DDH009417, DDH009418, DDH009392, DDH009386, DDH001022, DDH001023, DDH001013, DDH001012, DDH009398, DDH009439, DDH009395, DDH009421, DDH009422, DDH009443, DDH009384, DDH009380, DDH009385, DDH001015, DDH001014, DDH009399, DDH009415, DDH009412, DDH009413, DDH009628, DDH009629, DDH009632, DDH009604, DDH002018, DDH002019, DDH009445, DDH009387, DDH009388, DDH009389, DDH009390, DDH009391, DDH009393, DDH009402, DDH009401, DDH009400, DDH009429, DDH009430, DDH009435, DDH009434, DDH009433, DDH002023, DDH009428, DDH009631, DDH009630, DDH009605, DDH009603, DDH009609, DDH009606
4	DDH001019, DDH009454
5	DDH009863, DDH009902, DDH010018, DDH010019

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Figures

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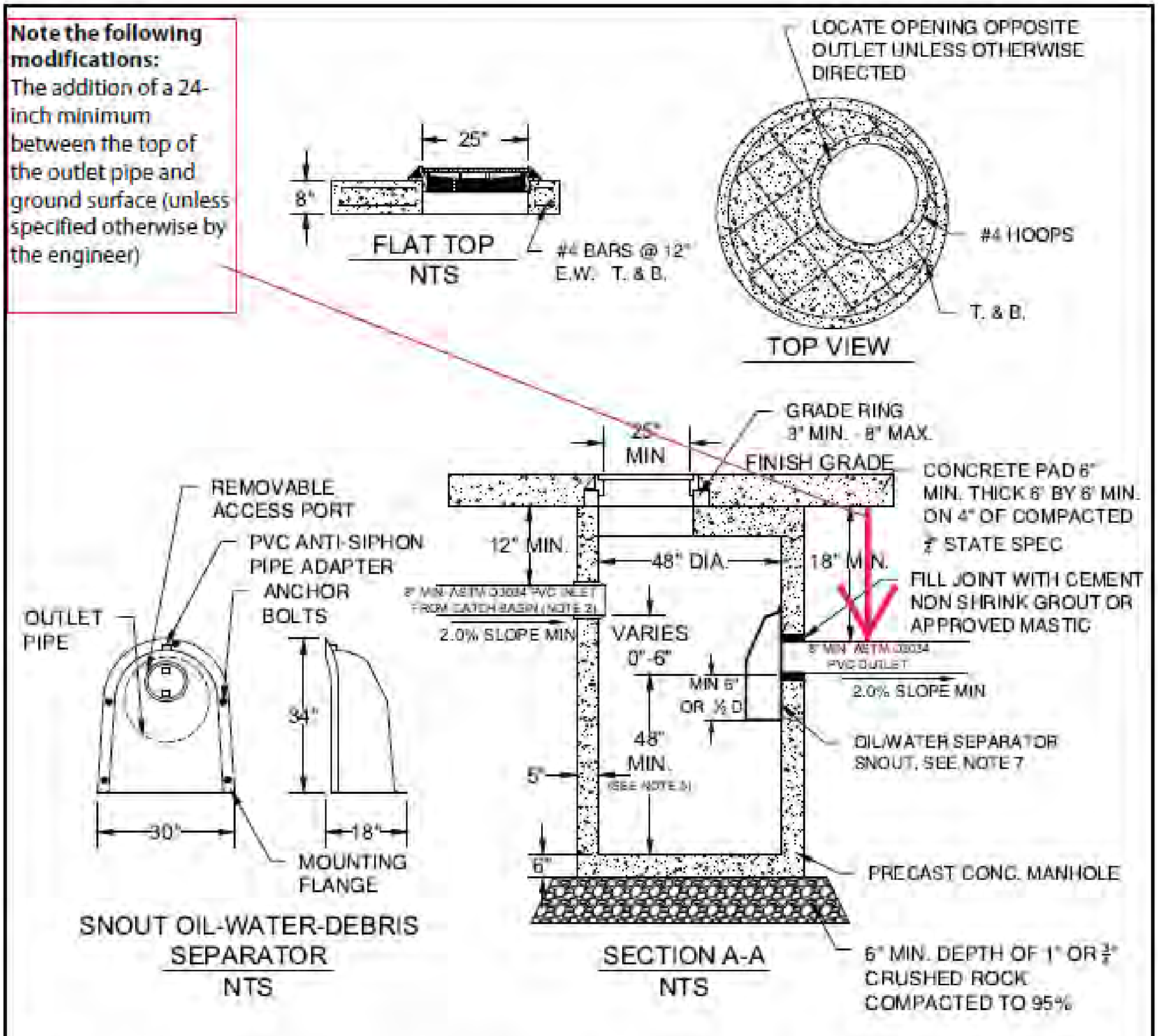

Note the following modifications:
The addition of a 24-inch minimum between the top of the outlet pipe and ground surface (unless specified otherwise by the engineer)

NOTES:
1. ALL PRE-CAST SECTIONS SHALL CONFORM TO REQUIREMENTS OF ASTM C-478.
2. AWWA C900 PIPE SHALL BE USED WITHIN TRAVEL AREAS. ASTM D3034 PIPE WHERE STORM PIPE WILL BE INSTALLED PERSANITARY SEWER REQUIREMENTS OR OUTSIDE OF TRAVEL AREAS.
3. MANHOLES SHALL BE PLACED OUTSIDE SIDEWALK, APRONS & STREET SURFACES UNLESS APPROVED BY THE CITY ENGINEER.
4. A 3 POINT MECHANICAL ADJUSTMENT SYSTEM SUCH AS RAD'S OR APPROVED EQUAL SHALL BE USED TO ADJUST MANHOLE FRAME AND COVER TO FINISH GRADE.
5. SUMP SIZE TO BE DESIGNED IN ACCORDANCE WITH COSM - 20 CF OF SUMP VOLUME FOR EACH 1.0 CFS DESIGN FLOW - NOT LESS THAN 48" DEPTH.
6. MANHOLES WITH MORE THAN 3 CONNECTIONS, OR PIPES 12" OR LARGER TO BE 60" MANHOLES
7. OIL/WATER SEPARATOR SNOUT BMP 24R, OR APPROVED EQUAL. SECURE TO MANHOLE WITH FIVE (5)$\frac{3}{8}$x1-12" STAINLESS STEEL RED HEAD BOLTS, WASHERS AND NUTS, OR AS APPROVED BY MANUFACTURER.

DRAWN AJD
BY STORM
REV. DATE

CITY OF BEND

CITY OF BEND
STANDARD DRAWING
710 NW WALL ST., BEND, OREGON 97701

STORMWATER SEDIMENTATION MANHOLE

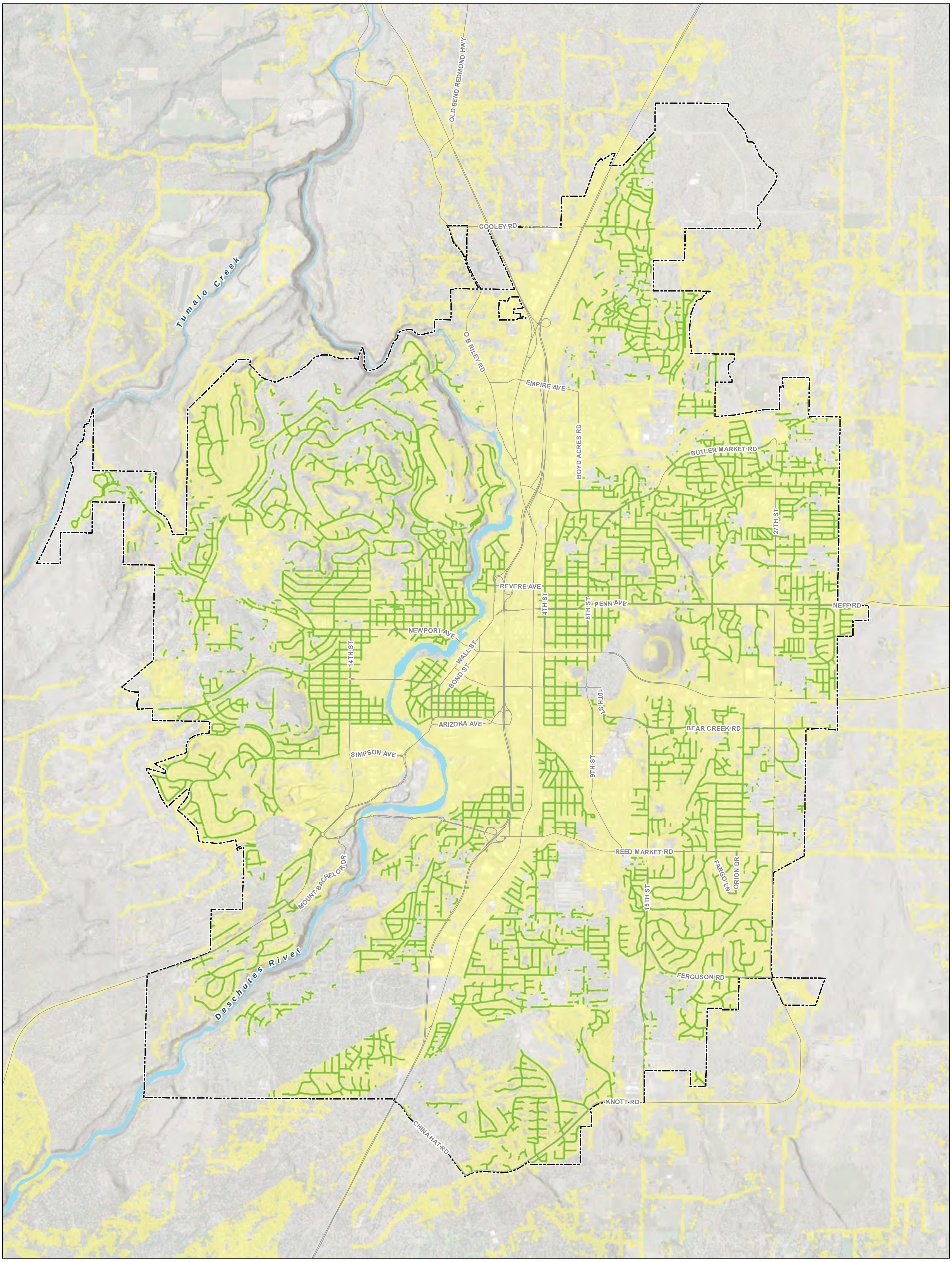
SCALE NTS
DATE 01/31/2022
APPR
STD DWG STRM-7

FIGURE 1

Modified Bend Stormwater Sedimentation Manhole

City of Bend Modified Drywell Siting Criteria and Drillhole Decommissioning Framework

GSI Water Solutions, Inc.



LEGEND

🟩 Green Light - Impervious surfaces, residential land use; local, collector, minor arterial, resource, and service roads; outside of two-year time-of-travel zones and >500 ft from water wells; and outside of areas with perched groundwater

🟨 Yellow Light - Impervious areas that are outside of the two-year ToT and greater than 100 feet from all water wells

All Other Features

City Boundary

Major Road

Watercourse

Waterbody

FIGURE 2

Areas that Meet Siting Criteria

City of Bend Modified Drywell Siting Criteria
and Drillhole Decommissioning Framework

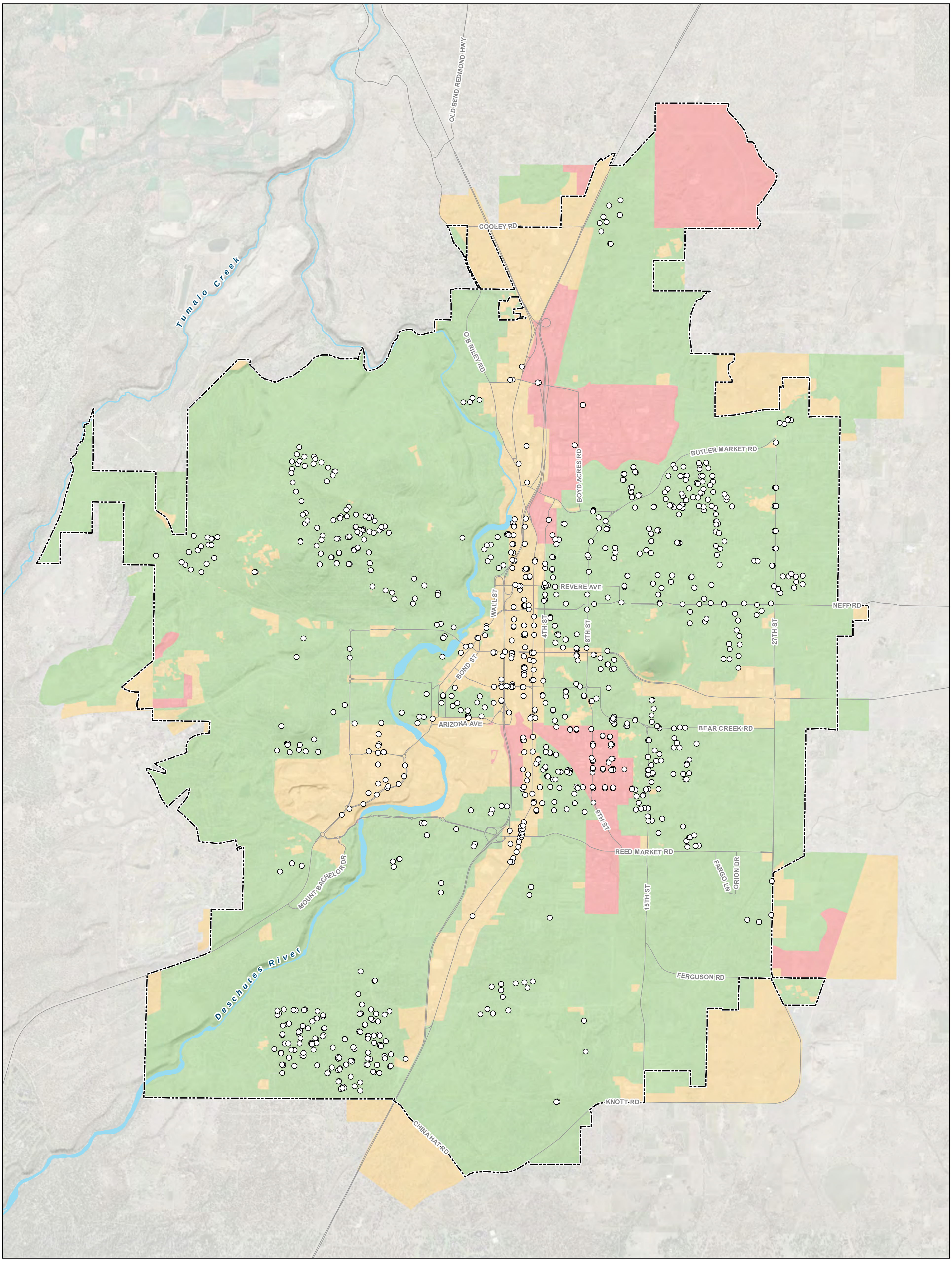
Date: July 24, 2025
Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

N

0 2,000 4,000 6,000
Feet

GSI Water Solutions, Inc.

Document Path: Y:\0655_Otak\Source_Figures\004_Bend_SW_Master_Plan\Modified_Drywell_Siting\Figure2_Siting_Criteria.mxd, npalmer



LEGEND

○ Drillhole

Land Use Risk

🟥 High Risk: Industrial

🟨 Moderate Risk: Commercial, Mixed-Use, Public Facility (AND >50% Impervious), Urban Area

🟩 Low Risk: Public Facility (AND <50% impervious), Professional Office, Residential

All Other Features

City Boundary

Major Road

Watercourse

Waterbody

FIGURE 3

Land Use

City of Bend Modified Drywell Siting Criteria
and Drillhole Decommissioning Framework

Date: July 3, 2024
Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

N

0 2,000 4,000 6,000
Feet

GSI Water Solutions, Inc.

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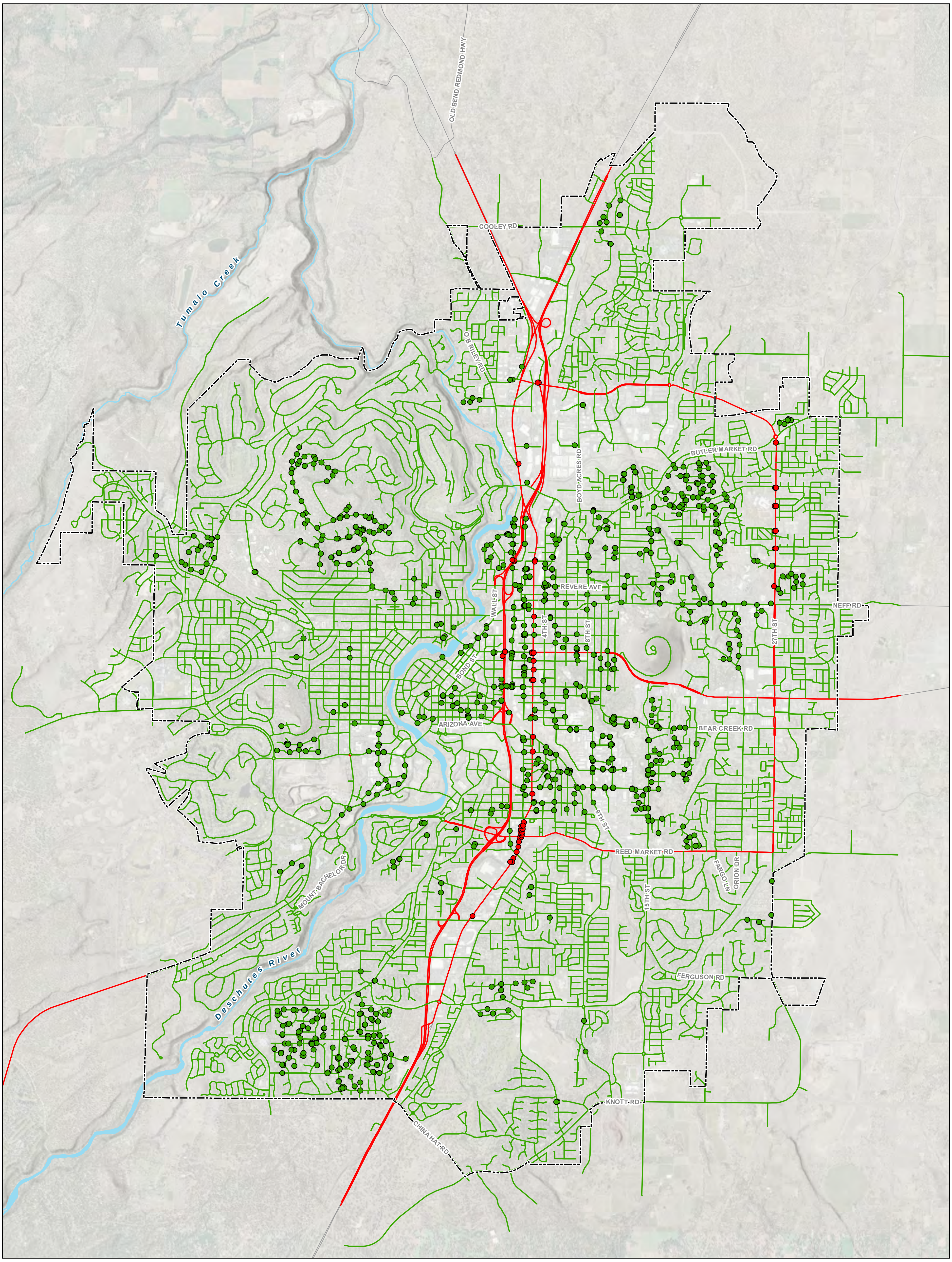

LEGEND

Drillhole

- ● High Risk
- ● Low-Moderate Risk

Traffic Volume Risk

- High Risk: Highways, Major Arterials, Ramps
- Low-Moderate Risk: Local, Collector, Minor Arterial, Resource, Service Roads

All Other Features

- City Boundary
- Major Road
- Watercourse
- Waterbody

FIGURE 4

Traffic Volume

City of Bend Modified Drywell Siting Criteria
and Drillhole Decommissioning Framework

Date: July 24, 2025
Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

N

0 2,000 4,000 6,000
Feet

GSI Water Solutions, Inc.

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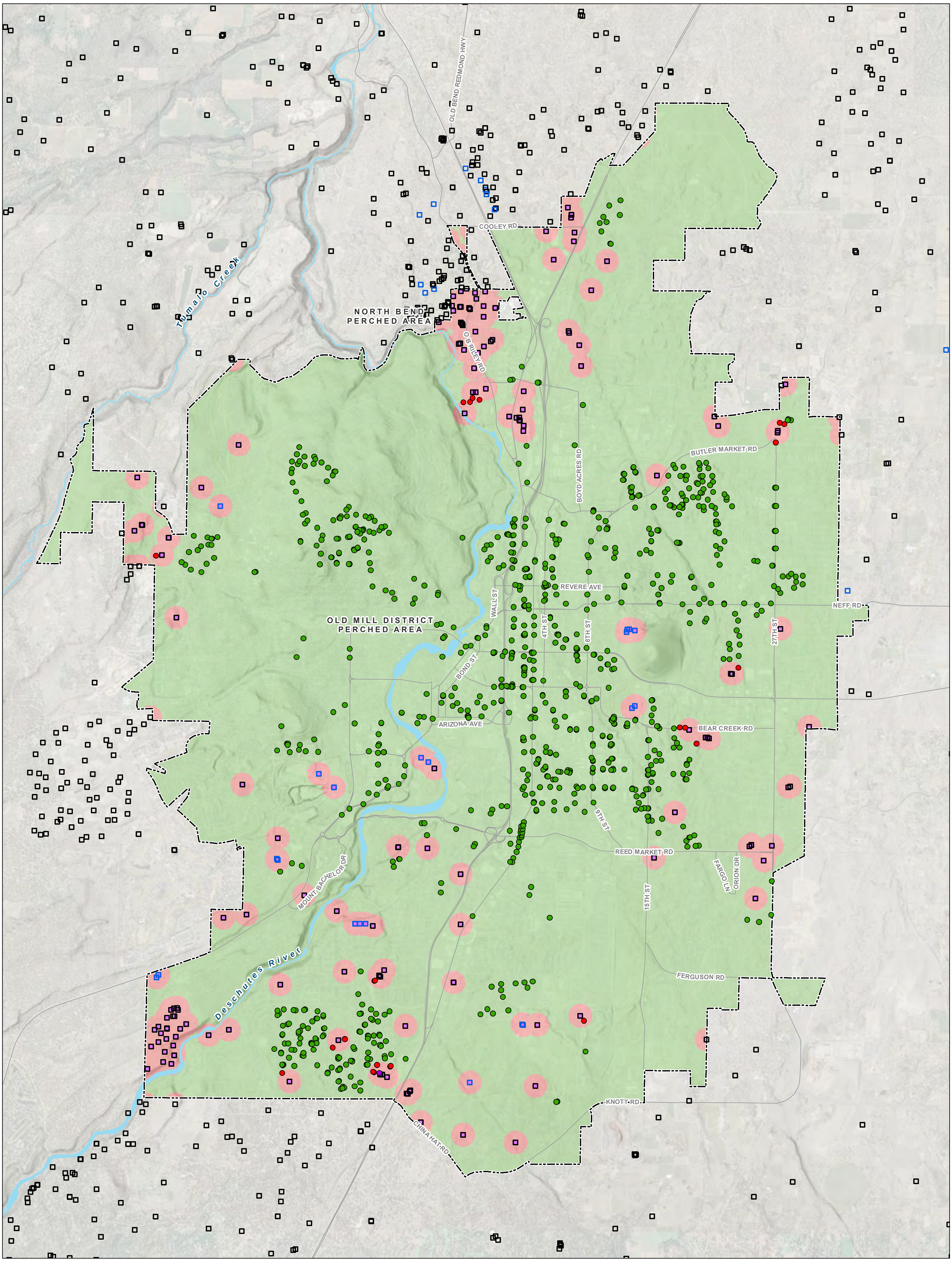

LEGEND

○ Drillhole

□ Private Water Well

□ Public Water Well

Risk Assigned to Water Well Locations

🟪 Extra High Risk: <100 ft from Water Well

🟥 High Risk: <500 ft from Water Well

🟩 Low Risk: >500 ft from Water Well

All Other Features

City Boundary

Major Road

Watercourse

Waterbody

FIGURE 5a

Risk Assigned to Water Well Locations – Distance from Water Wells

City of Bend Modified Drywell Siting Criteria and Drillhole Decommissioning Framework

Date: August 8, 2025
Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

N

0 2,000 4,000 6,000
Feet

GSI Water Solutions, Inc.

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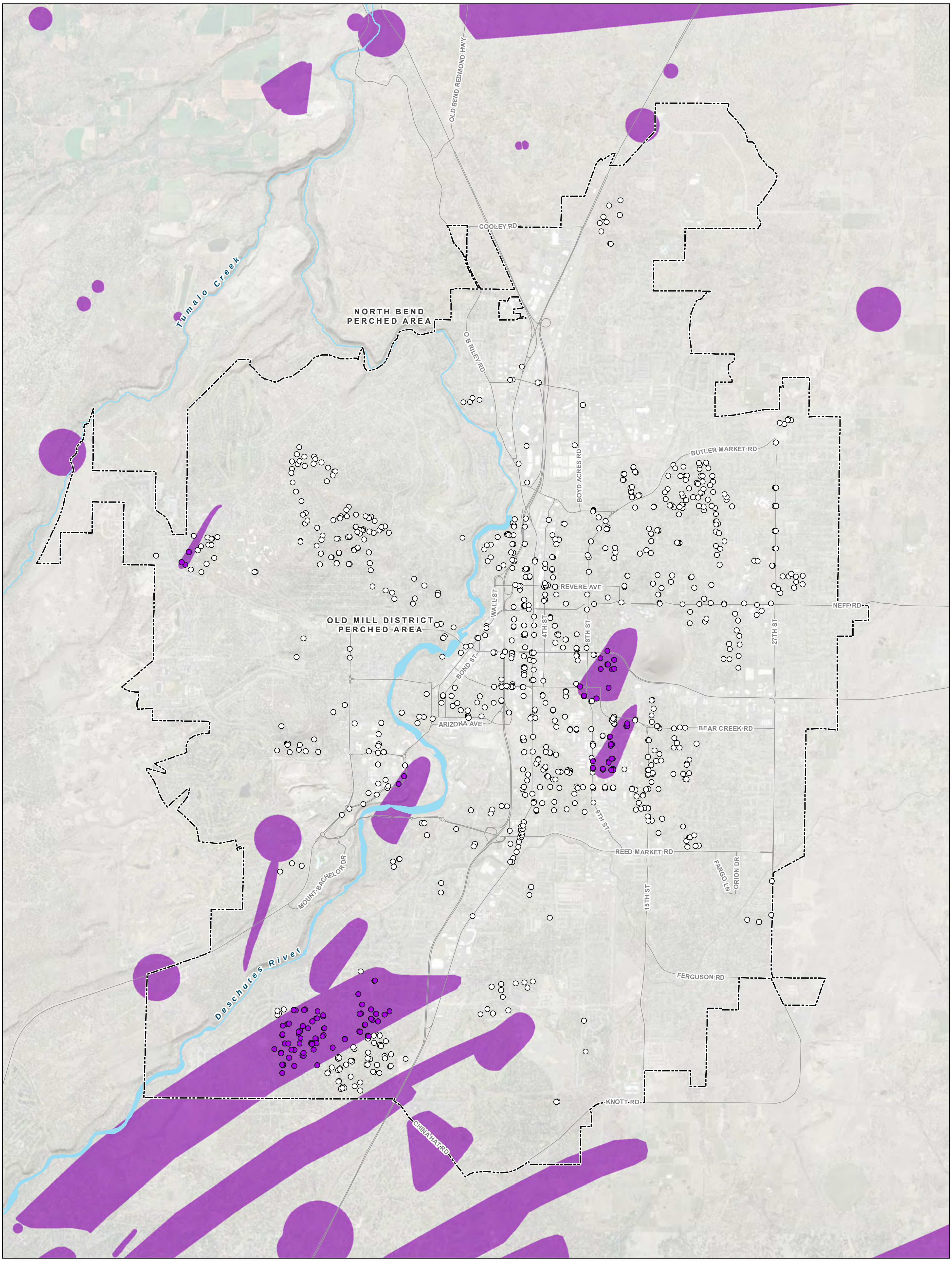

LEGEND

○ Drillhole

▨ Extra High Risk: Two-year time-of-travel of a public water well zones

All Other Features

⬚ City Boundary

╱╲ Major Road

〜 Watercourse

▨ Waterbody

FIGURE 5b

Risk Assigned to Water Well Locations – Risk to Public Water Wells

City of Bend Modified Drywell Siting Criteria and Drillhole Decommissioning Framework

Date: July 3, 2024
Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

N

0 2,000 4,000 6,000
Feet

GSI Water Solutions, Inc.

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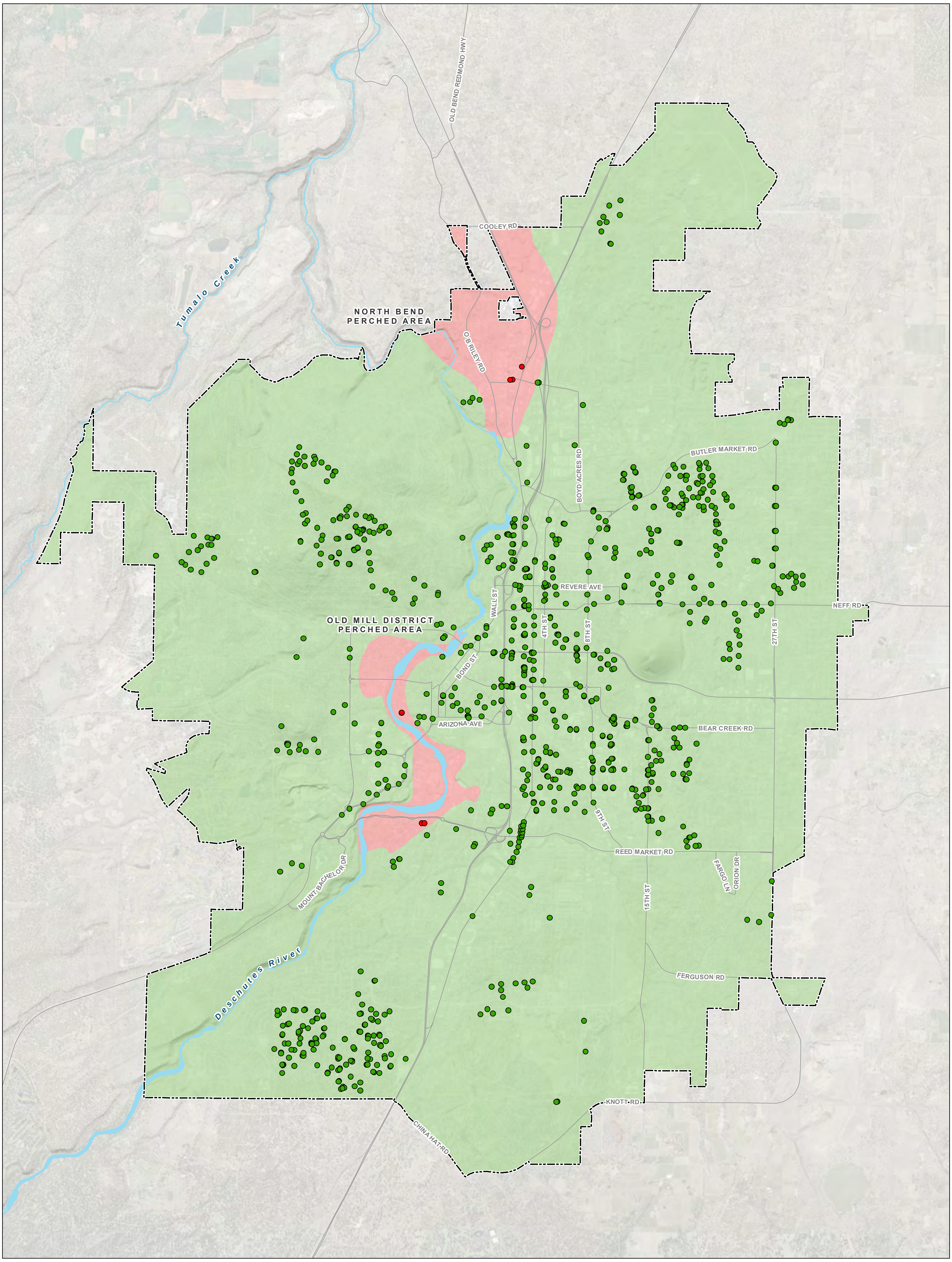

LEGEND

○ Drillhole

Risk Assigned to Water Well Locations

🟩 Low Risk: Outside of a perched groundwater area

🟥 High Risk: Areas of perched groundwater

🟪 Extra High Risk: Areas of perched groundwater AND <53 ft vertical separation from groundwater

All Other Features

City Boundary

Major Road

Watercourse

Waterbody

FIGURE 5c

Risk Assigned to Water Well Locations - Perched Groundwater within the "North Bend Perched Area" or the "Old Mill District Perched Area

City of Bend Modified Drywell Siting Criteria
and Drillhole Decommissioning Framework

Date: July 3, 2024
Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

N

0 2,000 4,000 6,000
Feet

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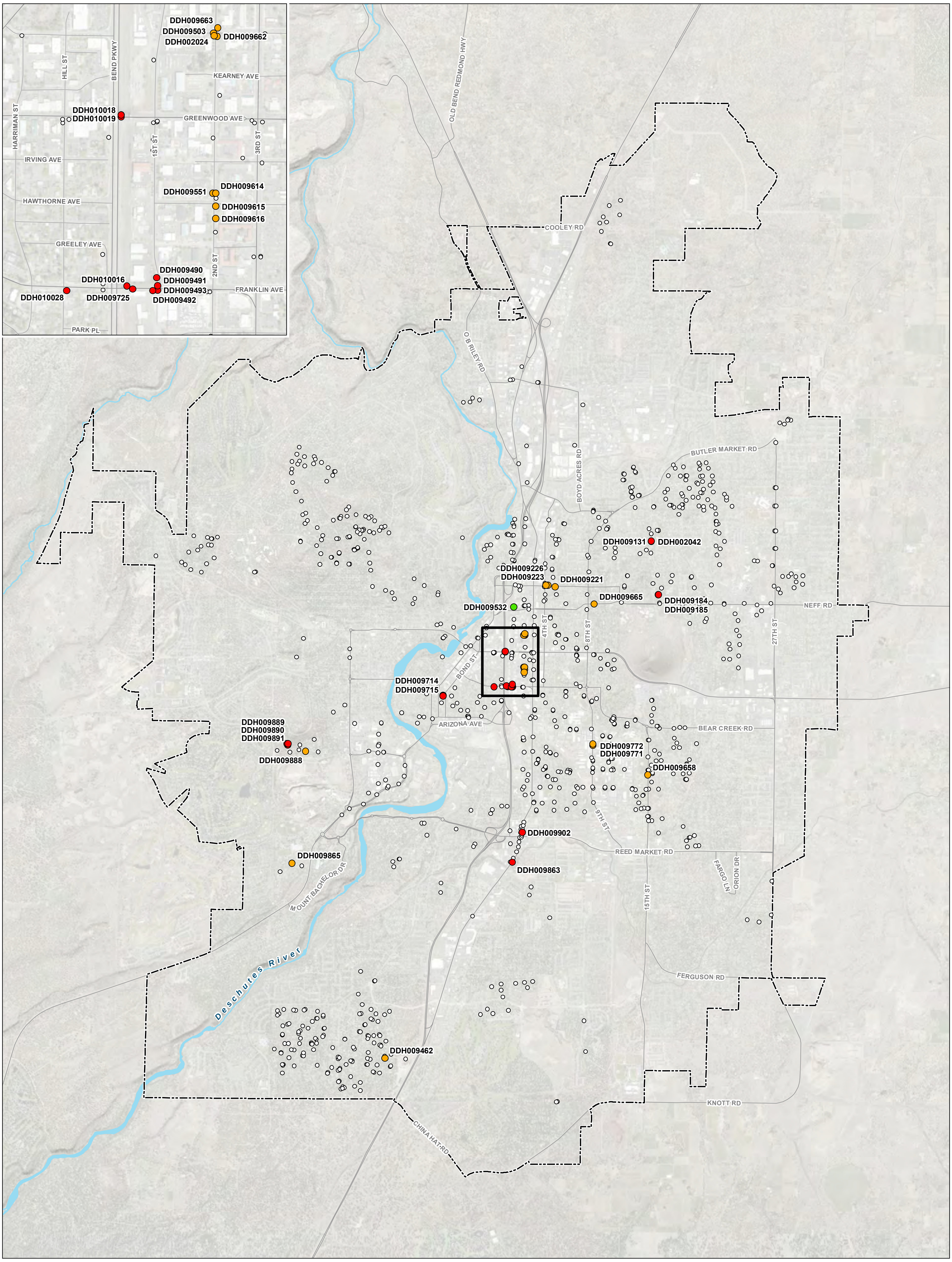

LEGEND

○ Drillhole

Risk Level Priority

- 🟥 High Risk: Level 1
- 🟧 Moderate Risk: Level 2
- 🟩 Low Risk: Level 3

All Other Features

- City Boundary
- Major Road
- Watercourse
- Waterbody

FIGURE 6

Current Drill Hole Conditions

City of Bend Modified Drywell Siting Criteria
and Drillhole Decommissioning Framework

Date: November 11, 2024
Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

N

0 2,000 4,000 6,000
Feet

GSI Water Solutions, Inc.

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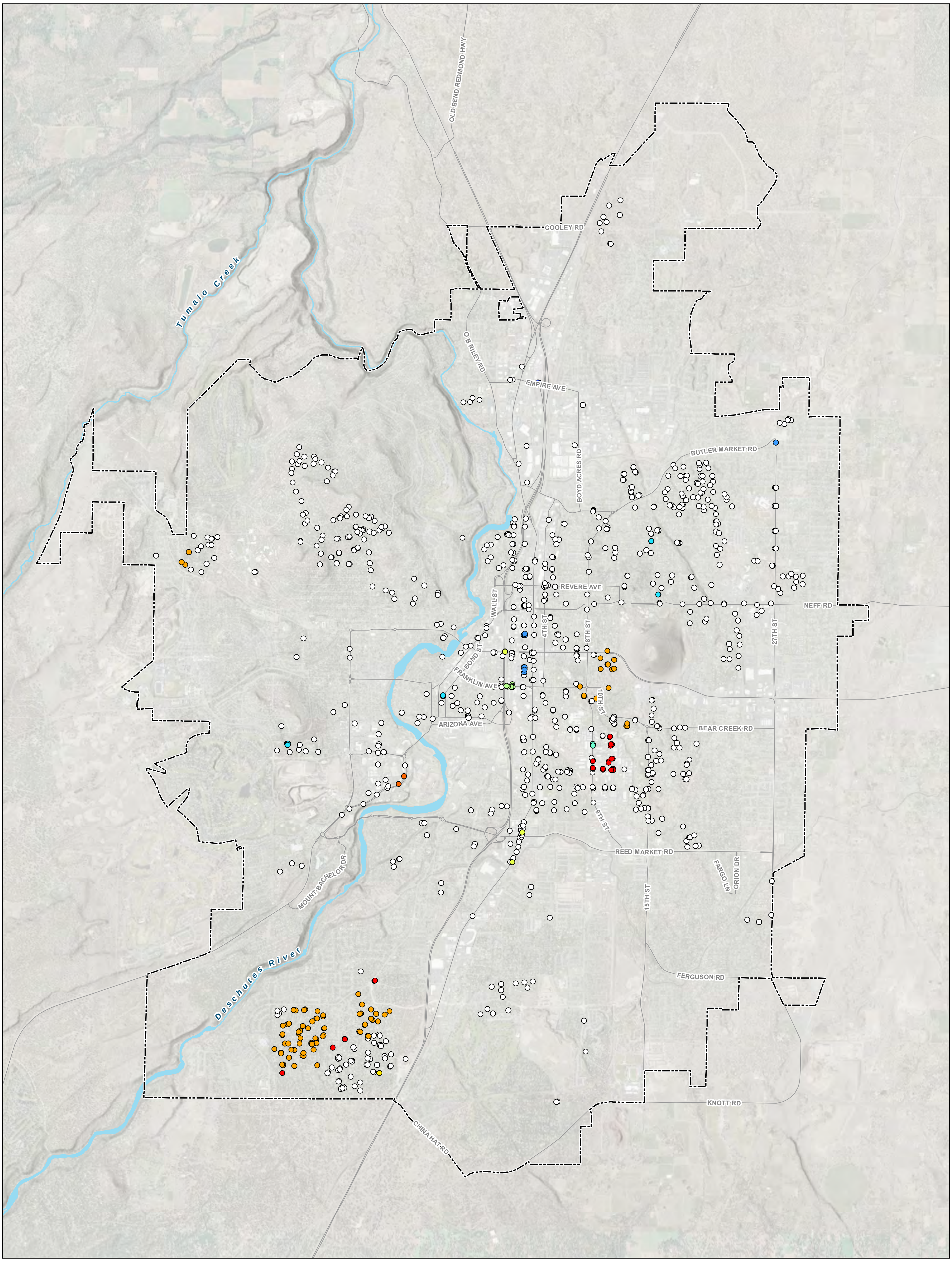

LEGEND

Drillhole Priority Rank (Quantity)
- ● 1 (23)
- ● 2 (2)
- ● 3 (85)
- ● 4 (1)
- ● 5 (4)
- ● 6 (7)
- ● 7 (2)
- ● 8 (9)
- ● 9 (9)
- ● 10 (2)
- ○ >10 (816)

All Other Features
- City Boundary
- Major Road
- Watercourse
- Waterbody

FIGURE 7

Priority Ranking

City of Bend Modified Drywell Siting Criteria
and Drillhole Decommissioning Framework

Date: August 14, 2025
Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

N

0 2,000 4,000 6,000
Feet

GSI Water Solutions, Inc.

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APPENDIX A

Drillhole Flooding Reports: Priority 1, Priority 2, and Priority 3 Locations

Priority 1 Locations

UTILITY DEPARTMENT

Stormwater Flooding Report

Work Order # 1415715
Nearest Address 1515 NE 2nd St
Asset Number DDW002067 [Long]
Date Reported: 4/1/2022 12:00:00 AM

Flooding Information	
Flooding Severity:	Right-of-Way (Moderate Traffic Impacts)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drywell

Flooding Description:

Drywell has completely failed causing water to puddle in roadway even with minimal precipitation.

Proposed Solution:

Install additional UIC's or maybe a regional pond in ROW.

Map:

Images:

Completed by ACE/SW Management Team	
Project Name:	2nd Street Drainage Improvements
Estimated Drainage Basin Size (Acres):	15
Priority Ranking:	14
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 1261386
Nearest Address 1080 SE 3rd St
Asset Number DDH009902
Date Reported: 11/15/2020 12:00:00 AM

Flooding Information	
Flooding Severity:	Right-of-Way (Serious Traffic Impacts)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drill Hole

Flooding Description:

Large puddle form along shoulder and into the 2nd northbound travel lane

Proposed Solution:

Install additional catch basins and UIC's

Additional Information:

This location floods more frequently in the wintertime due to snowplows blocking the storm drain. The drillhole does infiltrate slowly but becomes overwhelmed easily. When the system is overwhelmed water puddles in the road and in the business parking lot causing additional property damage.

Map:


SE 3rd St
S HWY 97
SE 3rd St
1080
1060
22
SE Reed Market Rd
SE REED M
d St

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Flooding Report

Work Order # 1448569
Nearest Address 1901 SW KNOLL AVE
Asset Numbers DDH009891 DDH009889 DDH009890
Date Reported: 11/4/2022 12:00:00 AM

Flooding Information

Flooding Severity:	Property Damage (Exterior)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Under Sized System

Flooding Description:

Inadequate drainage on SW Gleneagles Way, SW Troon, SW 19th and Knoll to handle the larger rain events. Stormwater flows onto private property causing damage.

Proposed Solution:

Install additional UIC's,

Additional Information:

There has been some swale work at the top of Gleneagles Way to capture some of the runoff from Overturf Butte but ultimately it becomes overwhelmed and flows down the hill. There has also been some concrete driveway work on Knoll Ave to try and keep stormwater in the right of way. UIC's in the area do not infiltrate well and are easily overwhelmed.

Map:


SW Turnberry Pl
SW Turnberry Pl
SW Prestwick Pl
SW Gleneagles Way
SW Troon Ave
Troon Ave
SW Troon Ave
SW Troon Ave
SW 19th St
SW Knoll Ave
SW Knoll Ave

Images:

Completed by ACE/SW Management Team	
Project Name:	Overturf Butte Sub. Drainage Improvements
Estimated Drainage Basin Size (Acres):	55
Priority Ranking:	3
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 1433112
Nearest Address 717 NW Georgia Ave
Asset Number DDH009715 DDH009714 DDW001987
Date Reported: 11/13/2020 12:00:00 AM

Flooding Information	
Flooding Severity:	Property Damage (Exterior)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drill Hole

Flooding Description:

During large rain events water from Bond and Wall converge and overwhelm the drillholes and flood on private property.

Proposed Solution:

Install new drainage/UIC’s

Additional Information:

Performed infiltration test on all three drillholes and none of them work very well.

Map:

406
730
728
734
732
720
Unit 2
716
Unit 1
704
NW Wall St
NW Bond St
404
402
NW GEORGIA AVE
NW Georgia Ave
NW Georgia Ave
Unit A
711
344
338
733
727
717
NW WALL ST
NW BOND ST
Unit C
Unit B
329
Suite 200

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 1261038
Nearest Address 1300 SE 3rd St.
Asset Number DDH009863
Date Reported: 11/13/2020 12:00:00 AM

Flooding Information	
Flooding Severity:	Property Damage (Exterior)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Under Sized System

Flooding Description:

Water puddles on road and flows down into parking lot and main lobby of the Budget Inn causing property damage during larger rain events.

Proposed Solution:

Install additional drainage, UIC's

Additional Information:

We have installed water-bars and lowered the asphalt level to keep water in the right of way going to the drillhole, but it still floods during the larger events. There may be legal issues with this location.

Map:


Cynthia's Sewing Center
1275
1245
Super 8
SE 3rd St
Brosterhous Rd
Central Oregon Canal
61555
AutoZone
1325
1300
SE 3rd St
SE 3RD ST · S HWY 97
61545
61543
Parrell Rd
61541
S Highway 97
Central Oregon Canal
Central Oregon Canal
Parrell Rd
61533

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 479871
Nearest Address 1648 NE Eastwood Dr
Asset Number DDH009185 DDH009184
Date Reported: 9/10/13

Flooding Information

Flooding Severity:	Property Damage (Exterior)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Under Sized System

Flooding Description:

Inadequate drainage to handle runoff. 1648 NE Eastwood is located at the low point in this basin. Water overwhelms the drill holes and floods onto property.

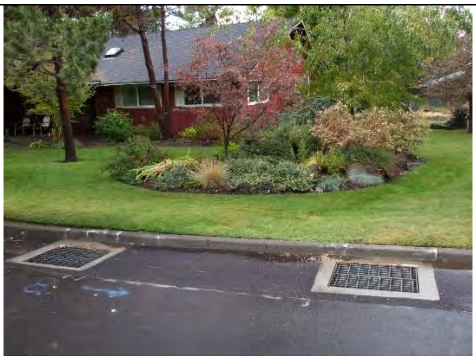
Proposed Solution:

Additional Information:

Map:


NE Shepard Rd
NE SHEPARD RD
NE EASTWOOD DR
NE Eastwood Dr
NE Neff Rd
NE NEFF

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 1213903
Nearest Address 2310 NE Shepard Rd
Asset Numbers DDH002042
DDH009131
Date Reported: 6/1/2020 12:00:00 AM

Flooding Information

Flooding Severity:	Structure Damage (Interior)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Under Sized System

Flooding Description:

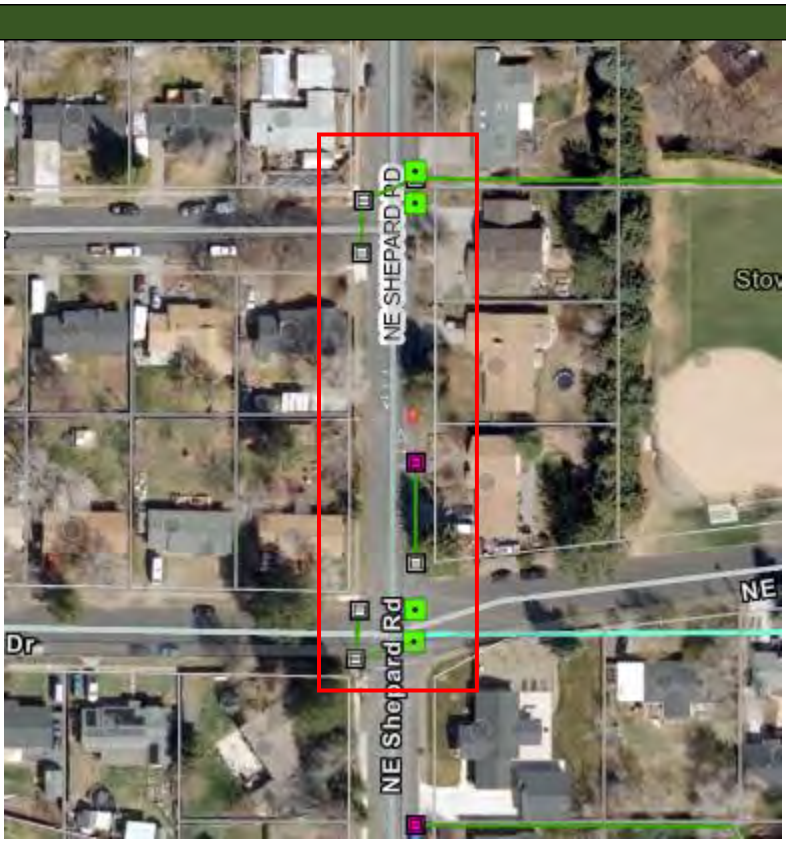
Stormwater overwhelms existing system. During large rain events the water has flowed onto private property causing damage.

Proposed Solution:

Remove and replace existing drainage with City standard storm drains, sedimentation manholes and drywells. Connect all the drainage from NE Watson Dr on Shepard to NE Dempsey. Bypass/Overflow out existing storm line to the east at 2342 NE Shepard.

Additional Information:

Map:



Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 141965
Nearest Address 19410 Century Dr
Asset Number DDW001276
Date Reported: 6/3/2022 12:00:00 AM

Flooding Information	
Flooding Severity:	Property Damage (Exterior)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Under Sized System

Flooding Description:

During large rain events water flows from West Campbell Rd and Tetherow overland through several properties and into the right of way

Proposed Solution:

Install UIC's, install regional swale, install erosion control measures

Additional Information:

There are several homes that were built in the natural drainage and there is no stormwater infrastructure in the area. West Campbell Rd was re-graded to try and shed water to the opposite side, but water still flows through the properties.

Map:


SWARENS AV
W Campbell Rd
W Campbell Rd
W Campbell Rd
W CAMPBELL RD
W Campbell Rd
SW Century Dr
SW Century Dr

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

Stormwater Project Request

Work Order #	878656
Nearest Address	633 NW York Dr
Asset Number	DDW008446 DDW008445 DDW008444
Date Reported:	2/8/2017 12:00:00 AM

Flooding Information

Flooding Severity:	Right-of-Way (Serious Traffic Impacts)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drywell

Flooding Description:

Large puddle forms in the right of way and up over the curb during large rain/snow events.

Proposed Solution:

Install additional UIC's, install regional swale

Additional Information:

This location typically only floods during the winter months when the ground is frozen

Map:


NW Charbonneau St
2796
655
633
628
2797
NW YORK DR
NW York Dr
NW Clearwater Dr
NW CLEARWATER DR
NW Clearwater Dr
NW Clearwater Dr
NW York Dr
rk Dr

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Flooding Report

Work Order # 1483259
Nearest Address 125 NE Franklin Ave
Asset Numbers DDH009725 DDH010016
DDH009492 DDH009493
DDH009491 DDH010028
DDH010018 DDH009490
DDH010019
Date Reported: 12/26/2022 12:00:00 AM

Flooding Information

Flooding Severity:	Right-of-Way (Serious Traffic Impacts)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drill Hole

Flooding Description:

There is 1 working drill hole servicing the underpass runoff and it is failing. Storm water puddles in roadway requiring underpass to be closed. The other assets listed are part of the underpass drainage basin.

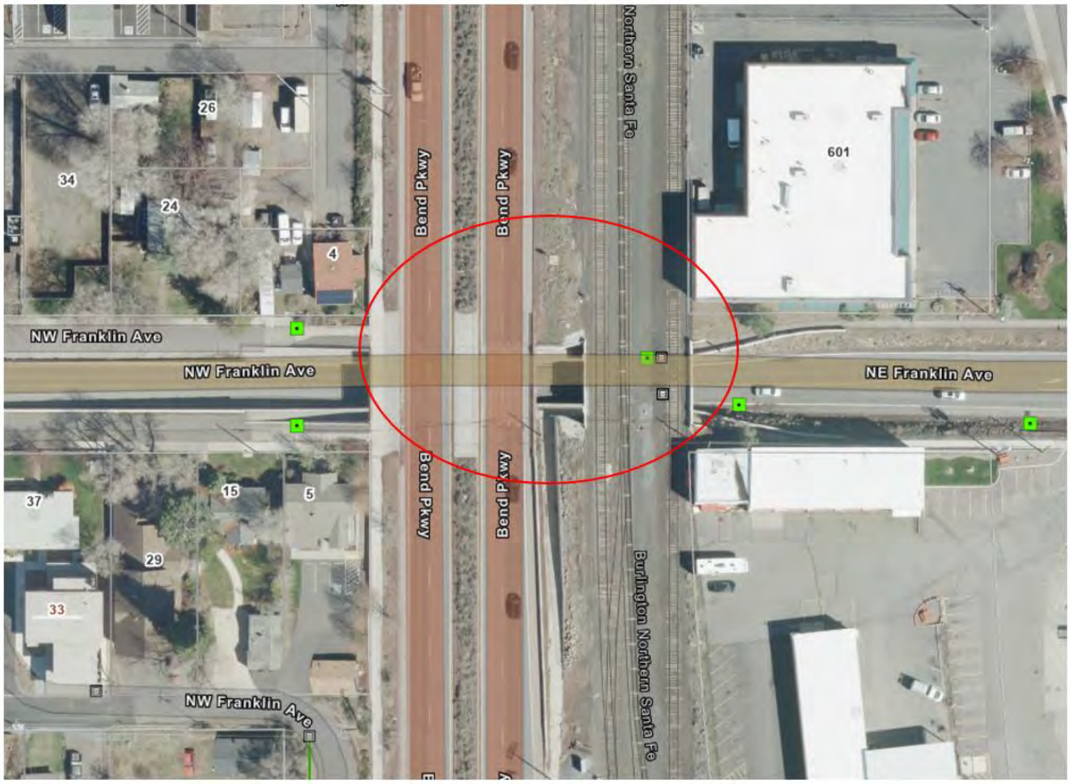
Proposed Solution:

Install a storm system sed. manhole, storm drains, drywells or pump station.

Additional Information:

There is a large amount of sediment erosion along the road and sidewalk that are contributing to the expedited failure of the drillhole (DDH010016).

Map:


Bend Pkwy
Bend Pkwy
Northern Santa Fe
601
26
34
24
4
NW Franklin Ave
NW Franklin Ave
NE Franklin Ave
37
15
5
29
33
Bend Pkwy
Bend Pkwy
Burlington Northern Santa Fe
NW Franklin Ave

Images:

Completed by ACE/SW Management Team	
Project Name:	Franklin Underpass Drainage Improvements
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	1

Project Category:	Master Plan
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Flooding Report

Work Order # 1483284
Nearest Address 5 NW Greenwood Ave
Asset Numbers DDH010018 DDH010019
Date Reported: 12/26/2022 12:00:00 AM

Flooding Information

Flooding Severity:	Right-of-Way (Serious Traffic Impacts)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drill Hole

Flooding Description:

There are 2 drill holes servicing the underpass runoff and they are inadequate in large rain events. Storm water puddles in roadway requiring underpass to be closed.

Proposed Solution:

Install a storm system sed. manhole, storm drains, drywells, or pump station.

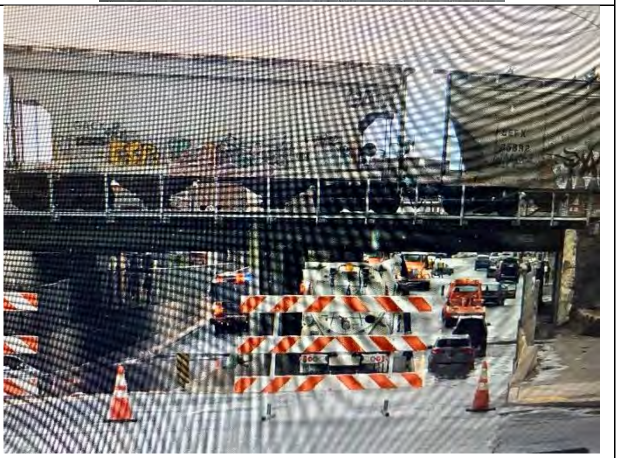
Additional Information:

Drillhole (DDH010018) in west bound lane was recently re-drilled to 100ft. Both drillholes still infiltrate poorly and ultimately all drainage needs to be upgraded.

Map:

21
35
26
40
24
20
Bend Pkwy
Bend Pkwy
Burlington Northern Santa Fe
NE 1st St
NW Greenwood Ave
NE Greenwood Ave
51
37
23
19
15
17
5
957
313
Bend Pkwy
Bend Pkwy
Burlington Northern Santa Fe
NE 1st St

Images:



Completed by ACE/SW Management Team	
Project Name:	Greenwood Underpass Drainage Improvements
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	2
Project Category:	Master Plan
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 1219584
Nearest Address NW Summit/NW Mt. Washington
Asset Number DDW007037
Date Reported: 2/13/2024 12:00:00 AM

Flooding Information	
Flooding Severity:	Right-of-Way (Serious Traffic Impacts)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drywell

Flooding Description:

Water from NW Summit Dr flows down hill and overwhelms drywell on SW corner. Very slow draining drywell.

Proposed Solution:

Install additional drainage/UIC's on Summit, rehab/replace existing drywell, install drillhole in existing drywell, swale

Additional Information:

This large drainage area has become a stormwater hotspot for flooding. Drywell has completely failed and water either builds up enough to flow across the intersection and down to the next drainage area or it evaporates.

Map:


WAY
3020
NW Merchant Way
NW MT WASHINGTON DR
3037
NW FAIRWA
NW Summit Dr
NW Mount Washington Dr
3025
NW SUMMIT DR
3000
30
NW Lucus Ct
NW LUCUS CT
2990

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 779132
Nearest Address 858 NW Wall St.
Asset Numbers DDW007557 DDW007558
Date Reported: 6/8/2016 12:00:00 AM

Flooding Information

Flooding Severity:	Property Damage (Exterior)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drywell

Flooding Description:

The drywells in this area have completely failed and sit full of water year-round. Water builds up and floods into several businesses before it can flow south to the mainline to the river.

Proposed Solution:

Install new UIC’s, extend pipeline to the river, install pre-treatment

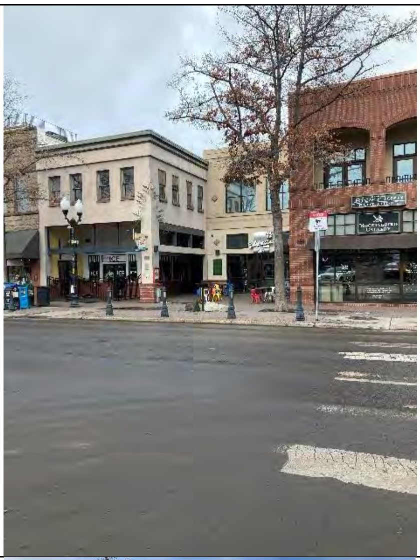
Additional Information:

All downtown drainage is aging and needs to be addressed. This location floods more frequently than any other downtown location.

Map:


NW Brooks St
NW BROOKS ST
NW Wall St
NW Wall St
NW Minnesota Ave
NW Gasoline Aly
NW GASOLINE ALY
NW WALL ST
NW Wall St
NW MINNESOTA AVE
NW Gasoline Aly
NW Bond St

Images:



Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

Priority 2 Locations

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 715133
Nearest Address 151 SW Shevlin LN
Asset Number DDW003166
Date Reported: 5/21/2015 12:00:00 AM

Flooding Information	
Flooding Severity:	Right-of-Way (Serious Traffic Impacts)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drywell

Flooding Description:

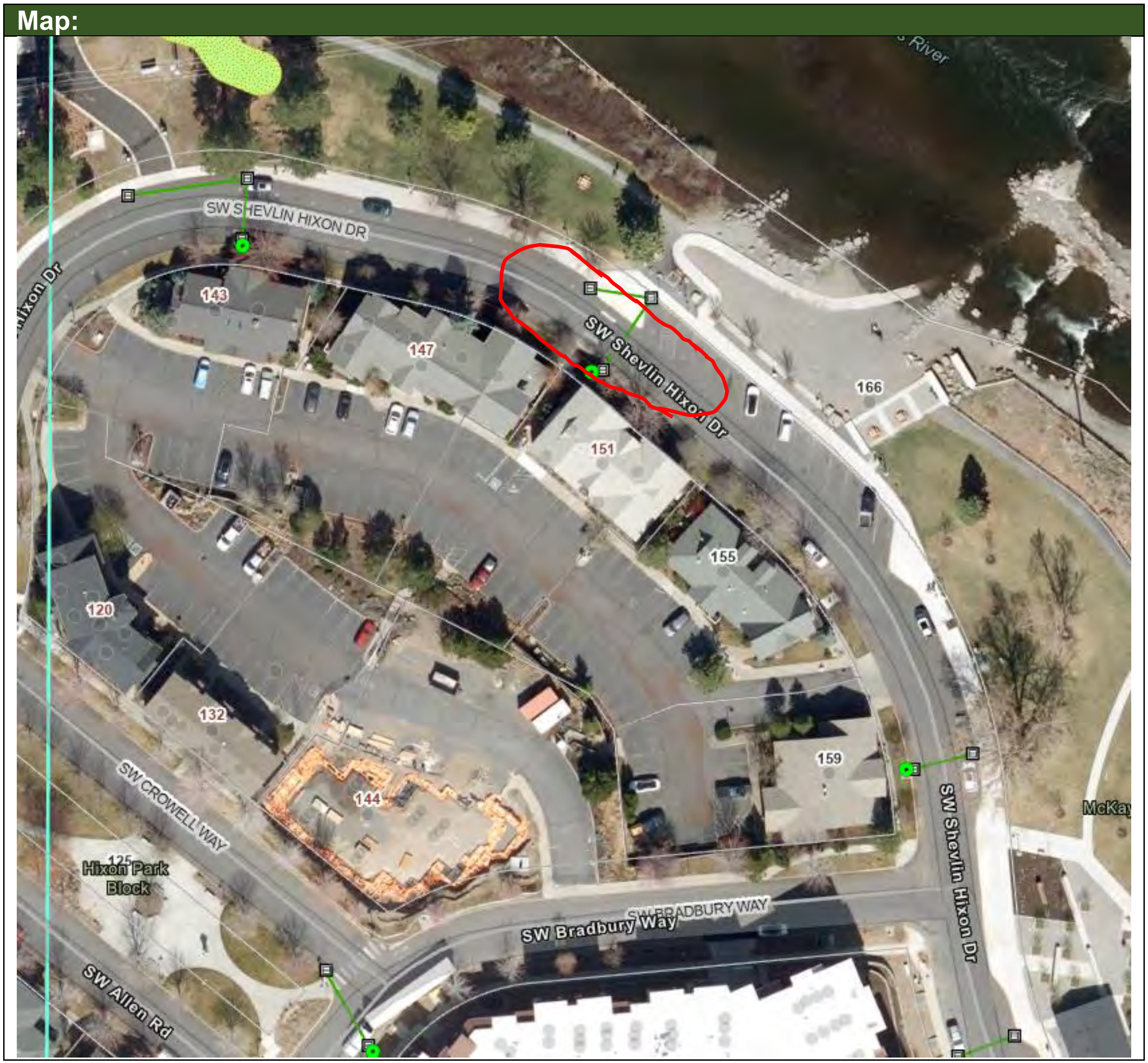
Drywells at this location have wet feet. Floods across entire width of roadway.

Proposed Solution:

Install pretreatment and discharge to river.

Additional Information:

Map:


River
SW SHEVLIN HIXON DR
Hixon Dr
143
147
SW Shevlin Hixon Dr
166
151
155
120
132
159
McKay
144
125
Hixon Park Block
SW CROWELL WAY
SW BRADBURY WAY
SW Bradbury Way
SW Shevlin Hixon Dr
SW Allen Rd

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 694128
Nearest Address 330 SE 15th St.
Asset Number DDH009658
Date Reported: [Date Added]

Flooding Information	
Flooding Severity:	Right-of-Way (Moderate Traffic Impacts)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drill Hole

Flooding Description:

Water puddles in bike lane and road causing traffic to drive into on-coming lane.

Proposed Solution:

Install UIC, connect to drill hole on east side of the road

Additional Information:

This drillhole is easily overwhelmed, but it does catch up it just takes a while. It cannot be re-drilled due to overhead powerlines.

Map:

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 1024531
Nearest Address 510 NW Sean Ct.
Asset Numbers DDW007204 DDW007205
Date Reported: 5/24/2018 12:00:00 AM

Flooding Information

Flooding Severity:	Property Damage (Exterior)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drywell

Flooding Description:

Runoff from Overturf Butte runs downhill onto private property and overwhelms the catch basin and drywell. The drywell does infiltrate slowly but is undersized for the area.

Proposed Solution:

Install additional UIC's, better control of runoff on Overturf Butte

Additional Information:

The stormwater maintenance crew installed several erosion control measures on Overturf Butte including: straw wattles, check dams, and re-vegetation. This did help, but the larger storms still cause problems.

Map:

Deschutes County - Assessor's Office | City of Bend, OR, Maxar, Microsoft | Esri Community

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 1082838

Nearest Address 821 NE 2nd St

Asset Numbers DDH009551 DDH009614
DDH011033 DDW0077539
DDH009615 DDH009616

Date Reported: 12/18/2018 12:00:00 AM

Flooding Information	
Flooding Severity:	Right-of-Way (Serious Traffic Impacts)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drill Hole

Flooding Description:

Water puddles in intersection during large rain events.

Proposed Solution:

Install additional UIC’s, install regional swale

Additional Information:

Over the years this intersection has undergone several changes including the addition of swales and a new drywell system to try and help the failing drillholes. Still needs additional UIC’s on South and East and West side.

Map:


841
839
NE 2ND ST
150
Pilot Butte Canal
821
NE 2nd St
846
805
Jack in the Box
NE 3RD ST
NE 3rd St
Pilot Butte Canal
NE HAWTHORNE AVE
NE Hawthorne Ave
NE Hawthorne Ave
155
755
BottleDrop Express
Spirit
205
221
NE 2nd St
755
735
NE 3rd St
Campfire Hotel

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 1141148
Nearest Address 902 SE Textron
Asset Numbers DDH009772 DDH009771
Date Reported: [Date Added]

Flooding Information	
Flooding Severity:	Right-of-Way (Moderate Traffic Impacts)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drill Hole

Flooding Description:

Water puddles on SE corner, drillhole infiltrates very slowly

Proposed Solution:

Re-drill, install UIC's

Additional Information:

The drillhole on the NE corner has been re-drilled and works, but water still puddles on the SE side of the intersection. Southeast drill hole is scheduled to be reconditioned spring 2024.

Map:


SE 9TH ST
SE 9th St
SE Textron Dr
SE TEXTRON DR
SE Textr
SE 9th St
9th St

Images:

<table>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
</table>

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 770608

Nearest Address 1125 NE 2nd St

Asset Number DDH009662 DDH009503
DDH002024 DDH009663

Date Reported: 4/15/2016

Flooding Information	
Flooding Severity:	Right-of-Way (Moderate Traffic Impacts)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drill Hole

Flooding Description:

Old/minimal stormwater infrastructure. Some of the drill holes work, some do not. We have issues with the storm grates plugging at this location.

Proposed Solution:

Install additional upstream storm systems and expand or replace storm system at the intersection.

Additional Information:

Map:


1201
Pilot Butte Canal
NE 2nd St
Daniel Automotive
220
1219
NE 3rd St
NE Lafayette Ave
225
235
1132
Brandy's Automotive
1143
Dutch Bros. Coffee
1125
Humm Kombucha
Pilot Butte Canal
NE 2nd St
Press Pros
NE 3rd St
NE 2ND ST
NE 3RD ST
1115
Abby's

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Flooding Report

Work Order # 1483252

Nearest Address 1193 Ross Rd

Asset Number DDW007179

Date Added: 4/12/2023 12:00:00 AM

Flooding Information

Flooding Severity:	Right-of-Way (Serious Traffic Impacts)
Triggering Rain Event Size (In):	1.5
Problem Code:	Failing Drywell

Flooding Description:

Drywell is failing and easily overwhelmed

Proposed Solution:

Install additional drainage, drywell or drill hole in drywell

Map:

Images:

Completed by ACE/SW Management Team	
Project Name:	Ross Rd Drainage Improvements
Estimated Drainage Basin Size (Acres):	1.5
Priority Ranking:	**3**
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order #
Nearest Address 1212 SW Simpson Ave
Asset Numbers DDW008127 DDW010340
Date Reported:

Flooding Information	
Flooding Severity:	Right-of-Way (Serious Traffic Impacts)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drywell

Flooding Description:

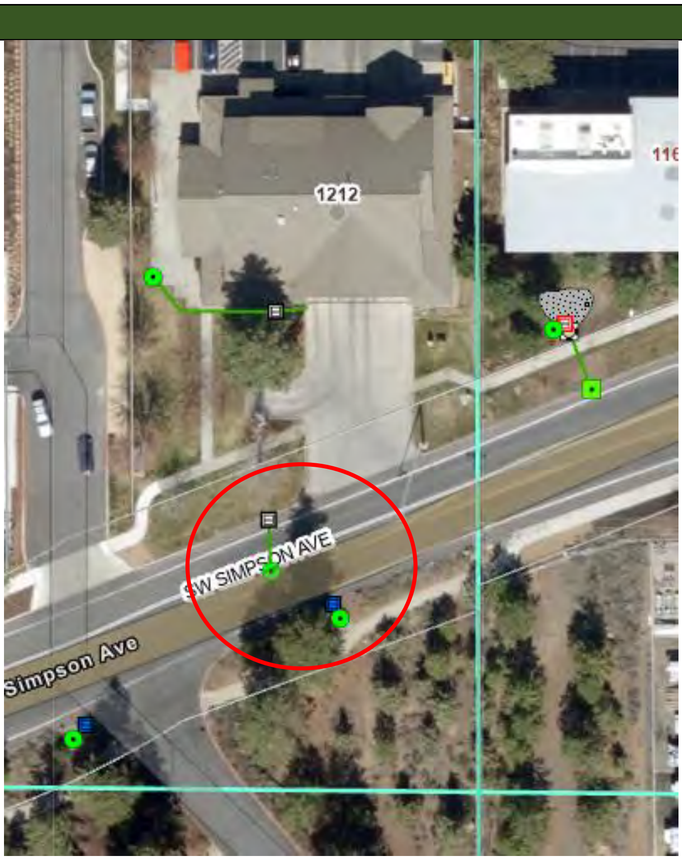
The two drywells at this location are failing. Stormwater floods across the entire roadway.

Proposed Solution:

Replace old storm system.

Additional Information:

Map:



Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 1420496
Nearest Address 1501 NE Neff Rd
Asset Number DDH009221
Date Reported: 6/28/2022 12:00:00 AM

Flooding Information

Flooding Severity:	Right-of-Way (Serious Traffic Impacts)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drill Hole

Flooding Description:

This one drillhole serves a very large drainage basin and can be overwhelmed easily. During large rain events, erosion from Pilot Butte contributes a large amount of sediment.

Proposed Solution:

Install flanking catch basins to protect drillhole, install additional UIC’s, install regional swale, install erosion control measures on Pilot Butte and vacant lot

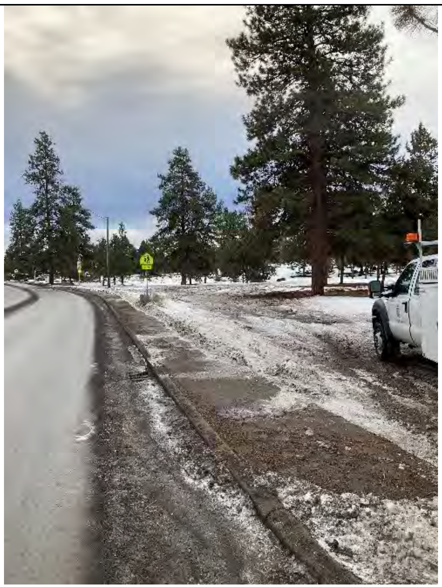
Additional Information:

This drillhole has been re-drilled to 95ft and does infiltrate well now. The entire Penn/Neff corridor from 8th St. to NE Cliff Dr. needs additional stormwater infrastructure. This has been a known flooding area for years and was also previously identified in the 2014 masterplan.

Map:

Deschutes County - Assessor's Office | City of Bend, OR, Maxar, Microsoft | Esri Community Maps Contributors, City of Bend, OR, Oregon S

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 1087831
Nearest Address 1532 NE 9th St
Asset Number DDH009665
Date Reported: 1/29/2019 12:00:00 AM

Flooding Information

Flooding Severity:	Property Damage (Exterior)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drill Hole

Flooding Description:

Runoff from Pilot Butte all drains downhill to this location. There is no drainage infrastructure between 9th and 13th on Penn.

Proposed Solution:

Install additional UIC's on Penn, re-drill drillhole, install pre-treatment, connect drainage to swale on 8th and Penn

Additional Information:

There was some swale work done on the shoulder at this intersection, but it still floods and runs down onto private property

Map:


NE PENN AVE
NE Penn Ave
NE Penn Ave
NE Penn Ave
NE 9th St
NE 9TH ST
NE 9th St

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 1419415

Nearest Address 1567 SW Chandler Ave

Asset Numbers DDW008597 DDW008596 DDW008595

Date Reported: 6/1/2022 12:00:00 AM

Flooding Information	
Flooding Severity:	Right-of-Way (Moderate Traffic Impacts)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drywell

Flooding Description:

Water puddles across the road during large rain events

Proposed Solution:

Install additional UIC's, Install regional swale

Additional Information:

There are several drywells in this area that do infiltrate, but become overwhelmed during large rain events. There is a lot of pumice soil in the area that does not drain well.

Map:


Tykeson Hall
Bend Science Station
Obsidian Hall
SW Chandler Ave
SW Chandler Ave
Ave
Yates Dr

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 1225892
Nearest Address 1757 Forest Ridge Ave
Asset Number DDH009888
Date Reported: 7/21/2020 12:00:00 AM

Flooding Information	
Flooding Severity:	Property Damage (Exterior)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drill Hole

Flooding Description:

During large rain events water from both sides of Forest Ridge overwhelm the drillhole and flood on private property.

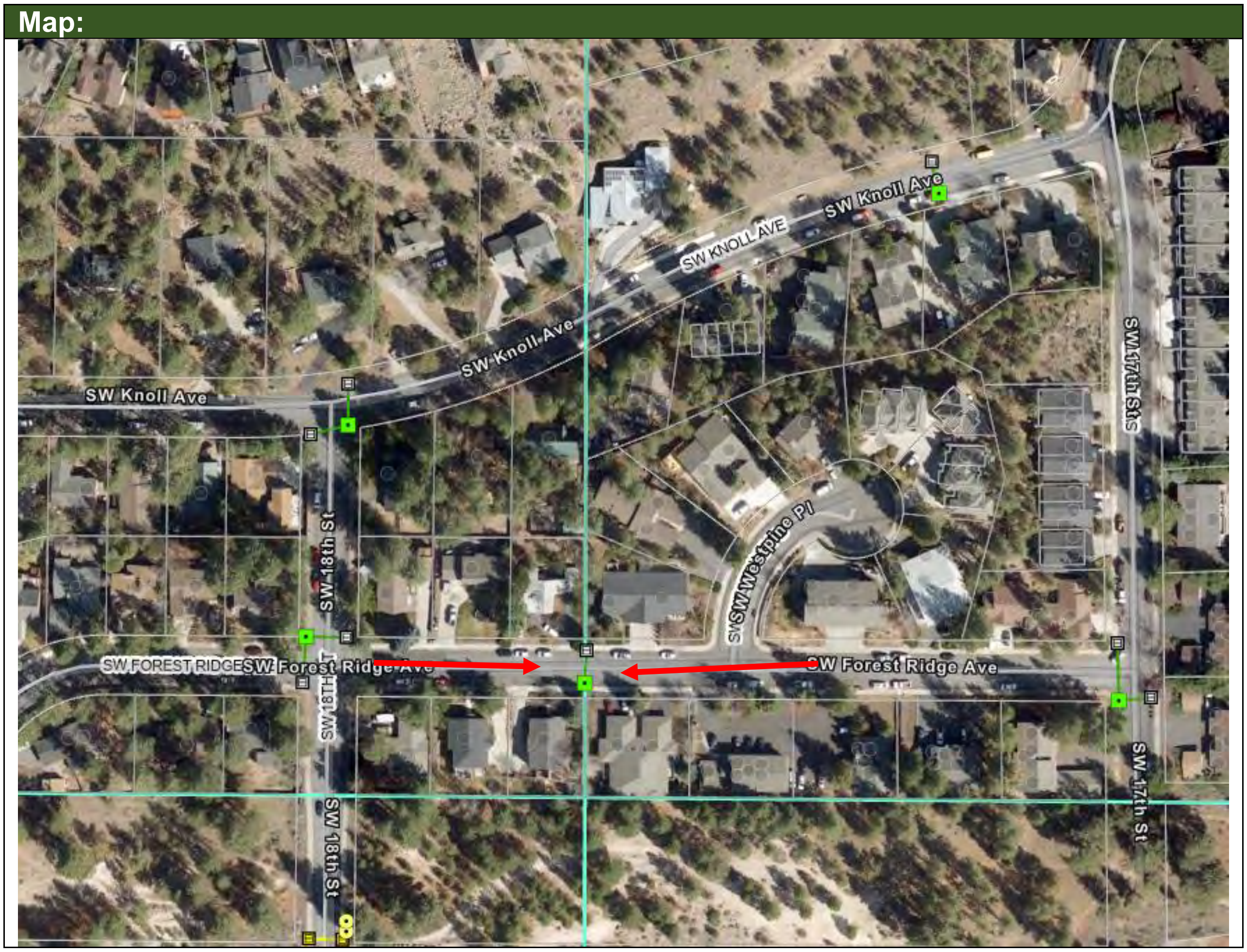
Proposed Solution:

Install new drainage/UIC's

Additional Information:

This drillhole was re-drilled in 2015 to 87ft but still only takes 44 gpm. This drillhole has since filled in due to loose pumice-soil.

Map:


SW Knoll Ave
SW Knoll Ave
SW KNOLL AVE
SW Knoll Ave
SW 18th St
SW FOREST RIDGE
SW Forest Ridge Ave
SW 18TH ST
SW 18th St
SW Westpine Pl
SW Forest Ridge Ave
SW 17th St
SW 17th St

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # [Work Order #]
Nearest Address 60924 SW McMullin
Asset Number DDH009462
Date Reported: [Date Added]

Flooding Information

Flooding Severity:	Property Damage (Exterior)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drill Hole

Flooding Description:

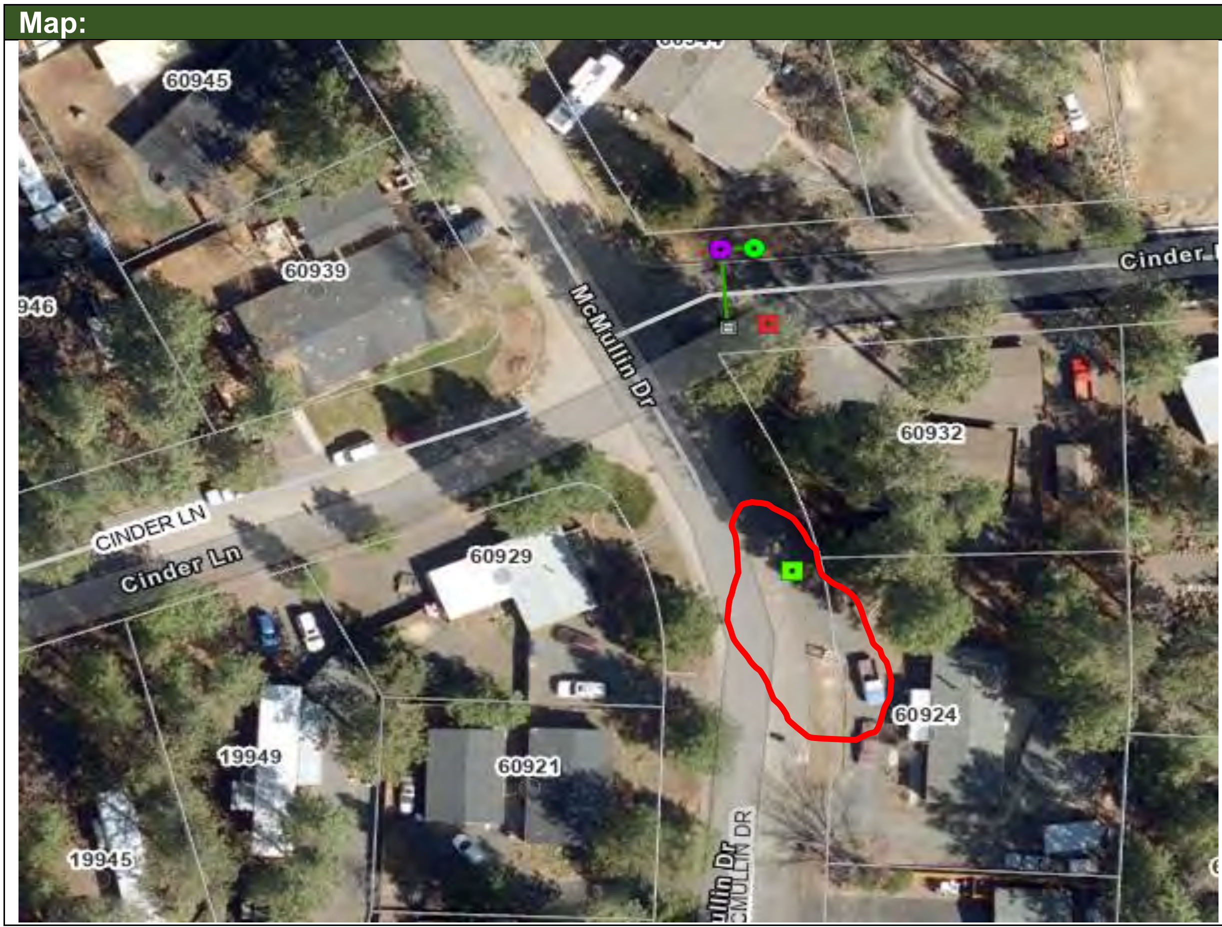
Failed drill hole causing water to puddle in the roadway and flow onto private property.

Proposed Solution:

Install new storm system or connect to new storm system located 100’ to the north.

Additional Information:

Map:


60945
60939
946
McMullin Dr
Cinder Ln
CINDER LN
Cinder Ln
60932
60929
60924
19949
60921
19945
McMullin Dr
MCMULLIN DR

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 780398
Nearest Address 61553 Westridge Ave
Asset Number DDH009865
Date Reported: 6/20/2016

Flooding Information

Flooding Severity:	Property Damage (Exterior)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drill Hole

Flooding Description:

Drill hole has failed. Stormwater builds up and flows over driveway approach onto property causing erosion.

Proposed Solution:

Install new storm system

Additional Information:

Map:


61553
61552
SW Westridge Ave
WEST RIDGE AVE
SW Westridge Ave
SW Westridge Ave
SW

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 1310021
Nearest Address 63275 Wishing Well Ln.
Asset Numbers DDW007000 DDW009788 DDW010035
Date Reported: 6/24/2021 12:00:00 AM

Flooding Information

Flooding Severity:	Property Damage (Exterior)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drywell

Flooding Description:

During large rain events the entire intersection floods over the curb onto private property.

Proposed Solution:

Install additional drainage/UIC’s, install regional swale

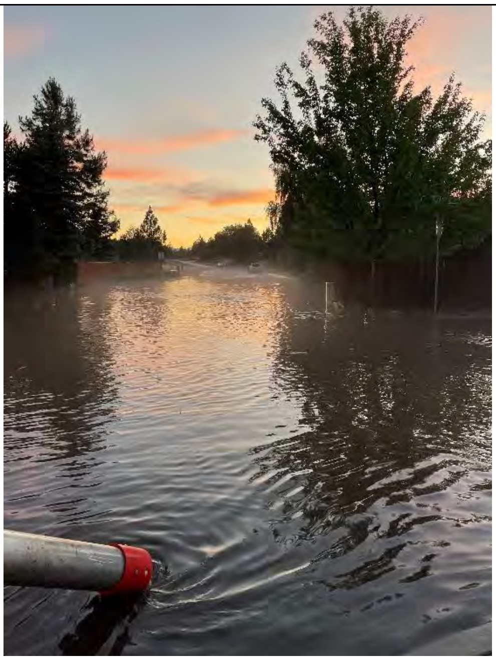
Additional Information:

On 6/24/2021 we removed approximately 24 Vactor loads of water from this intersection. The drywells in this area do infiltrate but can be overwhelmed during large events.

Map:


BOYD ACRES RD
Carly Ln
Ridgefield Dr
NE Majestic
Liberty Ln
AMBER CT
NE Amber Way
AMBER WAY
NE Morningstar Dr
NE Morningstar Dr
NE Morningstar Dr
MORNINGSTAR DR
PEALE ST
Wishing Well Ln
WISHING WELL LN
NE Gallop Ct
GALLOP RD
Gallop Rd

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 1082854

Nearest Address NE 4th St/NE Revere Ave

Asset Number DDH009226 DDH009225 DDH009223

Date Reported: 12/18/2018 12:00:00 AM

Flooding Information

Flooding Severity:	Right-of-Way (Moderate Traffic Impacts)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Under Sized System

Flooding Description:

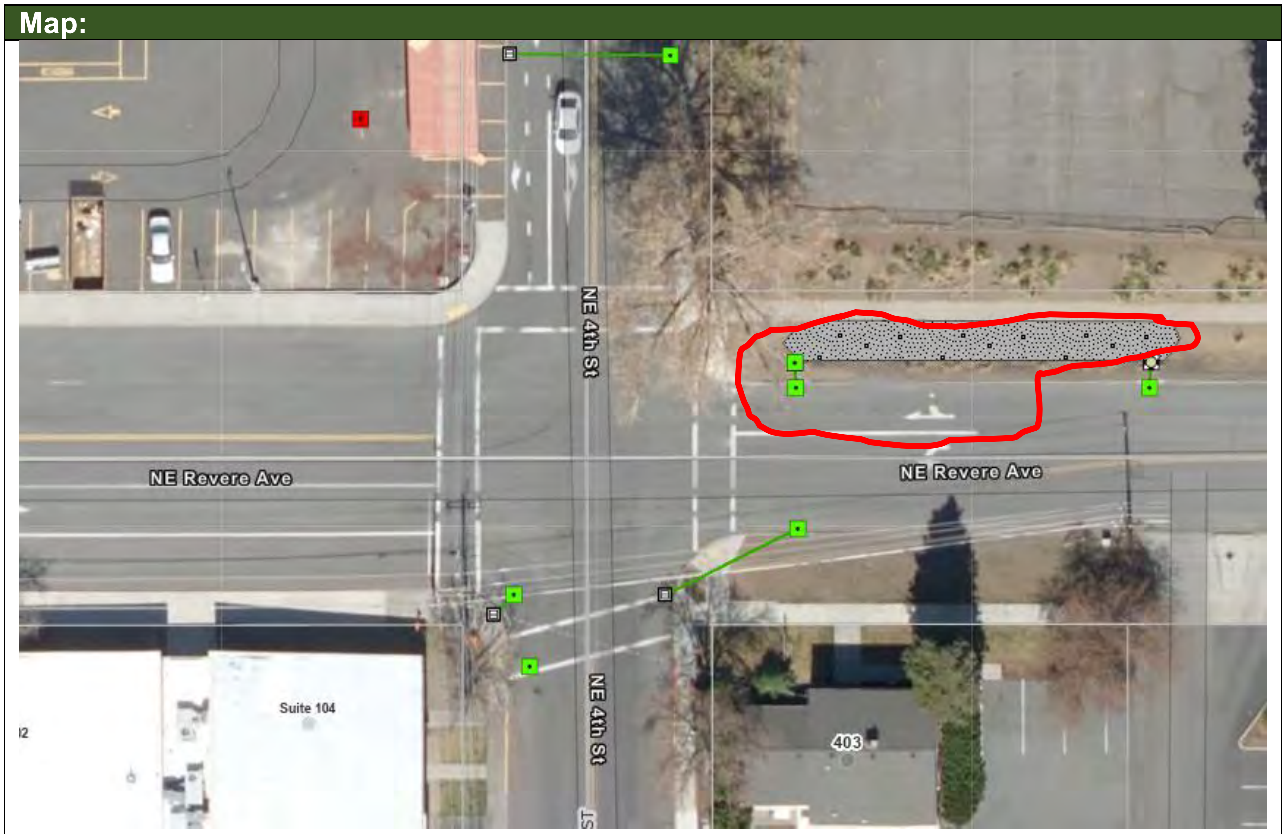
Stormwater runoff overwhelms drill holes and the swale causing water puddle in the roadway.

Proposed Solution:

Install additional UIC’s with pretreatment to handle runoff.

Additional Information:

Map:



Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 715134
Nearest Address NE 4th at NE Onley Ave
Asset Number DDW003050
Date Reported: 5/21/2015 12:00:00 AM

Flooding Information	
Flooding Severity:	Select Option
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	[Problem Code]

Flooding Description:

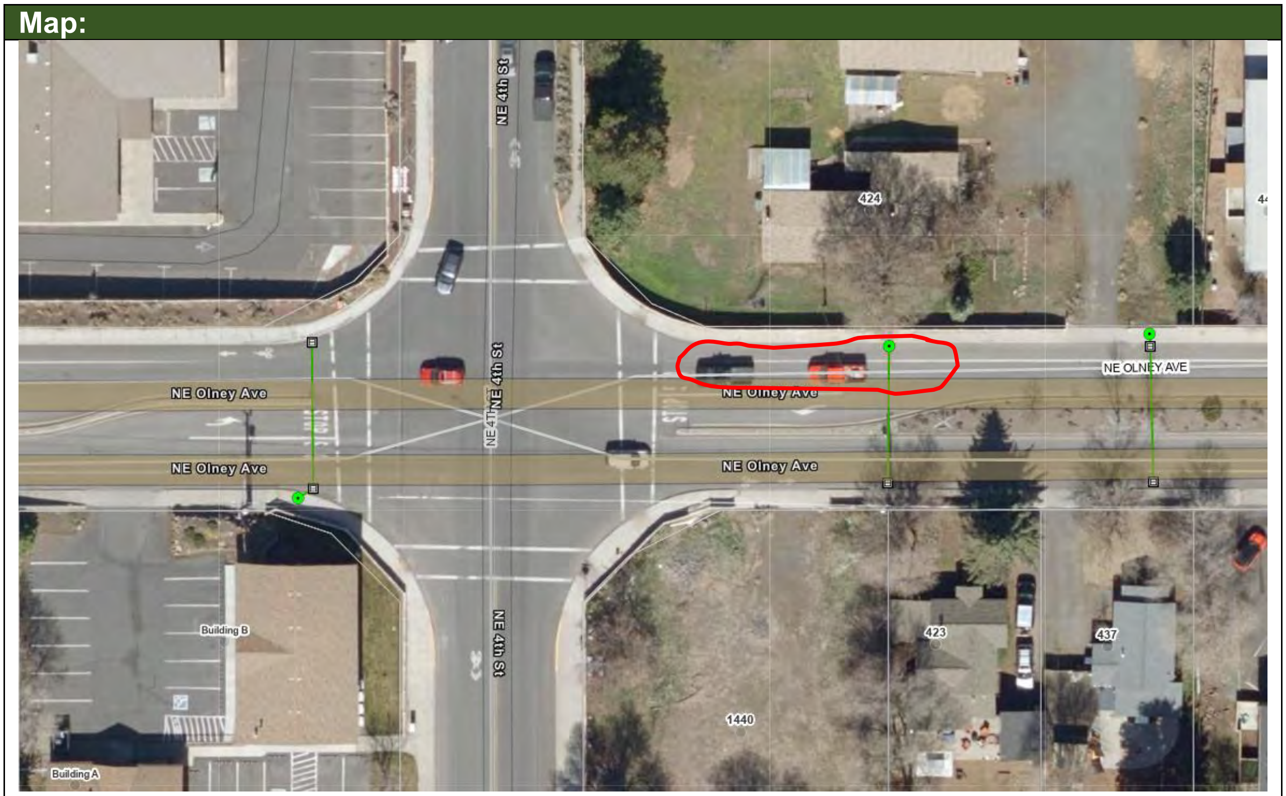
There is a failing drywell at this location that becomes overwhelmed during rain events. We have responded to this location for more than 20 years. New drainage has been added uphill of this intersection over the years which has reduced the amount of water this UIC’c receives. Response to this location is now less frequent.

Proposed Solution:

Add an additional UIC or connected drywell to the drywell that works 85’ to the east.

Additional Information:

Map:


NE 4th St
424
NE OLNEY AVE
NE Olney Ave
NE 4TH
NE 4th St
NE Olney Ave
NE Olney Ave
NE Olney Ave
Building B
423
437
NE 4th St
1440
Building A

Images:

Completed by ACE/SW Management Team

Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

Priority 3 Locations

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # N/A
Nearest Address 59 SW Hayes Ave
Asset Number DDW008118
Date Reported: 3/1/2024 12:00:00 AM

Flooding Information

Flooding Severity:	Right-of-Way (Moderate Traffic Impacts)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	No Drainage Systems

Flooding Description:

Historic flooding location, water puddles in road before it can flow east to the catch basin and drywell

Proposed Solution:

Install additional catch basins and connect to drywell, install additional UIC’s, install regional swale

Additional Information:

Mike’s Fence Center did some work on their property to control stormwater which helps, but water still puddles in the driveway to the food bank

Map:


SW Hayes Ave
7-Eleven
SE Division St
SE 3RD ST
Cynthia's Sewing Center
Super 8
SE 3rd St

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # 1419952
Nearest Address 576 NW Lindsay Ct.
Asset Number DDW007203
Date Reported: 6/6/2022 12:00:00 AM

Flooding Information	
Flooding Severity:	Property Damage (Exterior)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drywell

Flooding Description:

Runoff from Overturf Butte runs downhill onto private property and overwhelms the catch basin and drywell. The drywell does infiltrate slowly but is undersized for the area.

Proposed Solution:

Install additional UIC’s, better control of runoff on Overturf Butte

Additional Information:

The stormwater maintenance crew installed several erosion control measures on Overturf Butte including: straw wattles, check dams, and re-vegetation. This did help, but the larger storms still cause problems.

Map:

Deschutes County - Assessor's Office | City of Bend, OR, Maxar, Microsoft | Esri Community

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

UTILITY DEPARTMENT

Stormwater Project Request

Work Order # N/A
Nearest Address 1507 NE 1st St.
Asset Number DDH009532
Date Reported: 3/1/2024 12:00:00 AM

Flooding Information

Flooding Severity:	Property Damage (Exterior)
Triggering Rain Event Size (In):	[Rain Event (In):]
Problem Code	Failing Drill Hole

Flooding Description:

Historic flooding location, water from Olney and 1st converge causing flooding on private property

Proposed Solution:

Install additional UIC’s, install regional swale

Additional Information:

There is one drillhole in the are that does infiltrate, but can become overwhelmed during larger rain events. Water puddles on the north and south side of the intersection.

Map:


Burlington N
1507
1506
NE 1st Ave
1515
NW Olney Ave
NE Olney Ave
NE Ol
1470
21
147
Burlington Northern Santa Fe
NE 1st St

Images:

Completed by ACE/SW Management Team	
Project Name:	[Project Name]
Estimated Drainage Basin Size (Acres):	[Drainage Basin Size]
Priority Ranking:	[Priority Ranking]
Project Category:	Under Review
Estimated Budget:	[Estimated Budget:]
Project Funding Year:	[Project Funding Year:]
Project Status:	Open

APPENDIX B

Drillhole Prioritizations

Appendix B. Score Assigned to Drill Holes

Drill Hole ID	Land Use Risk	Traffic Volume Risk	Water Well Locations Risk	TOT Zones Risk	Perched GW Risk	Current Drill Hole Condition Risk	Total Score (Formula)	Total Score	Priority Ranking
DDH002049	1	1	3	20	1		=(C3+D3+E3)*F3*G3	100	1
DDH009381	1	1	3	20	1		=(C4+D4+E4)*F4*G4	100	1
DDH009446	1	1	3	20	1		=(C5+D5+E5)*F5*G5	100	1
DDH009447	1	1	3	20	1		=(C6+D6+E6)*F6*G6	100	1
DDH009482	1	1	3	20	1		=(C7+D7+E7)*F7*G7	100	1
DDH009485	3	1	1	20	1		=(C8+D8+E8)*F8*G8	100	1
DDH009498	3	1	1	20	1		=(C9+D9+E9)*F9*G9	100	1
DDH009510	3	1	1	20	1		=(C10+D10+E10)*F10*G10	100	1
DDH009513	3	1	1	20	1		=(C11+D11+E11)*F11*G11	100	1
DDH009514	3	1	1	20	1		=(C12+D12+E12)*F12*G12	100	1
DDH009520	3	1	1	20	1		=(C13+D13+E13)*F13*G13	100	1
DDH009550	3	1	1	20	1		=(C14+D14+E14)*F14*G14	100	1
DDH009624	3	1	1	20	1		=(C15+D15+E15)*F15*G15	100	1
DDH009625	3	1	1	20	1		=(C16+D16+E16)*F16*G16	100	1
DDH009727	3	1	1	20	1		=(C17+D17+E17)*F17*G17	100	1
DDH009728	3	1	1	20	1		=(C18+D18+E18)*F18*G18	100	1
DDH009763	3	1	1	20	1		=(C19+D19+E19)*F19*G19	100	1
DDH009764	3	1	1	20	1		=(C20+D20+E20)*F20*G20	100	1
DDH009765	3	1	1	20	1		=(C21+D21+E21)*F21*G21	100	1
DDH009766	3	1	1	20	1		=(C22+D22+E22)*F22*G22	100	1
DDH009767	3	1	1	20	1		=(C23+D23+E23)*F23*G23	100	1
DDH009841	3	1	1	20	1		=(C24+D24+E24)*F24*G24	100	1
DDH010013	1	1	3	20	1		=(C25+D25+E25)*F25*G25	100	1
DDH009875	2	1	1	20	1		=(C26+D26+E26)*F26*G26	80	2
DDH009932	2	1	1	20	1		=(C27+D27+E27)*F27*G27	80	2
DDH001012	1	1	1	20	1		=(C28+D28+E28)*F28*G28	60	3
DDH001013	1	1	1	20	1		=(C29+D29+E29)*F29*G29	60	3
DDH001014	1	1	1	20	1		=(C30+D30+E30)*F30*G30	60	3
DDH001015	1	1	1	20	1		=(C31+D31+E31)*F31*G31	60	3

DDH001022	1	1	1	20	1	=(C32+D32+E32)*F32*G32	60	3
DDH001023	1	1	1	20	1	=(C33+D33+E33)*F33*G33	60	3
DDH002018	1	1	1	20	1	=(C34+D34+E34)*F34*G34	60	3
DDH002019	1	1	1	20	1	=(C35+D35+E35)*F35*G35	60	3
DDH002020	1	1	1	20	1	=(C36+D36+E36)*F36*G36	60	3
DDH002022	1	1	1	20	1	=(C37+D37+E37)*F37*G37	60	3
DDH002023	1	1	1	20	1	=(C38+D38+E38)*F38*G38	60	3
DDH009122	1	1	1	20	1	=(C39+D39+E39)*F39*G39	60	3
DDH009129	1	1	1	20	1	=(C40+D40+E40)*F40*G40	60	3
DDH009130	1	1	1	20	1	=(C41+D41+E41)*F41*G41	60	3
DDH009380	1	1	1	20	1	=(C42+D42+E42)*F42*G42	60	3
DDH009384	1	1	1	20	1	=(C43+D43+E43)*F43*G43	60	3
DDH009385	1	1	1	20	1	=(C44+D44+E44)*F44*G44	60	3
DDH009386	1	1	1	20	1	=(C45+D45+E45)*F45*G45	60	3
DDH009387	1	1	1	20	1	=(C46+D46+E46)*F46*G46	60	3
DDH009388	1	1	1	20	1	=(C47+D47+E47)*F47*G47	60	3
DDH009389	1	1	1	20	1	=(C48+D48+E48)*F48*G48	60	3
DDH009390	1	1	1	20	1	=(C49+D49+E49)*F49*G49	60	3
DDH009391	1	1	1	20	1	=(C50+D50+E50)*F50*G50	60	3
DDH009392	1	1	1	20	1	=(C51+D51+E51)*F51*G51	60	3
DDH009393	1	1	1	20	1	=(C52+D52+E52)*F52*G52	60	3
DDH009394	1	1	1	20	1	=(C53+D53+E53)*F53*G53	60	3
DDH009395	1	1	1	20	1	=(C54+D54+E54)*F54*G54	60	3
DDH009396	1	1	1	20	1	=(C55+D55+E55)*F55*G55	60	3
DDH009397	1	1	1	20	1	=(C56+D56+E56)*F56*G56	60	3
DDH009398	1	1	1	20	1	=(C57+D57+E57)*F57*G57	60	3
DDH009399	1	1	1	20	1	=(C58+D58+E58)*F58*G58	60	3
DDH009400	1	1	1	20	1	=(C59+D59+E59)*F59*G59	60	3
DDH009401	1	1	1	20	1	=(C60+D60+E60)*F60*G60	60	3
DDH009402	1	1	1	20	1	=(C61+D61+E61)*F61*G61	60	3
DDH009403	1	1	1	20	1	=(C62+D62+E62)*F62*G62	60	3
DDH009404	1	1	1	20	1	=(C63+D63+E63)*F63*G63	60	3
DDH009405	1	1	1	20	1	=(C64+D64+E64)*F64*G64	60	3

DDH009406	1	1	1	20	1	=(C65+D65+E65)*F65*G65	60	3
DDH009407	1	1	1	20	1	=(C66+D66+E66)*F66*G66	60	3
DDH009412	1	1	1	20	1	=(C67+D67+E67)*F67*G67	60	3
DDH009413	1	1	1	20	1	=(C68+D68+E68)*F68*G68	60	3
DDH009415	1	1	1	20	1	=(C69+D69+E69)*F69*G69	60	3
DDH009416	1	1	1	20	1	=(C70+D70+E70)*F70*G70	60	3
DDH009417	1	1	1	20	1	=(C71+D71+E71)*F71*G71	60	3
DDH009418	1	1	1	20	1	=(C72+D72+E72)*F72*G72	60	3
DDH009419	1	1	1	20	1	=(C73+D73+E73)*F73*G73	60	3
DDH009420	1	1	1	20	1	=(C74+D74+E74)*F74*G74	60	3
DDH009421	1	1	1	20	1	=(C75+D75+E75)*F75*G75	60	3
DDH009422	1	1	1	20	1	=(C76+D76+E76)*F76*G76	60	3
DDH009423	1	1	1	20	1	=(C77+D77+E77)*F77*G77	60	3
DDH009424	1	1	1	20	1	=(C78+D78+E78)*F78*G78	60	3
DDH009425	1	1	1	20	1	=(C79+D79+E79)*F79*G79	60	3
DDH009426	1	1	1	20	1	=(C80+D80+E80)*F80*G80	60	3
DDH009428	1	1	1	20	1	=(C81+D81+E81)*F81*G81	60	3
DDH009429	1	1	1	20	1	=(C82+D82+E82)*F82*G82	60	3
DDH009430	1	1	1	20	1	=(C83+D83+E83)*F83*G83	60	3
DDH009431	1	1	1	20	1	=(C84+D84+E84)*F84*G84	60	3
DDH009433	1	1	1	20	1	=(C85+D85+E85)*F85*G85	60	3
DDH009434	1	1	1	20	1	=(C86+D86+E86)*F86*G86	60	3
DDH009435	1	1	1	20	1	=(C87+D87+E87)*F87*G87	60	3
DDH009436	1	1	1	20	1	=(C88+D88+E88)*F88*G88	60	3
DDH009437	1	1	1	20	1	=(C89+D89+E89)*F89*G89	60	3
DDH009438	1	1	1	20	1	=(C90+D90+E90)*F90*G90	60	3
DDH009439	1	1	1	20	1	=(C91+D91+E91)*F91*G91	60	3
DDH009440	1	1	1	20	1	=(C92+D92+E92)*F92*G92	60	3
DDH009441	1	1	1	20	1	=(C93+D93+E93)*F93*G93	60	3
DDH009443	1	1	1	20	1	=(C94+D94+E94)*F94*G94	60	3
DDH009444	1	1	1	20	1	=(C95+D95+E95)*F95*G95	60	3
DDH009445	1	1	1	20	1	=(C96+D96+E96)*F96*G96	60	3
DDH009571	1	1	1	20	1	=(C97+D97+E97)*F97*G97	60	3

DDH009572	1	1	1	20	1		=(C98+D98+E98)*F98*G98	60	3
DDH009573	1	1	1	20	1		=(C99+D99+E99)*F99*G99	60	3
DDH009583	1	1	1	20	1		=(C100+D100+E100)*F100*G100	60	3
DDH009585	1	1	1	20	1		=(C101+D101+E101)*F101*G101	60	3
DDH009586	1	1	1	20	1		=(C102+D102+E102)*F102*G102	60	3
DDH009603	1	1	1	20	1		=(C103+D103+E103)*F103*G103	60	3
DDH009604	1	1	1	20	1		=(C104+D104+E104)*F104*G104	60	3
DDH009605	1	1	1	20	1		=(C105+D105+E105)*F105*G105	60	3
DDH009606	1	1	1	20	1		=(C106+D106+E106)*F106*G106	60	3
DDH009609	1	1	1	20	1		=(C107+D107+E107)*F107*G107	60	3
DDH009628	1	1	1	20	1		=(C108+D108+E108)*F108*G108	60	3
DDH009629	1	1	1	20	1		=(C109+D109+E109)*F109*G109	60	3
DDH009630	1	1	1	20	1		=(C110+D110+E110)*F110*G110	60	3
DDH009631	1	1	1	20	1		=(C111+D111+E111)*F111*G111	60	3
DDH009632	1	1	1	20	1		=(C112+D112+E112)*F112*G112	60	3
DDH001019	1	1	10	1	1		=(C113+D113)*E113*F113*G113	20	4
DDH009454	1	1	10	1	1		=(C114+D114)*E114*F114*G114	20	4
DDH009863	2	3	1	1	1	3	=(C115+D115+E115)*F115*G115*H115	18	5
DDH009902	2	3	1	1	1	3	=(C116+D116+E116)*F116*G116*H116	18	5
DDH010018	2	3	1	1	1	3	=(C117+D117+E117)*F117*G117*H117	18	5
DDH010019	2	3	1	1	1	3	=(C118+D118+E118)*F118*G118*H118	18	5
DDH009490	2	1	1	1	1	3	=(C119+D119+E119)*F119*G119*H119	12	6
DDH009491	2	1	1	1	1	3	=(C120+D120+E120)*F120*G120*H120	12	6
DDH009492	2	1	1	1	1	3	=(C121+D121+E121)*F121*G121*H121	12	6
DDH009493	2	1	1	1	1	3	=(C122+D122+E122)*F122*G122*H122	12	6
DDH009725	2	1	1	1	1	3	=(C123+D123+E123)*F123*G123*H123	12	6
DDH010016	2	1	1	1	1	3	=(C124+D124+E124)*F124*G124*H124	12	6
DDH010028	2	1	1	1	1	3	=(C125+D125+E125)*F125*G125*H125	12	6
DDH009771	3	1	1	1	1	2	=(C126+D126+E126)*F126*G126*H126	10	7
DDH009772	3	1	1	1	1	2	=(C127+D127+E127)*F127*G127*H127	10	7
DDH002042	1	1	1	1	1	3	=(C128+D128+E128)*F128*G128*H128	9	8
DDH009131	1	1	1	1	1	3	=(C129+D129+E129)*F129*G129*H129	9	8
DDH009184	1	1	1	1	1	3	=(C130+D130+E130)*F130*G130*H130	9	8

DDH009185	1	1	1	1	1	3	=(C131+D131+E131)*F131*G131*H131	9	8
DDH009714	1	1	1	1	1	3	=(C132+D132+E132)*F132*G132*H132	9	8
DDH009715	1	1	1	1	1	3	=(C133+D133+E133)*F133*G133*H133	9	8
DDH009889	1	1	1	1	1	3	=(C134+D134+E134)*F134*G134*H134	9	8
DDH009890	1	1	1	1	1	3	=(C135+D135+E135)*F135*G135*H135	9	8
DDH009891	1	1	1	1	1	3	=(C136+D136+E136)*F136*G136*H136	9	8
DDH002024	2	1	1	1	1	2	=(C137+D137+E137)*F137*G137*H137	8	9
DDH009038	2	3	3	1	1		=(C138+D138+E138)*F138*G138	8	9
DDH009503	2	1	1	1	1	2	=(C139+D139+E139)*F139*G139*H139	8	9
DDH009551	2	1	1	1	1	2	=(C140+D140+E140)*F140*G140*H140	8	9
DDH009614	2	1	1	1	1	2	=(C141+D141+E141)*F141*G141*H141	8	9
DDH009615	2	1	1	1	1	2	=(C142+D142+E142)*F142*G142*H142	8	9
DDH009616	2	1	1	1	1	2	=(C143+D143+E143)*F143*G143*H143	8	9
DDH009662	2	1	1	1	1	2	=(C144+D144+E144)*F144*G144*H144	8	9
DDH009663	2	1	1	1	1	2	=(C145+D145+E145)*F145*G145*H145	8	9
DDH002048	3	3	1	1	1		=(C146+D146+E146)*F146*G146	7	10
DDH009024	3	3	1	1	1		=(C147+D147+E147)*F147*G147	7	10
DDH002025	2	3	1	1	1		=(C148+D148+E148)*F148*G148	6	11
DDH002036	2	3	1	1	1		=(C149+D149+E149)*F149*G149	6	11
DDH009016	2	1	1	1	1.5		=(C150+D150+E150)*F150*G150	6	11
DDH009017	2	1	1	1	1.5		=(C151+D151+E151)*F151*G151	6	11
DDH009018	2	1	1	1	1.5		=(C152+D152+E152)*F152*G152	6	11
DDH009032	2	3	1	1	1		=(C153+D153+E153)*F153*G153	6	11
DDH009221	1	1	1	1	1	2	=(C154+D154+E154)*F154*G154*H154	6	11
DDH009223	1	1	1	1	1	2	=(C155+D155+E155)*F155*G155*H155	6	11
DDH009225	1	1	1	1	1	2	=(C156+D156+E156)*F156*G156*H156	6	11
DDH009226	1	1	1	1	1	2	=(C157+D157+E157)*F157*G157*H157	6	11
DDH009245	2	3	1	1	1		=(C158+D158+E158)*F158*G158	6	11
DDH009246	2	3	1	1	1		=(C159+D159+E159)*F159*G159	6	11
DDH009345	2	3	1	1	1		=(C160+D160+E160)*F160*G160	6	11
DDH009346	2	3	1	1	1		=(C161+D161+E161)*F161*G161	6	11
DDH009347	2	3	1	1	1		=(C162+D162+E162)*F162*G162	6	11
DDH009462	1	1	1	1	1	2	=(C163+D163+E163)*F163*G163*H163	6	11

DDH009588	2	3	1	1	1		=(C164+D164+E164)*F164*G164	6	11
DDH009613	2	3	1	1	1		=(C165+D165+E165)*F165*G165	6	11
DDH009618	2	3	1	1	1		=(C166+D166+E166)*F166*G166	6	11
DDH009621	2	3	1	1	1		=(C167+D167+E167)*F167*G167	6	11
DDH009653	2	3	1	1	1		=(C168+D168+E168)*F168*G168	6	11
DDH009654	2	3	1	1	1		=(C169+D169+E169)*F169*G169	6	11
DDH009655	2	3	1	1	1		=(C170+D170+E170)*F170*G170	6	11
DDH009656	2	3	1	1	1		=(C171+D171+E171)*F171*G171	6	11
DDH009658	1	1	1	1	1	2	=(C172+D172+E172)*F172*G172*H172	6	11
DDH009665	1	1	1	1	1	2	=(C173+D173+E173)*F173*G173*H173	6	11
DDH009787	2	3	1	1	1		=(C174+D174+E174)*F174*G174	6	11
DDH009849	2	1	3	1	1		=(C175+D175+E175)*F175*G175	6	11
DDH009851	2	3	1	1	1		=(C176+D176+E176)*F176*G176	6	11
DDH009852	2	3	1	1	1		=(C177+D177+E177)*F177*G177	6	11
DDH009853	2	3	1	1	1		=(C178+D178+E178)*F178*G178	6	11
DDH009860	2	3	1	1	1		=(C179+D179+E179)*F179*G179	6	11
DDH009862	2	3	1	1	1		=(C180+D180+E180)*F180*G180	6	11
DDH009864	2	3	1	1	1		=(C181+D181+E181)*F181*G181	6	11
DDH009865	1	1	1	1	1	2	=(C182+D182+E182)*F182*G182*H182	6	11
DDH009888	1	1	1	1	1	2	=(C183+D183+E183)*F183*G183*H183	6	11
DDH009895	2	3	1	1	1		=(C184+D184+E184)*F184*G184	6	11
DDH009898	2	3	1	1	1		=(C185+D185+E185)*F185*G185	6	11
DDH009899	2	3	1	1	1		=(C186+D186+E186)*F186*G186	6	11
DDH009900	2	3	1	1	1		=(C187+D187+E187)*F187*G187	6	11
DDH009901	2	3	1	1	1		=(C188+D188+E188)*F188*G188	6	11
DDH009903	2	3	1	1	1		=(C189+D189+E189)*F189*G189	6	11
DDH009904	2	3	1	1	1		=(C190+D190+E190)*F190*G190	6	11
DDH009905	2	3	1	1	1		=(C191+D191+E191)*F191*G191	6	11
DDH009909	2	3	1	1	1		=(C192+D192+E192)*F192*G192	6	11
DDH009965	2	3	1	1	1		=(C193+D193+E193)*F193*G193	6	11
DDH010004	2	3	1	1	1		=(C194+D194+E194)*F194*G194	6	11
DDH010012	2	3	1	1	1		=(C195+D195+E195)*F195*G195	6	11
DDH001018	1	1	3	1	1		=(C196+D196+E196)*F196*G196	5	12

DDH001020	1	1	3	1	1	=(C197+D197+E197)*F197*G197	5	12
DDH001021	1	1	3	1	1	=(C198+D198+E198)*F198*G198	5	12
DDH001024	1	1	3	1	1	=(C199+D199+E199)*F199*G199	5	12
DDH001028	1	3	1	1	1	=(C200+D200+E200)*F200*G200	5	12
DDH001029	1	3	1	1	1	=(C201+D201+E201)*F201*G201	5	12
DDH001030	1	3	1	1	1	=(C202+D202+E202)*F202*G202	5	12
DDH001031	1	3	1	1	1	=(C203+D203+E203)*F203*G203	5	12
DDH002046	1	3	1	1	1	=(C204+D204+E204)*F204*G204	5	12
DDH002047	1	3	1	1	1	=(C205+D205+E205)*F205*G205	5	12
DDH002050	3	1	1	1	1	=(C206+D206+E206)*F206*G206	5	12
DDH009019	1	1	3	1	1	=(C207+D207+E207)*F207*G207	5	12
DDH009020	1	1	3	1	1	=(C208+D208+E208)*F208*G208	5	12
DDH009021	1	1	3	1	1	=(C209+D209+E209)*F209*G209	5	12
DDH009022	1	1	3	1	1	=(C210+D210+E210)*F210*G210	5	12
DDH009050	1	1	3	1	1	=(C211+D211+E211)*F211*G211	5	12
DDH009051	1	1	3	1	1	=(C212+D212+E212)*F212*G212	5	12
DDH009113	1	3	1	1	1	=(C213+D213+E213)*F213*G213	5	12
DDH009116	1	3	1	1	1	=(C214+D214+E214)*F214*G214	5	12
DDH009160	3	1	1	1	1	=(C215+D215+E215)*F215*G215	5	12
DDH009161	3	1	1	1	1	=(C216+D216+E216)*F216*G216	5	12
DDH009163	3	1	1	1	1	=(C217+D217+E217)*F217*G217	5	12
DDH009175	1	3	1	1	1	=(C218+D218+E218)*F218*G218	5	12
DDH009455	1	1	3	1	1	=(C219+D219+E219)*F219*G219	5	12
DDH009456	1	1	3	1	1	=(C220+D220+E220)*F220*G220	5	12
DDH009476	1	1	3	1	1	=(C221+D221+E221)*F221*G221	5	12
DDH009477	1	1	3	1	1	=(C222+D222+E222)*F222*G222	5	12
DDH009478	1	1	3	1	1	=(C223+D223+E223)*F223*G223	5	12
DDH009511	3	1	1	1	1	=(C224+D224+E224)*F224*G224	5	12
DDH009512	3	1	1	1	1	=(C225+D225+E225)*F225*G225	5	12
DDH009641	1	1	3	1	1	=(C226+D226+E226)*F226*G226	5	12
DDH009648	3	1	1	1	1	=(C227+D227+E227)*F227*G227	5	12
DDH009690	3	1	1	1	1	=(C228+D228+E228)*F228*G228	5	12
DDH009729	3	1	1	1	1	=(C229+D229+E229)*F229*G229	5	12

DDH009730	3	1	1	1	1	=(C230+D230+E230)*F230*G230	5	12
DDH009731	3	1	1	1	1	=(C231+D231+E231)*F231*G231	5	12
DDH009732	3	1	1	1	1	=(C232+D232+E232)*F232*G232	5	12
DDH009733	3	1	1	1	1	=(C233+D233+E233)*F233*G233	5	12
DDH009734	3	1	1	1	1	=(C234+D234+E234)*F234*G234	5	12
DDH009735	3	1	1	1	1	=(C235+D235+E235)*F235*G235	5	12
DDH009768	3	1	1	1	1	=(C236+D236+E236)*F236*G236	5	12
DDH009769	3	1	1	1	1	=(C237+D237+E237)*F237*G237	5	12
DDH009770	3	1	1	1	1	=(C238+D238+E238)*F238*G238	5	12
DDH009773	3	1	1	1	1	=(C239+D239+E239)*F239*G239	5	12
DDH009774	3	1	1	1	1	=(C240+D240+E240)*F240*G240	5	12
DDH009775	3	1	1	1	1	=(C241+D241+E241)*F241*G241	5	12
DDH009776	3	1	1	1	1	=(C242+D242+E242)*F242*G242	5	12
DDH009777	3	1	1	1	1	=(C243+D243+E243)*F243*G243	5	12
DDH009778	3	1	1	1	1	=(C244+D244+E244)*F244*G244	5	12
DDH009815	1	1	3	1	1	=(C245+D245+E245)*F245*G245	5	12
DDH009846	1	1	3	1	1	=(C246+D246+E246)*F246*G246	5	12
DDH009938	3	1	1	1	1	=(C247+D247+E247)*F247*G247	5	12
DDH009955	3	1	1	1	1	=(C248+D248+E248)*F248*G248	5	12
DDH010015	3	1	1	1	1	=(C249+D249+E249)*F249*G249	5	12
DDH010031	3	1	1	1	1	=(C250+D250+E250)*F250*G250	5	12
DDH009722	1	1	1	1	1.5	=(C251+D251+E251)*F251*G251	4.5	13
DDH009723	1	1	1	1	1.5	=(C252+D252+E252)*F252*G252	4.5	13
DDH009914	1	1	1	1	1.5	=(C253+D253+E253)*F253*G253	4.5	13
DDH009916	1	1	1	1	1.5	=(C254+D254+E254)*F254*G254	4.5	13
DDH001032	2	1	1	1	1	=(C255+D255+E255)*F255*G255	4	14
DDH001033	2	1	1	1	1	=(C256+D256+E256)*F256*G256	4	14
DDH001034	2	1	1	1	1	=(C257+D257+E257)*F257*G257	4	14
DDH002006	2	1	1	1	1	=(C258+D258+E258)*F258*G258	4	14
DDH002007	2	1	1	1	1	=(C259+D259+E259)*F259*G259	4	14
DDH002035	2	1	1	1	1	=(C260+D260+E260)*F260*G260	4	14
DDH002059	2	1	1	1	1	=(C261+D261+E261)*F261*G261	4	14
DDH002061	2	1	1	1	1	=(C262+D262+E262)*F262*G262	4	14

DDH002067	2	1	1	1	1	=(C263+D263+E263)*F263*G263	4	14
DDH009139	2	1	1	1	1	=(C264+D264+E264)*F264*G264	4	14
DDH009159	2	1	1	1	1	=(C265+D265+E265)*F265*G265	4	14
DDH009231	2	1	1	1	1	=(C266+D266+E266)*F266*G266	4	14
DDH009232	2	1	1	1	1	=(C267+D267+E267)*F267*G267	4	14
DDH009233	2	1	1	1	1	=(C268+D268+E268)*F268*G268	4	14
DDH009249	2	1	1	1	1	=(C269+D269+E269)*F269*G269	4	14
DDH009258	2	1	1	1	1	=(C270+D270+E270)*F270*G270	4	14
DDH009259	2	1	1	1	1	=(C271+D271+E271)*F271*G271	4	14
DDH009333	2	1	1	1	1	=(C272+D272+E272)*F272*G272	4	14
DDH009334	2	1	1	1	1	=(C273+D273+E273)*F273*G273	4	14
DDH009335	2	1	1	1	1	=(C274+D274+E274)*F274*G274	4	14
DDH009342	2	1	1	1	1	=(C275+D275+E275)*F275*G275	4	14
DDH009348	2	1	1	1	1	=(C276+D276+E276)*F276*G276	4	14
DDH009349	2	1	1	1	1	=(C277+D277+E277)*F277*G277	4	14
DDH009350	2	1	1	1	1	=(C278+D278+E278)*F278*G278	4	14
DDH009351	2	1	1	1	1	=(C279+D279+E279)*F279*G279	4	14
DDH009352	2	1	1	1	1	=(C280+D280+E280)*F280*G280	4	14
DDH009362	2	1	1	1	1	=(C281+D281+E281)*F281*G281	4	14
DDH009363	2	1	1	1	1	=(C282+D282+E282)*F282*G282	4	14
DDH009364	2	1	1	1	1	=(C283+D283+E283)*F283*G283	4	14
DDH009365	2	1	1	1	1	=(C284+D284+E284)*F284*G284	4	14
DDH009366	2	1	1	1	1	=(C285+D285+E285)*F285*G285	4	14
DDH009367	2	1	1	1	1	=(C286+D286+E286)*F286*G286	4	14
DDH009368	2	1	1	1	1	=(C287+D287+E287)*F287*G287	4	14
DDH009374	2	1	1	1	1	=(C288+D288+E288)*F288*G288	4	14
DDH009442	2	1	1	1	1	=(C289+D289+E289)*F289*G289	4	14
DDH009488	2	1	1	1	1	=(C290+D290+E290)*F290*G290	4	14
DDH009489	2	1	1	1	1	=(C291+D291+E291)*F291*G291	4	14
DDH009494	2	1	1	1	1	=(C292+D292+E292)*F292*G292	4	14
DDH009495	2	1	1	1	1	=(C293+D293+E293)*F293*G293	4	14
DDH009501	2	1	1	1	1	=(C294+D294+E294)*F294*G294	4	14
DDH009502	2	1	1	1	1	=(C295+D295+E295)*F295*G295	4	14

DDH009504	2	1	1	1	1		=(C296+D296+E296)*F296*G296	4	14
DDH009505	2	1	1	1	1		=(C297+D297+E297)*F297*G297	4	14
DDH009506	2	1	1	1	1		=(C298+D298+E298)*F298*G298	4	14
DDH009507	2	1	1	1	1		=(C299+D299+E299)*F299*G299	4	14
DDH009508	2	1	1	1	1		=(C300+D300+E300)*F300*G300	4	14
DDH009509	2	1	1	1	1		=(C301+D301+E301)*F301*G301	4	14
DDH009516	2	1	1	1	1		=(C302+D302+E302)*F302*G302	4	14
DDH009517	2	1	1	1	1		=(C303+D303+E303)*F303*G303	4	14
DDH009518	2	1	1	1	1		=(C304+D304+E304)*F304*G304	4	14
DDH009521	2	1	1	1	1		=(C305+D305+E305)*F305*G305	4	14
DDH009522	2	1	1	1	1		=(C306+D306+E306)*F306*G306	4	14
DDH009523	2	1	1	1	1		=(C307+D307+E307)*F307*G307	4	14
DDH009530	2	1	1	1	1		=(C308+D308+E308)*F308*G308	4	14
DDH009531	2	1	1	1	1		=(C309+D309+E309)*F309*G309	4	14
DDH009532	2	1	1	1	1	1	=(C310+D310+E310)*F310*G310*H310	4	14
DDH009533	2	1	1	1	1		=(C311+D311+E311)*F311*G311	4	14
DDH009534	2	1	1	1	1		=(C312+D312+E312)*F312*G312	4	14
DDH009535	2	1	1	1	1		=(C313+D313+E313)*F313*G313	4	14
DDH009536	2	1	1	1	1		=(C314+D314+E314)*F314*G314	4	14
DDH009537	2	1	1	1	1		=(C315+D315+E315)*F315*G315	4	14
DDH009541	2	1	1	1	1		=(C316+D316+E316)*F316*G316	4	14
DDH009567	2	1	1	1	1		=(C317+D317+E317)*F317*G317	4	14
DDH009581	2	1	1	1	1		=(C318+D318+E318)*F318*G318	4	14
DDH009589	2	1	1	1	1		=(C319+D319+E319)*F319*G319	4	14
DDH009592	2	1	1	1	1		=(C320+D320+E320)*F320*G320	4	14
DDH009597	2	1	1	1	1		=(C321+D321+E321)*F321*G321	4	14
DDH009598	2	1	1	1	1		=(C322+D322+E322)*F322*G322	4	14
DDH009601	2	1	1	1	1		=(C323+D323+E323)*F323*G323	4	14
DDH009602	2	1	1	1	1		=(C324+D324+E324)*F324*G324	4	14
DDH009617	2	1	1	1	1		=(C325+D325+E325)*F325*G325	4	14
DDH009622	2	1	1	1	1		=(C326+D326+E326)*F326*G326	4	14
DDH009626	2	1	1	1	1		=(C327+D327+E327)*F327*G327	4	14
DDH009627	2	1	1	1	1		=(C328+D328+E328)*F328*G328	4	14

DDH009640	2	1	1	1	1	=(C329+D329+E329)*F329*G329	4	14
DDH009643	2	1	1	1	1	=(C330+D330+E330)*F330*G330	4	14
DDH009644	2	1	1	1	1	=(C331+D331+E331)*F331*G331	4	14
DDH009645	2	1	1	1	1	=(C332+D332+E332)*F332*G332	4	14
DDH009646	2	1	1	1	1	=(C333+D333+E333)*F333*G333	4	14
DDH009649	2	1	1	1	1	=(C334+D334+E334)*F334*G334	4	14
DDH009650	2	1	1	1	1	=(C335+D335+E335)*F335*G335	4	14
DDH009651	2	1	1	1	1	=(C336+D336+E336)*F336*G336	4	14
DDH009652	2	1	1	1	1	=(C337+D337+E337)*F337*G337	4	14
DDH009659	2	1	1	1	1	=(C338+D338+E338)*F338*G338	4	14
DDH009661	2	1	1	1	1	=(C339+D339+E339)*F339*G339	4	14
DDH009674	2	1	1	1	1	=(C340+D340+E340)*F340*G340	4	14
DDH009682	2	1	1	1	1	=(C341+D341+E341)*F341*G341	4	14
DDH009684	2	1	1	1	1	=(C342+D342+E342)*F342*G342	4	14
DDH009686	2	1	1	1	1	=(C343+D343+E343)*F343*G343	4	14
DDH009687	2	1	1	1	1	=(C344+D344+E344)*F344*G344	4	14
DDH009688	2	1	1	1	1	=(C345+D345+E345)*F345*G345	4	14
DDH009698	2	1	1	1	1	=(C346+D346+E346)*F346*G346	4	14
DDH009748	2	1	1	1	1	=(C347+D347+E347)*F347*G347	4	14
DDH009749	2	1	1	1	1	=(C348+D348+E348)*F348*G348	4	14
DDH009750	2	1	1	1	1	=(C349+D349+E349)*F349*G349	4	14
DDH009751	2	1	1	1	1	=(C350+D350+E350)*F350*G350	4	14
DDH009752	2	1	1	1	1	=(C351+D351+E351)*F351*G351	4	14
DDH009753	2	1	1	1	1	=(C352+D352+E352)*F352*G352	4	14
DDH009754	2	1	1	1	1	=(C353+D353+E353)*F353*G353	4	14
DDH009788	2	1	1	1	1	=(C354+D354+E354)*F354*G354	4	14
DDH009869	2	1	1	1	1	=(C355+D355+E355)*F355*G355	4	14
DDH009870	2	1	1	1	1	=(C356+D356+E356)*F356*G356	4	14
DDH009871	2	1	1	1	1	=(C357+D357+E357)*F357*G357	4	14
DDH009872	2	1	1	1	1	=(C358+D358+E358)*F358*G358	4	14
DDH009873	2	1	1	1	1	=(C359+D359+E359)*F359*G359	4	14
DDH009874	2	1	1	1	1	=(C360+D360+E360)*F360*G360	4	14
DDH009876	2	1	1	1	1	=(C361+D361+E361)*F361*G361	4	14

Appendix B. Score Assigned to Drill Holes

DDH009877	2	1	1	1	1	=(C362+D362+E362)*F362*G362	4	14
DDH009878	2	1	1	1	1	=(C363+D363+E363)*F363*G363	4	14
DDH009879	2	1	1	1	1	=(C364+D364+E364)*F364*G364	4	14
DDH009880	2	1	1	1	1	=(C365+D365+E365)*F365*G365	4	14
DDH009881	2	1	1	1	1	=(C366+D366+E366)*F366*G366	4	14
DDH009882	2	1	1	1	1	=(C367+D367+E367)*F367*G367	4	14
DDH009883	2	1	1	1	1	=(C368+D368+E368)*F368*G368	4	14
DDH009896	2	1	1	1	1	=(C369+D369+E369)*F369*G369	4	14
DDH009906	2	1	1	1	1	=(C370+D370+E370)*F370*G370	4	14
DDH009930	2	1	1	1	1	=(C371+D371+E371)*F371*G371	4	14
DDH009931	2	1	1	1	1	=(C372+D372+E372)*F372*G372	4	14
DDH009933	2	1	1	1	1	=(C373+D373+E373)*F373*G373	4	14
DDH009936	2	1	1	1	1	=(C374+D374+E374)*F374*G374	4	14
DDH009937	2	1	1	1	1	=(C375+D375+E375)*F375*G375	4	14
DDH009963	2	1	1	1	1	=(C376+D376+E376)*F376*G376	4	14
DDH009964	2	1	1	1	1	=(C377+D377+E377)*F377*G377	4	14
DDH009966	2	1	1	1	1	=(C378+D378+E378)*F378*G378	4	14
DDH009967	2	1	1	1	1	=(C379+D379+E379)*F379*G379	4	14
DDH009971	2	1	1	1	1	=(C380+D380+E380)*F380*G380	4	14
DDH009972	2	1	1	1	1	=(C381+D381+E381)*F381*G381	4	14
DDH010006	2	1	1	1	1	=(C382+D382+E382)*F382*G382	4	14
DDH010007	2	1	1	1	1	=(C383+D383+E383)*F383*G383	4	14
DDH010014	2	1	1	1	1	=(C384+D384+E384)*F384*G384	4	14
DDH010022	2	1	1	1	1	=(C385+D385+E385)*F385*G385	4	14
DDH010026	2	1	1	1	1	=(C386+D386+E386)*F386*G386	4	14
DDH010027	2	1	1	1	1	=(C387+D387+E387)*F387*G387	4	14
DDH010033	2	1	1	1	1	=(C388+D388+E388)*F388*G388	4	14
DDH010035	2	1	1	1	1	=(C389+D389+E389)*F389*G389	4	14
DDH010036	2	1	1	1	1	=(C390+D390+E390)*F390*G390	4	14
DDH001000	1	1	1	1	1	=(C391+D391+E391)*F391*G391	3	15
DDH001001	1	1	1	1	1	=(C392+D392+E392)*F392*G392	3	15
DDH001003	1	1	1	1	1	=(C393+D393+E393)*F393*G393	3	15
DDH001004	1	1	1	1	1	=(C394+D394+E394)*F394*G394	3	15

Appendix B. Score Assigned to Drill Holes

DDH001005	1	1	1	1	1	=(C395+D395+E395)*F395*G395	3	15
DDH001006	1	1	1	1	1	=(C396+D396+E396)*F396*G396	3	15
DDH001007	1	1	1	1	1	=(C397+D397+E397)*F397*G397	3	15
DDH001008	1	1	1	1	1	=(C398+D398+E398)*F398*G398	3	15
DDH001009	1	1	1	1	1	=(C399+D399+E399)*F399*G399	3	15
DDH001010	1	1	1	1	1	=(C400+D400+E400)*F400*G400	3	15
DDH001011	1	1	1	1	1	=(C401+D401+E401)*F401*G401	3	15
DDH001016	1	1	1	1	1	=(C402+D402+E402)*F402*G402	3	15
DDH001017	1	1	1	1	1	=(C403+D403+E403)*F403*G403	3	15
DDH001025	1	1	1	1	1	=(C404+D404+E404)*F404*G404	3	15
DDH001026	1	1	1	1	1	=(C405+D405+E405)*F405*G405	3	15
DDH001027	1	1	1	1	1	=(C406+D406+E406)*F406*G406	3	15
DDH001035	1	1	1	1	1	=(C407+D407+E407)*F407*G407	3	15
DDH001036	1	1	1	1	1	=(C408+D408+E408)*F408*G408	3	15
DDH002000	1	1	1	1	1	=(C409+D409+E409)*F409*G409	3	15
DDH002001	1	1	1	1	1	=(C410+D410+E410)*F410*G410	3	15
DDH002002	1	1	1	1	1	=(C411+D411+E411)*F411*G411	3	15
DDH002003	1	1	1	1	1	=(C412+D412+E412)*F412*G412	3	15
DDH002004	1	1	1	1	1	=(C413+D413+E413)*F413*G413	3	15
DDH002008	1	1	1	1	1	=(C414+D414+E414)*F414*G414	3	15
DDH002009	1	1	1	1	1	=(C415+D415+E415)*F415*G415	3	15
DDH002010	1	1	1	1	1	=(C416+D416+E416)*F416*G416	3	15
DDH002011	1	1	1	1	1	=(C417+D417+E417)*F417*G417	3	15
DDH002012	1	1	1	1	1	=(C418+D418+E418)*F418*G418	3	15
DDH002013	1	1	1	1	1	=(C419+D419+E419)*F419*G419	3	15
DDH002014	1	1	1	1	1	=(C420+D420+E420)*F420*G420	3	15
DDH002015	1	1	1	1	1	=(C421+D421+E421)*F421*G421	3	15
DDH002016	1	1	1	1	1	=(C422+D422+E422)*F422*G422	3	15
DDH002017	1	1	1	1	1	=(C423+D423+E423)*F423*G423	3	15
DDH002021	1	1	1	1	1	=(C424+D424+E424)*F424*G424	3	15
DDH002029	1	1	1	1	1	=(C425+D425+E425)*F425*G425	3	15
DDH002030	1	1	1	1	1	=(C426+D426+E426)*F426*G426	3	15
DDH002033	1	1	1	1	1	=(C427+D427+E427)*F427*G427	3	15

Appendix B. Score Assigned to Drill Holes

DDH002034	1	1	1	1	1	=(C428+D428+E428)*F428*G428	3	15
DDH002039	1	1	1	1	1	=(C429+D429+E429)*F429*G429	3	15
DDH002040	1	1	1	1	1	=(C430+D430+E430)*F430*G430	3	15
DDH002041	1	1	1	1	1	=(C431+D431+E431)*F431*G431	3	15
DDH002043	1	1	1	1	1	=(C432+D432+E432)*F432*G432	3	15
DDH002044	1	1	1	1	1	=(C433+D433+E433)*F433*G433	3	15
DDH002051	1	1	1	1	1	=(C434+D434+E434)*F434*G434	3	15
DDH002052	1	1	1	1	1	=(C435+D435+E435)*F435*G435	3	15
DDH002053	1	1	1	1	1	=(C436+D436+E436)*F436*G436	3	15
DDH002054	1	1	1	1	1	=(C437+D437+E437)*F437*G437	3	15
DDH002055	1	1	1	1	1	=(C438+D438+E438)*F438*G438	3	15
DDH002056	1	1	1	1	1	=(C439+D439+E439)*F439*G439	3	15
DDH002058	1	1	1	1	1	=(C440+D440+E440)*F440*G440	3	15
DDH002064	1	1	1	1	1	=(C441+D441+E441)*F441*G441	3	15
DDH002065	1	1	1	1	1	=(C442+D442+E442)*F442*G442	3	15
DDH002068	1	1	1	1	1	=(C443+D443+E443)*F443*G443	3	15
DDH002069	1	1	1	1	1	=(C444+D444+E444)*F444*G444	3	15
DDH002070	1	1	1	1	1	=(C445+D445+E445)*F445*G445	3	15
DDH009000	1	1	1	1	1	=(C446+D446+E446)*F446*G446	3	15
DDH009001	1	1	1	1	1	=(C447+D447+E447)*F447*G447	3	15
DDH009002	1	1	1	1	1	=(C448+D448+E448)*F448*G448	3	15
DDH009003	1	1	1	1	1	=(C449+D449+E449)*F449*G449	3	15
DDH009004	1	1	1	1	1	=(C450+D450+E450)*F450*G450	3	15
DDH009005	1	1	1	1	1	=(C451+D451+E451)*F451*G451	3	15
DDH009006	1	1	1	1	1	=(C452+D452+E452)*F452*G452	3	15
DDH009007	1	1	1	1	1	=(C453+D453+E453)*F453*G453	3	15
DDH009008	1	1	1	1	1	=(C454+D454+E454)*F454*G454	3	15
DDH009009	1	1	1	1	1	=(C455+D455+E455)*F455*G455	3	15
DDH009010	1	1	1	1	1	=(C456+D456+E456)*F456*G456	3	15
DDH009011	1	1	1	1	1	=(C457+D457+E457)*F457*G457	3	15
DDH009012	1	1	1	1	1	=(C458+D458+E458)*F458*G458	3	15
DDH009013	1	1	1	1	1	=(C459+D459+E459)*F459*G459	3	15
DDH009014	1	1	1	1	1	=(C460+D460+E460)*F460*G460	3	15

DDH009015	1	1	1	1	1	=(C461+D461+E461)*F461*G461	3	15
DDH009034	1	1	1	1	1	=(C462+D462+E462)*F462*G462	3	15
DDH009035	1	1	1	1	1	=(C463+D463+E463)*F463*G463	3	15
DDH009036	1	1	1	1	1	=(C464+D464+E464)*F464*G464	3	15
DDH009037	1	1	1	1	1	=(C465+D465+E465)*F465*G465	3	15
DDH009039	1	1	1	1	1	=(C466+D466+E466)*F466*G466	3	15
DDH009040	1	1	1	1	1	=(C467+D467+E467)*F467*G467	3	15
DDH009041	1	1	1	1	1	=(C468+D468+E468)*F468*G468	3	15
DDH009042	1	1	1	1	1	=(C469+D469+E469)*F469*G469	3	15
DDH009043	1	1	1	1	1	=(C470+D470+E470)*F470*G470	3	15
DDH009044	1	1	1	1	1	=(C471+D471+E471)*F471*G471	3	15
DDH009047	1	1	1	1	1	=(C472+D472+E472)*F472*G472	3	15
DDH009048	1	1	1	1	1	=(C473+D473+E473)*F473*G473	3	15
DDH009049	1	1	1	1	1	=(C474+D474+E474)*F474*G474	3	15
DDH009052	1	1	1	1	1	=(C475+D475+E475)*F475*G475	3	15
DDH009053	1	1	1	1	1	=(C476+D476+E476)*F476*G476	3	15
DDH009054	1	1	1	1	1	=(C477+D477+E477)*F477*G477	3	15
DDH009055	1	1	1	1	1	=(C478+D478+E478)*F478*G478	3	15
DDH009056	1	1	1	1	1	=(C479+D479+E479)*F479*G479	3	15
DDH009057	1	1	1	1	1	=(C480+D480+E480)*F480*G480	3	15
DDH009058	1	1	1	1	1	=(C481+D481+E481)*F481*G481	3	15
DDH009059	1	1	1	1	1	=(C482+D482+E482)*F482*G482	3	15
DDH009060	1	1	1	1	1	=(C483+D483+E483)*F483*G483	3	15
DDH009061	1	1	1	1	1	=(C484+D484+E484)*F484*G484	3	15
DDH009062	1	1	1	1	1	=(C485+D485+E485)*F485*G485	3	15
DDH009063	1	1	1	1	1	=(C486+D486+E486)*F486*G486	3	15
DDH009064	1	1	1	1	1	=(C487+D487+E487)*F487*G487	3	15
DDH009065	1	1	1	1	1	=(C488+D488+E488)*F488*G488	3	15
DDH009066	1	1	1	1	1	=(C489+D489+E489)*F489*G489	3	15
DDH009068	1	1	1	1	1	=(C490+D490+E490)*F490*G490	3	15
DDH009069	1	1	1	1	1	=(C491+D491+E491)*F491*G491	3	15
DDH009070	1	1	1	1	1	=(C492+D492+E492)*F492*G492	3	15
DDH009071	1	1	1	1	1	=(C493+D493+E493)*F493*G493	3	15

Appendix B. Score Assigned to Drill Holes

DDH009072	1	1	1	1	1	=(C494+D494+E494)*F494*G494	3	15
DDH009073	1	1	1	1	1	=(C495+D495+E495)*F495*G495	3	15
DDH009074	1	1	1	1	1	=(C496+D496+E496)*F496*G496	3	15
DDH009075	1	1	1	1	1	=(C497+D497+E497)*F497*G497	3	15
DDH009076	1	1	1	1	1	=(C498+D498+E498)*F498*G498	3	15
DDH009077	1	1	1	1	1	=(C499+D499+E499)*F499*G499	3	15
DDH009078	1	1	1	1	1	=(C500+D500+E500)*F500*G500	3	15
DDH009079	1	1	1	1	1	=(C501+D501+E501)*F501*G501	3	15
DDH009080	1	1	1	1	1	=(C502+D502+E502)*F502*G502	3	15
DDH009081	1	1	1	1	1	=(C503+D503+E503)*F503*G503	3	15
DDH009082	1	1	1	1	1	=(C504+D504+E504)*F504*G504	3	15
DDH009083	1	1	1	1	1	=(C505+D505+E505)*F505*G505	3	15
DDH009084	1	1	1	1	1	=(C506+D506+E506)*F506*G506	3	15
DDH009085	1	1	1	1	1	=(C507+D507+E507)*F507*G507	3	15
DDH009086	1	1	1	1	1	=(C508+D508+E508)*F508*G508	3	15
DDH009087	1	1	1	1	1	=(C509+D509+E509)*F509*G509	3	15
DDH009088	1	1	1	1	1	=(C510+D510+E510)*F510*G510	3	15
DDH009089	1	1	1	1	1	=(C511+D511+E511)*F511*G511	3	15
DDH009090	1	1	1	1	1	=(C512+D512+E512)*F512*G512	3	15
DDH009091	1	1	1	1	1	=(C513+D513+E513)*F513*G513	3	15
DDH009092	1	1	1	1	1	=(C514+D514+E514)*F514*G514	3	15
DDH009093	1	1	1	1	1	=(C515+D515+E515)*F515*G515	3	15
DDH009094	1	1	1	1	1	=(C516+D516+E516)*F516*G516	3	15
DDH009095	1	1	1	1	1	=(C517+D517+E517)*F517*G517	3	15
DDH009096	1	1	1	1	1	=(C518+D518+E518)*F518*G518	3	15
DDH009097	1	1	1	1	1	=(C519+D519+E519)*F519*G519	3	15
DDH009098	1	1	1	1	1	=(C520+D520+E520)*F520*G520	3	15
DDH009099	1	1	1	1	1	=(C521+D521+E521)*F521*G521	3	15
DDH009100	1	1	1	1	1	=(C522+D522+E522)*F522*G522	3	15
DDH009101	1	1	1	1	1	=(C523+D523+E523)*F523*G523	3	15
DDH009102	1	1	1	1	1	=(C524+D524+E524)*F524*G524	3	15
DDH009103	1	1	1	1	1	=(C525+D525+E525)*F525*G525	3	15
DDH009104	1	1	1	1	1	=(C526+D526+E526)*F526*G526	3	15

Appendix B. Score Assigned to Drill Holes

DDH009105	1	1	1	1	1	=(C527+D527+E527)*F527*G527	3	15
DDH009106	1	1	1	1	1	=(C528+D528+E528)*F528*G528	3	15
DDH009107	1	1	1	1	1	=(C529+D529+E529)*F529*G529	3	15
DDH009108	1	1	1	1	1	=(C530+D530+E530)*F530*G530	3	15
DDH009110	1	1	1	1	1	=(C531+D531+E531)*F531*G531	3	15
DDH009111	1	1	1	1	1	=(C532+D532+E532)*F532*G532	3	15
DDH009112	1	1	1	1	1	=(C533+D533+E533)*F533*G533	3	15
DDH009118	1	1	1	1	1	=(C534+D534+E534)*F534*G534	3	15
DDH009119	1	1	1	1	1	=(C535+D535+E535)*F535*G535	3	15
DDH009120	1	1	1	1	1	=(C536+D536+E536)*F536*G536	3	15
DDH009121	1	1	1	1	1	=(C537+D537+E537)*F537*G537	3	15
DDH009123	1	1	1	1	1	=(C538+D538+E538)*F538*G538	3	15
DDH009124	1	1	1	1	1	=(C539+D539+E539)*F539*G539	3	15
DDH009125	1	1	1	1	1	=(C540+D540+E540)*F540*G540	3	15
DDH009126	1	1	1	1	1	=(C541+D541+E541)*F541*G541	3	15
DDH009127	1	1	1	1	1	=(C542+D542+E542)*F542*G542	3	15
DDH009128	1	1	1	1	1	=(C543+D543+E543)*F543*G543	3	15
DDH009132	1	1	1	1	1	=(C544+D544+E544)*F544*G544	3	15
DDH009133	1	1	1	1	1	=(C545+D545+E545)*F545*G545	3	15
DDH009134	1	1	1	1	1	=(C546+D546+E546)*F546*G546	3	15
DDH009135	1	1	1	1	1	=(C547+D547+E547)*F547*G547	3	15
DDH009136	1	1	1	1	1	=(C548+D548+E548)*F548*G548	3	15
DDH009137	1	1	1	1	1	=(C549+D549+E549)*F549*G549	3	15
DDH009141	1	1	1	1	1	=(C550+D550+E550)*F550*G550	3	15
DDH009146	1	1	1	1	1	=(C551+D551+E551)*F551*G551	3	15
DDH009147	1	1	1	1	1	=(C552+D552+E552)*F552*G552	3	15
DDH009148	1	1	1	1	1	=(C553+D553+E553)*F553*G553	3	15
DDH009149	1	1	1	1	1	=(C554+D554+E554)*F554*G554	3	15
DDH009150	1	1	1	1	1	=(C555+D555+E555)*F555*G555	3	15
DDH009151	1	1	1	1	1	=(C556+D556+E556)*F556*G556	3	15
DDH009152	1	1	1	1	1	=(C557+D557+E557)*F557*G557	3	15
DDH009153	1	1	1	1	1	=(C558+D558+E558)*F558*G558	3	15
DDH009154	1	1	1	1	1	=(C559+D559+E559)*F559*G559	3	15

Appendix B. Score Assigned to Drill Holes

DDH009155	1	1	1	1	1	=(C560+D560+E560)*F560*G560	3	15
DDH009156	1	1	1	1	1	=(C561+D561+E561)*F561*G561	3	15
DDH009157	1	1	1	1	1	=(C562+D562+E562)*F562*G562	3	15
DDH009158	1	1	1	1	1	=(C563+D563+E563)*F563*G563	3	15
DDH009164	1	1	1	1	1	=(C564+D564+E564)*F564*G564	3	15
DDH009165	1	1	1	1	1	=(C565+D565+E565)*F565*G565	3	15
DDH009166	1	1	1	1	1	=(C566+D566+E566)*F566*G566	3	15
DDH009167	1	1	1	1	1	=(C567+D567+E567)*F567*G567	3	15
DDH009168	1	1	1	1	1	=(C568+D568+E568)*F568*G568	3	15
DDH009169	1	1	1	1	1	=(C569+D569+E569)*F569*G569	3	15
DDH009170	1	1	1	1	1	=(C570+D570+E570)*F570*G570	3	15
DDH009171	1	1	1	1	1	=(C571+D571+E571)*F571*G571	3	15
DDH009172	1	1	1	1	1	=(C572+D572+E572)*F572*G572	3	15
DDH009173	1	1	1	1	1	=(C573+D573+E573)*F573*G573	3	15
DDH009174	1	1	1	1	1	=(C574+D574+E574)*F574*G574	3	15
DDH009176	1	1	1	1	1	=(C575+D575+E575)*F575*G575	3	15
DDH009177	1	1	1	1	1	=(C576+D576+E576)*F576*G576	3	15
DDH009178	1	1	1	1	1	=(C577+D577+E577)*F577*G577	3	15
DDH009179	1	1	1	1	1	=(C578+D578+E578)*F578*G578	3	15
DDH009180	1	1	1	1	1	=(C579+D579+E579)*F579*G579	3	15
DDH009182	1	1	1	1	1	=(C580+D580+E580)*F580*G580	3	15
DDH009183	1	1	1	1	1	=(C581+D581+E581)*F581*G581	3	15
DDH009186	1	1	1	1	1	=(C582+D582+E582)*F582*G582	3	15
DDH009187	1	1	1	1	1	=(C583+D583+E583)*F583*G583	3	15
DDH009188	1	1	1	1	1	=(C584+D584+E584)*F584*G584	3	15
DDH009189	1	1	1	1	1	=(C585+D585+E585)*F585*G585	3	15
DDH009190	1	1	1	1	1	=(C586+D586+E586)*F586*G586	3	15
DDH009191	1	1	1	1	1	=(C587+D587+E587)*F587*G587	3	15
DDH009192	1	1	1	1	1	=(C588+D588+E588)*F588*G588	3	15
DDH009193	1	1	1	1	1	=(C589+D589+E589)*F589*G589	3	15
DDH009194	1	1	1	1	1	=(C590+D590+E590)*F590*G590	3	15
DDH009195	1	1	1	1	1	=(C591+D591+E591)*F591*G591	3	15
DDH009196	1	1	1	1	1	=(C592+D592+E592)*F592*G592	3	15

DDH009197	1	1	1	1	1	=(C593+D593+E593)*F593*G593	3	15
DDH009199	1	1	1	1	1	=(C594+D594+E594)*F594*G594	3	15
DDH009200	1	1	1	1	1	=(C595+D595+E595)*F595*G595	3	15
DDH009201	1	1	1	1	1	=(C596+D596+E596)*F596*G596	3	15
DDH009202	1	1	1	1	1	=(C597+D597+E597)*F597*G597	3	15
DDH009203	1	1	1	1	1	=(C598+D598+E598)*F598*G598	3	15
DDH009204	1	1	1	1	1	=(C599+D599+E599)*F599*G599	3	15
DDH009205	1	1	1	1	1	=(C600+D600+E600)*F600*G600	3	15
DDH009206	1	1	1	1	1	=(C601+D601+E601)*F601*G601	3	15
DDH009208	1	1	1	1	1	=(C602+D602+E602)*F602*G602	3	15
DDH009209	1	1	1	1	1	=(C603+D603+E603)*F603*G603	3	15
DDH009210	1	1	1	1	1	=(C604+D604+E604)*F604*G604	3	15
DDH009211	1	1	1	1	1	=(C605+D605+E605)*F605*G605	3	15
DDH009212	1	1	1	1	1	=(C606+D606+E606)*F606*G606	3	15
DDH009214	1	1	1	1	1	=(C607+D607+E607)*F607*G607	3	15
DDH009215	1	1	1	1	1	=(C608+D608+E608)*F608*G608	3	15
DDH009216	1	1	1	1	1	=(C609+D609+E609)*F609*G609	3	15
DDH009219	1	1	1	1	1	=(C610+D610+E610)*F610*G610	3	15
DDH009222	1	1	1	1	1	=(C611+D611+E611)*F611*G611	3	15
DDH009224	1	1	1	1	1	=(C612+D612+E612)*F612*G612	3	15
DDH009227	1	1	1	1	1	=(C613+D613+E613)*F613*G613	3	15
DDH009228	1	1	1	1	1	=(C614+D614+E614)*F614*G614	3	15
DDH009229	1	1	1	1	1	=(C615+D615+E615)*F615*G615	3	15
DDH009235	1	1	1	1	1	=(C616+D616+E616)*F616*G616	3	15
DDH009237	1	1	1	1	1	=(C617+D617+E617)*F617*G617	3	15
DDH009238	1	1	1	1	1	=(C618+D618+E618)*F618*G618	3	15
DDH009239	1	1	1	1	1	=(C619+D619+E619)*F619*G619	3	15
DDH009240	1	1	1	1	1	=(C620+D620+E620)*F620*G620	3	15
DDH009241	1	1	1	1	1	=(C621+D621+E621)*F621*G621	3	15
DDH009242	1	1	1	1	1	=(C622+D622+E622)*F622*G622	3	15
DDH009243	1	1	1	1	1	=(C623+D623+E623)*F623*G623	3	15
DDH009250	1	1	1	1	1	=(C624+D624+E624)*F624*G624	3	15
DDH009251	1	1	1	1	1	=(C625+D625+E625)*F625*G625	3	15

Appendix B. Score Assigned to Drill Holes

DDH009252	1	1	1	1	1	=(C626+D626+E626)*F626*G626	3	15
DDH009253	1	1	1	1	1	=(C627+D627+E627)*F627*G627	3	15
DDH009254	1	1	1	1	1	=(C628+D628+E628)*F628*G628	3	15
DDH009255	1	1	1	1	1	=(C629+D629+E629)*F629*G629	3	15
DDH009256	1	1	1	1	1	=(C630+D630+E630)*F630*G630	3	15
DDH009260	1	1	1	1	1	=(C631+D631+E631)*F631*G631	3	15
DDH009262	1	1	1	1	1	=(C632+D632+E632)*F632*G632	3	15
DDH009264	1	1	1	1	1	=(C633+D633+E633)*F633*G633	3	15
DDH009265	1	1	1	1	1	=(C634+D634+E634)*F634*G634	3	15
DDH009273	1	1	1	1	1	=(C635+D635+E635)*F635*G635	3	15
DDH009275	1	1	1	1	1	=(C636+D636+E636)*F636*G636	3	15
DDH009276	1	1	1	1	1	=(C637+D637+E637)*F637*G637	3	15
DDH009277	1	1	1	1	1	=(C638+D638+E638)*F638*G638	3	15
DDH009278	1	1	1	1	1	=(C639+D639+E639)*F639*G639	3	15
DDH009279	1	1	1	1	1	=(C640+D640+E640)*F640*G640	3	15
DDH009280	1	1	1	1	1	=(C641+D641+E641)*F641*G641	3	15
DDH009281	1	1	1	1	1	=(C642+D642+E642)*F642*G642	3	15
DDH009282	1	1	1	1	1	=(C643+D643+E643)*F643*G643	3	15
DDH009283	1	1	1	1	1	=(C644+D644+E644)*F644*G644	3	15
DDH009284	1	1	1	1	1	=(C645+D645+E645)*F645*G645	3	15
DDH009285	1	1	1	1	1	=(C646+D646+E646)*F646*G646	3	15
DDH009287	1	1	1	1	1	=(C647+D647+E647)*F647*G647	3	15
DDH009288	1	1	1	1	1	=(C648+D648+E648)*F648*G648	3	15
DDH009290	1	1	1	1	1	=(C649+D649+E649)*F649*G649	3	15
DDH009291	1	1	1	1	1	=(C650+D650+E650)*F650*G650	3	15
DDH009292	1	1	1	1	1	=(C651+D651+E651)*F651*G651	3	15
DDH009293	1	1	1	1	1	=(C652+D652+E652)*F652*G652	3	15
DDH009294	1	1	1	1	1	=(C653+D653+E653)*F653*G653	3	15
DDH009295	1	1	1	1	1	=(C654+D654+E654)*F654*G654	3	15
DDH009296	1	1	1	1	1	=(C655+D655+E655)*F655*G655	3	15
DDH009297	1	1	1	1	1	=(C656+D656+E656)*F656*G656	3	15
DDH009298	1	1	1	1	1	=(C657+D657+E657)*F657*G657	3	15
DDH009299	1	1	1	1	1	=(C658+D658+E658)*F658*G658	3	15

DDH009300	1	1	1	1	1	=(C659+D659+E659)*F659*G659	3	15
DDH009301	1	1	1	1	1	=(C660+D660+E660)*F660*G660	3	15
DDH009302	1	1	1	1	1	=(C661+D661+E661)*F661*G661	3	15
DDH009303	1	1	1	1	1	=(C662+D662+E662)*F662*G662	3	15
DDH009304	1	1	1	1	1	=(C663+D663+E663)*F663*G663	3	15
DDH009305	1	1	1	1	1	=(C664+D664+E664)*F664*G664	3	15
DDH009306	1	1	1	1	1	=(C665+D665+E665)*F665*G665	3	15
DDH009307	1	1	1	1	1	=(C666+D666+E666)*F666*G666	3	15
DDH009308	1	1	1	1	1	=(C667+D667+E667)*F667*G667	3	15
DDH009309	1	1	1	1	1	=(C668+D668+E668)*F668*G668	3	15
DDH009310	1	1	1	1	1	=(C669+D669+E669)*F669*G669	3	15
DDH009311	1	1	1	1	1	=(C670+D670+E670)*F670*G670	3	15
DDH009312	1	1	1	1	1	=(C671+D671+E671)*F671*G671	3	15
DDH009313	1	1	1	1	1	=(C672+D672+E672)*F672*G672	3	15
DDH009314	1	1	1	1	1	=(C673+D673+E673)*F673*G673	3	15
DDH009315	1	1	1	1	1	=(C674+D674+E674)*F674*G674	3	15
DDH009316	1	1	1	1	1	=(C675+D675+E675)*F675*G675	3	15
DDH009317	1	1	1	1	1	=(C676+D676+E676)*F676*G676	3	15
DDH009318	1	1	1	1	1	=(C677+D677+E677)*F677*G677	3	15
DDH009319	1	1	1	1	1	=(C678+D678+E678)*F678*G678	3	15
DDH009320	1	1	1	1	1	=(C679+D679+E679)*F679*G679	3	15
DDH009321	1	1	1	1	1	=(C680+D680+E680)*F680*G680	3	15
DDH009322	1	1	1	1	1	=(C681+D681+E681)*F681*G681	3	15
DDH009323	1	1	1	1	1	=(C682+D682+E682)*F682*G682	3	15
DDH009324	1	1	1	1	1	=(C683+D683+E683)*F683*G683	3	15
DDH009325	1	1	1	1	1	=(C684+D684+E684)*F684*G684	3	15
DDH009326	1	1	1	1	1	=(C685+D685+E685)*F685*G685	3	15
DDH009328	1	1	1	1	1	=(C686+D686+E686)*F686*G686	3	15
DDH009329	1	1	1	1	1	=(C687+D687+E687)*F687*G687	3	15
DDH009330	1	1	1	1	1	=(C688+D688+E688)*F688*G688	3	15
DDH009331	1	1	1	1	1	=(C689+D689+E689)*F689*G689	3	15
DDH009332	1	1	1	1	1	=(C690+D690+E690)*F690*G690	3	15
DDH009338	1	1	1	1	1	=(C691+D691+E691)*F691*G691	3	15

Appendix B. Score Assigned to Drill Holes

DDH009339	1	1	1	1	1	=(C692+D692+E692)*F692*G692	3	15
DDH009340	1	1	1	1	1	=(C693+D693+E693)*F693*G693	3	15
DDH009343	1	1	1	1	1	=(C694+D694+E694)*F694*G694	3	15
DDH009344	1	1	1	1	1	=(C695+D695+E695)*F695*G695	3	15
DDH009353	1	1	1	1	1	=(C696+D696+E696)*F696*G696	3	15
DDH009354	1	1	1	1	1	=(C697+D697+E697)*F697*G697	3	15
DDH009355	1	1	1	1	1	=(C698+D698+E698)*F698*G698	3	15
DDH009356	1	1	1	1	1	=(C699+D699+E699)*F699*G699	3	15
DDH009357	1	1	1	1	1	=(C700+D700+E700)*F700*G700	3	15
DDH009358	1	1	1	1	1	=(C701+D701+E701)*F701*G701	3	15
DDH009359	1	1	1	1	1	=(C702+D702+E702)*F702*G702	3	15
DDH009360	1	1	1	1	1	=(C703+D703+E703)*F703*G703	3	15
DDH009361	1	1	1	1	1	=(C704+D704+E704)*F704*G704	3	15
DDH009371	1	1	1	1	1	=(C705+D705+E705)*F705*G705	3	15
DDH009373	1	1	1	1	1	=(C706+D706+E706)*F706*G706	3	15
DDH009375	1	1	1	1	1	=(C707+D707+E707)*F707*G707	3	15
DDH009376	1	1	1	1	1	=(C708+D708+E708)*F708*G708	3	15
DDH009377	1	1	1	1	1	=(C709+D709+E709)*F709*G709	3	15
DDH009378	1	1	1	1	1	=(C710+D710+E710)*F710*G710	3	15
DDH009379	1	1	1	1	1	=(C711+D711+E711)*F711*G711	3	15
DDH009382	1	1	1	1	1	=(C712+D712+E712)*F712*G712	3	15
DDH009383	1	1	1	1	1	=(C713+D713+E713)*F713*G713	3	15
DDH009408	1	1	1	1	1	=(C714+D714+E714)*F714*G714	3	15
DDH009409	1	1	1	1	1	=(C715+D715+E715)*F715*G715	3	15
DDH009410	1	1	1	1	1	=(C716+D716+E716)*F716*G716	3	15
DDH009414	1	1	1	1	1	=(C717+D717+E717)*F717*G717	3	15
DDH009427	1	1	1	1	1	=(C718+D718+E718)*F718*G718	3	15
DDH009432	1	1	1	1	1	=(C719+D719+E719)*F719*G719	3	15
DDH009448	1	1	1	1	1	=(C720+D720+E720)*F720*G720	3	15
DDH009449	1	1	1	1	1	=(C721+D721+E721)*F721*G721	3	15
DDH009450	1	1	1	1	1	=(C722+D722+E722)*F722*G722	3	15
DDH009451	1	1	1	1	1	=(C723+D723+E723)*F723*G723	3	15
DDH009452	1	1	1	1	1	=(C724+D724+E724)*F724*G724	3	15

DDH009453	1	1	1	1	1	=(C725+D725+E725)*F725*G725	3	15
DDH009457	1	1	1	1	1	=(C726+D726+E726)*F726*G726	3	15
DDH009458	1	1	1	1	1	=(C727+D727+E727)*F727*G727	3	15
DDH009459	1	1	1	1	1	=(C728+D728+E728)*F728*G728	3	15
DDH009460	1	1	1	1	1	=(C729+D729+E729)*F729*G729	3	15
DDH009461	1	1	1	1	1	=(C730+D730+E730)*F730*G730	3	15
DDH009463	1	1	1	1	1	=(C731+D731+E731)*F731*G731	3	15
DDH009464	1	1	1	1	1	=(C732+D732+E732)*F732*G732	3	15
DDH009465	1	1	1	1	1	=(C733+D733+E733)*F733*G733	3	15
DDH009466	1	1	1	1	1	=(C734+D734+E734)*F734*G734	3	15
DDH009467	1	1	1	1	1	=(C735+D735+E735)*F735*G735	3	15
DDH009468	1	1	1	1	1	=(C736+D736+E736)*F736*G736	3	15
DDH009469	1	1	1	1	1	=(C737+D737+E737)*F737*G737	3	15
DDH009470	1	1	1	1	1	=(C738+D738+E738)*F738*G738	3	15
DDH009471	1	1	1	1	1	=(C739+D739+E739)*F739*G739	3	15
DDH009472	1	1	1	1	1	=(C740+D740+E740)*F740*G740	3	15
DDH009473	1	1	1	1	1	=(C741+D741+E741)*F741*G741	3	15
DDH009474	1	1	1	1	1	=(C742+D742+E742)*F742*G742	3	15
DDH009475	1	1	1	1	1	=(C743+D743+E743)*F743*G743	3	15
DDH009479	1	1	1	1	1	=(C744+D744+E744)*F744*G744	3	15
DDH009480	1	1	1	1	1	=(C745+D745+E745)*F745*G745	3	15
DDH009481	1	1	1	1	1	=(C746+D746+E746)*F746*G746	3	15
DDH009483	1	1	1	1	1	=(C747+D747+E747)*F747*G747	3	15
DDH009484	1	1	1	1	1	=(C748+D748+E748)*F748*G748	3	15
DDH009524	1	1	1	1	1	=(C749+D749+E749)*F749*G749	3	15
DDH009525	1	1	1	1	1	=(C750+D750+E750)*F750*G750	3	15
DDH009543	1	1	1	1	1	=(C751+D751+E751)*F751*G751	3	15
DDH009544	1	1	1	1	1	=(C752+D752+E752)*F752*G752	3	15
DDH009545	1	1	1	1	1	=(C753+D753+E753)*F753*G753	3	15
DDH009546	1	1	1	1	1	=(C754+D754+E754)*F754*G754	3	15
DDH009547	1	1	1	1	1	=(C755+D755+E755)*F755*G755	3	15
DDH009548	1	1	1	1	1	=(C756+D756+E756)*F756*G756	3	15
DDH009549	1	1	1	1	1	=(C757+D757+E757)*F757*G757	3	15

Appendix B. Score Assigned to Drill Holes

DDH009552	1	1	1	1	1	=(C758+D758+E758)*F758*G758	3	15
DDH009553	1	1	1	1	1	=(C759+D759+E759)*F759*G759	3	15
DDH009554	1	1	1	1	1	=(C760+D760+E760)*F760*G760	3	15
DDH009555	1	1	1	1	1	=(C761+D761+E761)*F761*G761	3	15
DDH009556	1	1	1	1	1	=(C762+D762+E762)*F762*G762	3	15
DDH009557	1	1	1	1	1	=(C763+D763+E763)*F763*G763	3	15
DDH009559	1	1	1	1	1	=(C764+D764+E764)*F764*G764	3	15
DDH009561	1	1	1	1	1	=(C765+D765+E765)*F765*G765	3	15
DDH009562	1	1	1	1	1	=(C766+D766+E766)*F766*G766	3	15
DDH009563	1	1	1	1	1	=(C767+D767+E767)*F767*G767	3	15
DDH009564	1	1	1	1	1	=(C768+D768+E768)*F768*G768	3	15
DDH009566	1	1	1	1	1	=(C769+D769+E769)*F769*G769	3	15
DDH009569	1	1	1	1	1	=(C770+D770+E770)*F770*G770	3	15
DDH009570	1	1	1	1	1	=(C771+D771+E771)*F771*G771	3	15
DDH009574	1	1	1	1	1	=(C772+D772+E772)*F772*G772	3	15
DDH009575	1	1	1	1	1	=(C773+D773+E773)*F773*G773	3	15
DDH009576	1	1	1	1	1	=(C774+D774+E774)*F774*G774	3	15
DDH009577	1	1	1	1	1	=(C775+D775+E775)*F775*G775	3	15
DDH009578	1	1	1	1	1	=(C776+D776+E776)*F776*G776	3	15
DDH009579	1	1	1	1	1	=(C777+D777+E777)*F777*G777	3	15
DDH009580	1	1	1	1	1	=(C778+D778+E778)*F778*G778	3	15
DDH009582	1	1	1	1	1	=(C779+D779+E779)*F779*G779	3	15
DDH009584	1	1	1	1	1	=(C780+D780+E780)*F780*G780	3	15
DDH009587	1	1	1	1	1	=(C781+D781+E781)*F781*G781	3	15
DDH009594	1	1	1	1	1	=(C782+D782+E782)*F782*G782	3	15
DDH009595	1	1	1	1	1	=(C783+D783+E783)*F783*G783	3	15
DDH009596	1	1	1	1	1	=(C784+D784+E784)*F784*G784	3	15
DDH009599	1	1	1	1	1	=(C785+D785+E785)*F785*G785	3	15
DDH009610	1	1	1	1	1	=(C786+D786+E786)*F786*G786	3	15
DDH009611	1	1	1	1	1	=(C787+D787+E787)*F787*G787	3	15
DDH009612	1	1	1	1	1	=(C788+D788+E788)*F788*G788	3	15
DDH009633	1	1	1	1	1	=(C789+D789+E789)*F789*G789	3	15
DDH009634	1	1	1	1	1	=(C790+D790+E790)*F790*G790	3	15

DDH009636	1	1	1	1	1	=(C791+D791+E791)*F791*G791	3	15
DDH009637	1	1	1	1	1	=(C792+D792+E792)*F792*G792	3	15
DDH009638	1	1	1	1	1	=(C793+D793+E793)*F793*G793	3	15
DDH009639	1	1	1	1	1	=(C794+D794+E794)*F794*G794	3	15
DDH009642	1	1	1	1	1	=(C795+D795+E795)*F795*G795	3	15
DDH009657	1	1	1	1	1	=(C796+D796+E796)*F796*G796	3	15
DDH009660	1	1	1	1	1	=(C797+D797+E797)*F797*G797	3	15
DDH009668	1	1	1	1	1	=(C798+D798+E798)*F798*G798	3	15
DDH009672	1	1	1	1	1	=(C799+D799+E799)*F799*G799	3	15
DDH009677	1	1	1	1	1	=(C800+D800+E800)*F800*G800	3	15
DDH009678	1	1	1	1	1	=(C801+D801+E801)*F801*G801	3	15
DDH009679	1	1	1	1	1	=(C802+D802+E802)*F802*G802	3	15
DDH009680	1	1	1	1	1	=(C803+D803+E803)*F803*G803	3	15
DDH009691	1	1	1	1	1	=(C804+D804+E804)*F804*G804	3	15
DDH009692	1	1	1	1	1	=(C805+D805+E805)*F805*G805	3	15
DDH009693	1	1	1	1	1	=(C806+D806+E806)*F806*G806	3	15
DDH009694	1	1	1	1	1	=(C807+D807+E807)*F807*G807	3	15
DDH009695	1	1	1	1	1	=(C808+D808+E808)*F808*G808	3	15
DDH009696	1	1	1	1	1	=(C809+D809+E809)*F809*G809	3	15
DDH009699	1	1	1	1	1	=(C810+D810+E810)*F810*G810	3	15
DDH009704	1	1	1	1	1	=(C811+D811+E811)*F811*G811	3	15
DDH009708	1	1	1	1	1	=(C812+D812+E812)*F812*G812	3	15
DDH009709	1	1	1	1	1	=(C813+D813+E813)*F813*G813	3	15
DDH009710	1	1	1	1	1	=(C814+D814+E814)*F814*G814	3	15
DDH009716	1	1	1	1	1	=(C815+D815+E815)*F815*G815	3	15
DDH009718	1	1	1	1	1	=(C816+D816+E816)*F816*G816	3	15
DDH009720	1	1	1	1	1	=(C817+D817+E817)*F817*G817	3	15
DDH009721	1	1	1	1	1	=(C818+D818+E818)*F818*G818	3	15
DDH009724	1	1	1	1	1	=(C819+D819+E819)*F819*G819	3	15
DDH009726	1	1	1	1	1	=(C820+D820+E820)*F820*G820	3	15
DDH009736	1	1	1	1	1	=(C821+D821+E821)*F821*G821	3	15
DDH009737	1	1	1	1	1	=(C822+D822+E822)*F822*G822	3	15
DDH009738	1	1	1	1	1	=(C823+D823+E823)*F823*G823	3	15

DDH009739	1	1	1	1	1	=(C824+D824+E824)*F824*G824	3	15
DDH009740	1	1	1	1	1	=(C825+D825+E825)*F825*G825	3	15
DDH009741	1	1	1	1	1	=(C826+D826+E826)*F826*G826	3	15
DDH009742	1	1	1	1	1	=(C827+D827+E827)*F827*G827	3	15
DDH009743	1	1	1	1	1	=(C828+D828+E828)*F828*G828	3	15
DDH009745	1	1	1	1	1	=(C829+D829+E829)*F829*G829	3	15
DDH009746	1	1	1	1	1	=(C830+D830+E830)*F830*G830	3	15
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DDH009757	1	1	1	1	1	=(C832+D832+E832)*F832*G832	3	15
DDH009758	1	1	1	1	1	=(C833+D833+E833)*F833*G833	3	15
DDH009759	1	1	1	1	1	=(C834+D834+E834)*F834*G834	3	15
DDH009760	1	1	1	1	1	=(C835+D835+E835)*F835*G835	3	15
DDH009762	1	1	1	1	1	=(C836+D836+E836)*F836*G836	3	15
DDH009782	1	1	1	1	1	=(C837+D837+E837)*F837*G837	3	15
DDH009783	1	1	1	1	1	=(C838+D838+E838)*F838*G838	3	15
DDH009784	1	1	1	1	1	=(C839+D839+E839)*F839*G839	3	15
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DDH009786	1	1	1	1	1	=(C841+D841+E841)*F841*G841	3	15
DDH009789	1	1	1	1	1	=(C842+D842+E842)*F842*G842	3	15
DDH009790	1	1	1	1	1	=(C843+D843+E843)*F843*G843	3	15
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DDH009794	1	1	1	1	1	=(C847+D847+E847)*F847*G847	3	15
DDH009795	1	1	1	1	1	=(C848+D848+E848)*F848*G848	3	15
DDH009796	1	1	1	1	1	=(C849+D849+E849)*F849*G849	3	15
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DDH009799	1	1	1	1	1	=(C851+D851+E851)*F851*G851	3	15
DDH009800	1	1	1	1	1	=(C852+D852+E852)*F852*G852	3	15
DDH009801	1	1	1	1	1	=(C853+D853+E853)*F853*G853	3	15
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DDH009804	1	1	1	1	1	=(C855+D855+E855)*F855*G855	3	15
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DDH009806	1	1	1	1	1	=(C857+D857+E857)*F857*G857	3	15
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DDH009808	1	1	1	1	1	=(C859+D859+E859)*F859*G859	3	15
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DDH009811	1	1	1	1	1	=(C861+D861+E861)*F861*G861	3	15
DDH009812	1	1	1	1	1	=(C862+D862+E862)*F862*G862	3	15
DDH009813	1	1	1	1	1	=(C863+D863+E863)*F863*G863	3	15
DDH009814	1	1	1	1	1	=(C864+D864+E864)*F864*G864	3	15
DDH009816	1	1	1	1	1	=(C865+D865+E865)*F865*G865	3	15
DDH009817	1	1	1	1	1	=(C866+D866+E866)*F866*G866	3	15
DDH009818	1	1	1	1	1	=(C867+D867+E867)*F867*G867	3	15
DDH009819	1	1	1	1	1	=(C868+D868+E868)*F868*G868	3	15
DDH009820	1	1	1	1	1	=(C869+D869+E869)*F869*G869	3	15
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DDH009824	1	1	1	1	1	=(C873+D873+E873)*F873*G873	3	15
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DDH009829	1	1	1	1	1	=(C876+D876+E876)*F876*G876	3	15
DDH009830	1	1	1	1	1	=(C877+D877+E877)*F877*G877	3	15
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DDH009832	1	1	1	1	1	=(C879+D879+E879)*F879*G879	3	15
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DDH009834	1	1	1	1	1	=(C881+D881+E881)*F881*G881	3	15
DDH009835	1	1	1	1	1	=(C882+D882+E882)*F882*G882	3	15
DDH009836	1	1	1	1	1	=(C883+D883+E883)*F883*G883	3	15
DDH009837	1	1	1	1	1	=(C884+D884+E884)*F884*G884	3	15
DDH009838	1	1	1	1	1	=(C885+D885+E885)*F885*G885	3	15
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DDH009840	1	1	1	1	1	=(C887+D887+E887)*F887*G887	3	15
DDH009842	1	1	1	1	1	=(C888+D888+E888)*F888*G888	3	15
DDH009843	1	1	1	1	1	=(C889+D889+E889)*F889*G889	3	15

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DDH009866	1	1	1	1	1	=(C896+D896+E896)*F896*G896	3	15
DDH009868	1	1	1	1	1	=(C897+D897+E897)*F897*G897	3	15
DDH009886	1	1	1	1	1	=(C898+D898+E898)*F898*G898	3	15
DDH009887	1	1	1	1	1	=(C899+D899+E899)*F899*G899	3	15
DDH009892	1	1	1	1	1	=(C900+D900+E900)*F900*G900	3	15
DDH009893	1	1	1	1	1	=(C901+D901+E901)*F901*G901	3	15
DDH009894	1	1	1	1	1	=(C902+D902+E902)*F902*G902	3	15
DDH009911	1	1	1	1	1	=(C903+D903+E903)*F903*G903	3	15
DDH009912	1	1	1	1	1	=(C904+D904+E904)*F904*G904	3	15
DDH009913	1	1	1	1	1	=(C905+D905+E905)*F905*G905	3	15
DDH009918	1	1	1	1	1	=(C906+D906+E906)*F906*G906	3	15
DDH009924	1	1	1	1	1	=(C907+D907+E907)*F907*G907	3	15
DDH009925	1	1	1	1	1	=(C908+D908+E908)*F908*G908	3	15
DDH009927	1	1	1	1	1	=(C909+D909+E909)*F909*G909	3	15
DDH009928	1	1	1	1	1	=(C910+D910+E910)*F910*G910	3	15
DDH009929	1	1	1	1	1	=(C911+D911+E911)*F911*G911	3	15
DDH009945	1	1	1	1	1	=(C912+D912+E912)*F912*G912	3	15
DDH009946	1	1	1	1	1	=(C913+D913+E913)*F913*G913	3	15
DDH009947	1	1	1	1	1	=(C914+D914+E914)*F914*G914	3	15
DDH009948	1	1	1	1	1	=(C915+D915+E915)*F915*G915	3	15
DDH009949	1	1	1	1	1	=(C916+D916+E916)*F916*G916	3	15
DDH009950	1	1	1	1	1	=(C917+D917+E917)*F917*G917	3	15
DDH009951	1	1	1	1	1	=(C918+D918+E918)*F918*G918	3	15
DDH009952	1	1	1	1	1	=(C919+D919+E919)*F919*G919	3	15
DDH009953	1	1	1	1	1	=(C920+D920+E920)*F920*G920	3	15
DDH009954	1	1	1	1	1	=(C921+D921+E921)*F921*G921	3	15
DDH009956	1	1	1	1	1	=(C922+D922+E922)*F922*G922	3	15

Appendix B. Score Assigned to Drill Holes

DDH009957	1	1	1	1	1	=(C923+D923+E923)*F923*G923	3	15
DDH009958	1	1	1	1	1	=(C924+D924+E924)*F924*G924	3	15
DDH009959	1	1	1	1	1	=(C925+D925+E925)*F925*G925	3	15
DDH009960	1	1	1	1	1	=(C926+D926+E926)*F926*G926	3	15
DDH009961	1	1	1	1	1	=(C927+D927+E927)*F927*G927	3	15
DDH009962	1	1	1	1	1	=(C928+D928+E928)*F928*G928	3	15
DDH009969	1	1	1	1	1	=(C929+D929+E929)*F929*G929	3	15
DDH009970	1	1	1	1	1	=(C930+D930+E930)*F930*G930	3	15
DDH009973	1	1	1	1	1	=(C931+D931+E931)*F931*G931	3	15
DDH009976	1	1	1	1	1	=(C932+D932+E932)*F932*G932	3	15
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DDH009979	1	1	1	1	1	=(C935+D935+E935)*F935*G935	3	15
DDH009980	1	1	1	1	1	=(C936+D936+E936)*F936*G936	3	15
DDH009981	1	1	1	1	1	=(C937+D937+E937)*F937*G937	3	15
DDH009982	1	1	1	1	1	=(C938+D938+E938)*F938*G938	3	15
DDH009983	1	1	1	1	1	=(C939+D939+E939)*F939*G939	3	15
DDH009984	1	1	1	1	1	=(C940+D940+E940)*F940*G940	3	15
DDH009985	1	1	1	1	1	=(C941+D941+E941)*F941*G941	3	15
DDH009986	1	1	1	1	1	=(C942+D942+E942)*F942*G942	3	15
DDH009988	1	1	1	1	1	=(C943+D943+E943)*F943*G943	3	15
DDH009989	1	1	1	1	1	=(C944+D944+E944)*F944*G944	3	15
DDH009990	1	1	1	1	1	=(C945+D945+E945)*F945*G945	3	15
DDH009991	1	1	1	1	1	=(C946+D946+E946)*F946*G946	3	15
DDH009992	1	1	1	1	1	=(C947+D947+E947)*F947*G947	3	15
DDH009993	1	1	1	1	1	=(C948+D948+E948)*F948*G948	3	15
DDH009994	1	1	1	1	1	=(C949+D949+E949)*F949*G949	3	15
DDH009995	1	1	1	1	1	=(C950+D950+E950)*F950*G950	3	15
DDH009996	1	1	1	1	1	=(C951+D951+E951)*F951*G951	3	15
DDH009997	1	1	1	1	1	=(C952+D952+E952)*F952*G952	3	15
DDH009998	1	1	1	1	1	=(C953+D953+E953)*F953*G953	3	15
DDH009999	1	1	1	1	1	=(C954+D954+E954)*F954*G954	3	15
DDH010000	1	1	1	1	1	=(C955+D955+E955)*F955*G955	3	15

Appendix B. Score Assigned to Drill Holes

DDH010001	1	1	1	1	1	=(C956+D956+E956)*F956*G956	3	15
DDH010002	1	1	1	1	1	=(C957+D957+E957)*F957*G957	3	15
DDH010003	1	1	1	1	1	=(C958+D958+E958)*F958*G958	3	15
DDH010017	1	1	1	1	1	=(C959+D959+E959)*F959*G959	3	15
DDH010020	1	1	1	1	1	=(C960+D960+E960)*F960*G960	3	15
DDH010021	1	1	1	1	1	=(C961+D961+E961)*F961*G961	3	15
DDH010023	1	1	1	1	1	=(C962+D962+E962)*F962*G962	3	15
DDH010024	1	1	1	1	1	=(C963+D963+E963)*F963*G963	3	15
DDH010025	1	1	1	1	1	=(C964+D964+E964)*F964*G964	3	15
DDH010029	1	1	1	1	1	=(C965+D965+E965)*F965*G965	3	15
DDH010030	1	1	1	1	1	=(C966+D966+E966)*F966*G966	3	15

Final Improvement Plan

South Awbrey Butte Drainage Study

City of Bend Project #SR15AA

Bend, Oregon

October 17, 2017

REGISTERED PROFESSIONAL ENGINEER
58552
OREGON
JULY 21, 1998
CHRISTINE J. HIGGINS
EXPIRATION DATE: 06.30.19

TABLE OF CONTENTS

APPENDIX

ATTACHMENTS

1 Introduction

Drainage issues on Awbrey Butte and along Newport Avenue have persisted for decades and continue to inconvenience citizens and require a disproportionate amount of the City of Bend's (City) maintenance resources and funding. Additionally, numerous segments of the Newport Avenue Storm Sewer are known to be deficient and require replacement. To better understand the scope and magnitude of the issues, the City selected HDR Engineering, Inc. (HDR) to perform the South Awbrey Butte Drainage Study (Study). The overall objective of the Study is to develop a prioritized basin wide stormwater improvement plan that is strategic, effective and capable of phased implementation with limited public infrastructure funds. This is a planning level study and is intended to inform the next phases of design and the development of a Capital Improvement Plan, which was not a part of this work.

The Final Improvement Plan is the last major task element of the Study and presents the final prioritized stormwater improvement recommendations developed for the Study Area. The Study Area is defined as the portion of the south side of Awbrey Butte extending from College Way east to 9th Street, and from Newport Avenue north to the top of the Butte. Figure 1 shows this area. The recommendations included in Section 3 of this report are intended to be used by City staff to program and prioritize drainage improvements within the Study Area.

2 Scope of Work

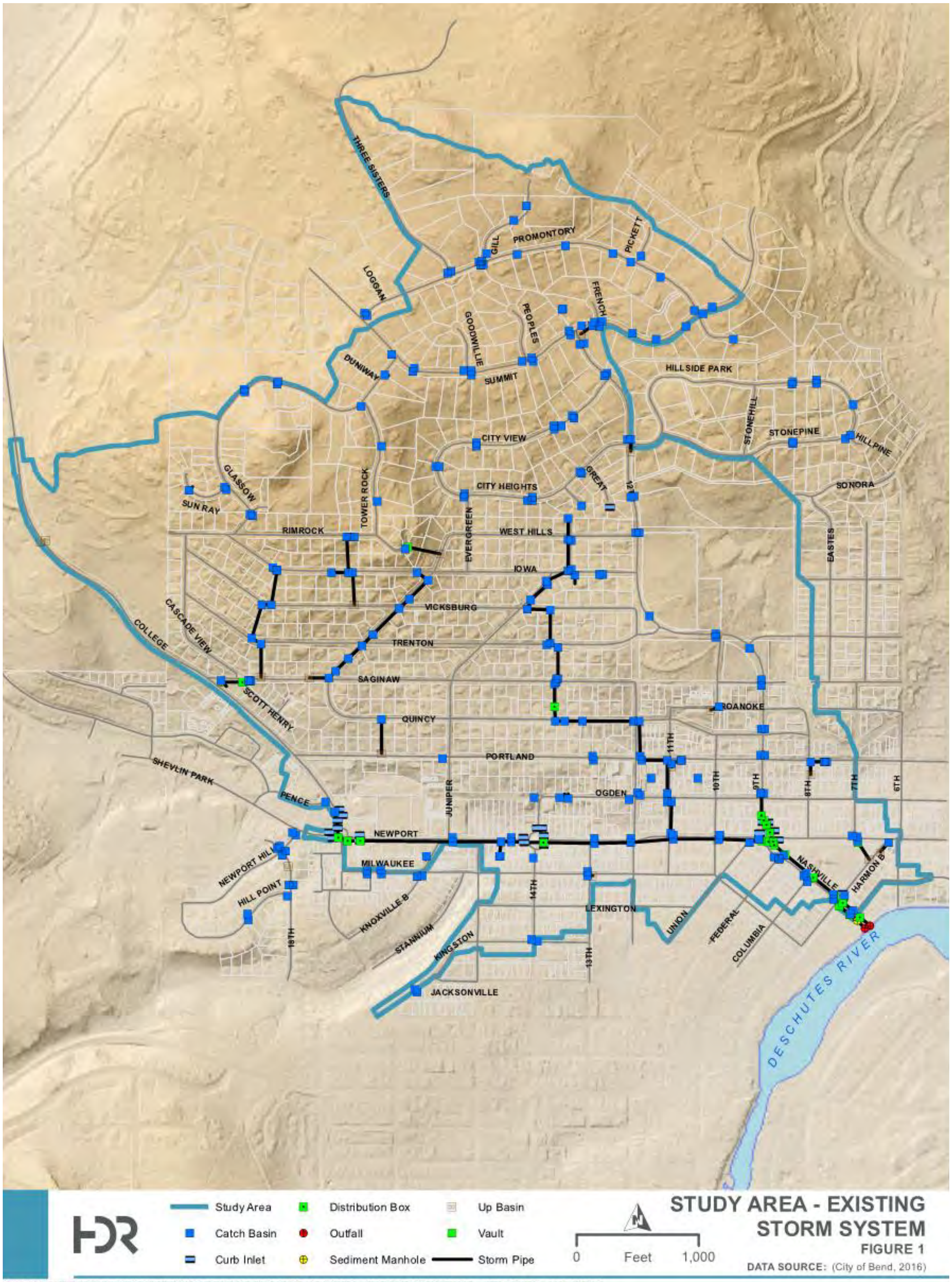
The South Awbrey Butte Drainage Study is a planning phase study to identify existing drainage issues, understand their impact within the project area, develop conceptual design alternatives, and ultimately develop a prioritized list of projects to address the most critical drainage issues.

The Study included the following major sequential task elements:

- Task 4: Existing Drainage System Evaluation (Included as Attachment 1)
- Task 5: Development of Preferred Improvement Areas (Included as Attachment 2)
- Task 6: Development and Evaluation of Design Alternatives (Included as Attachment 3)
- Task 7: Prioritization of Improvement Areas and Alternatives

Each of these major task elements are summarized in further detail below and were implemented in sequence to inform subsequent tasks.

Figure 1: Study Area



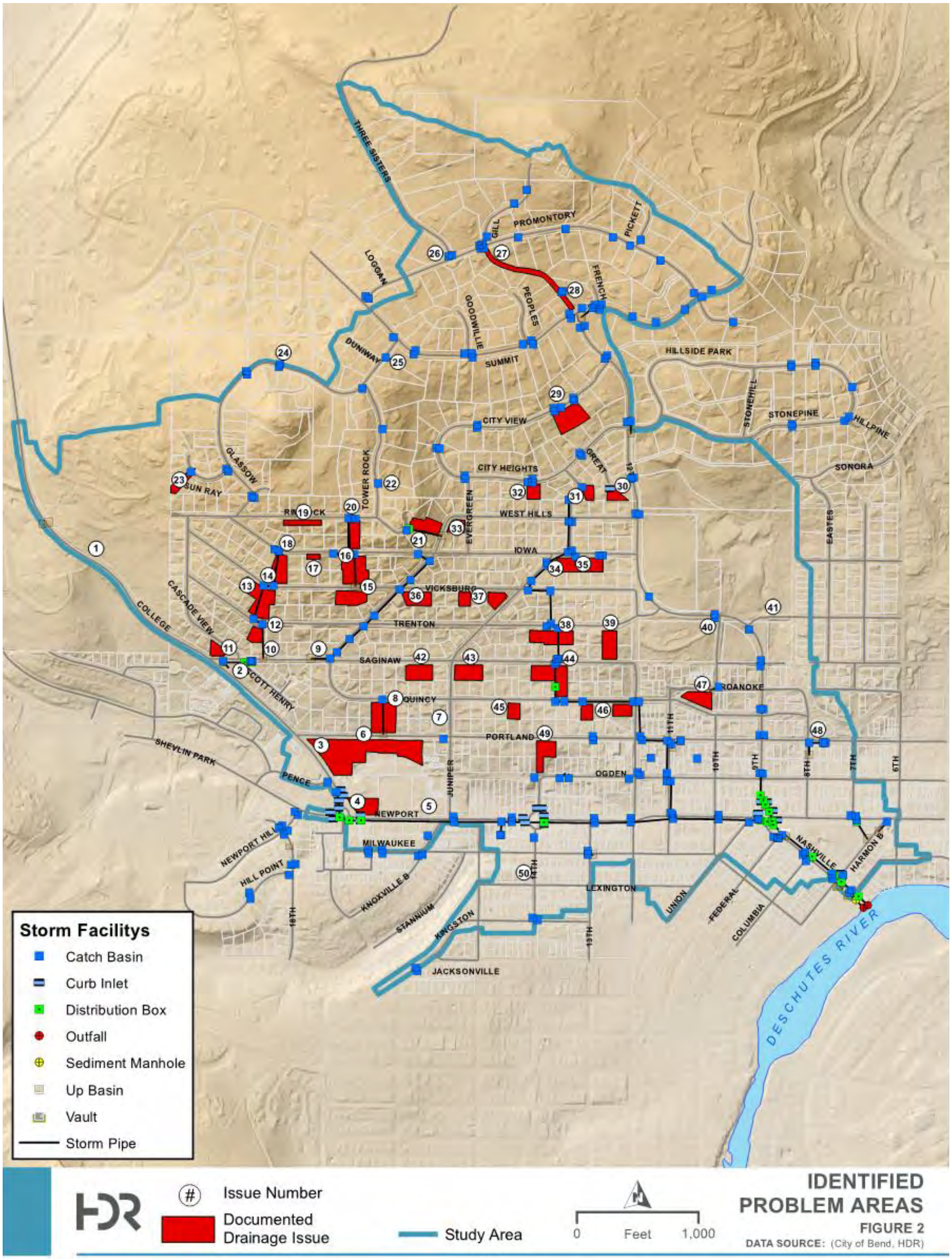
ATH: B:\PROJECTS\BEND\SOUTHAWBREYBUTTEDRAINAGESTUDY\MAP_DOCS\FIGURE 1 STUDY AREA – EXISTING STORM SYSTEM.MXD - USER: LLSMITH - DATE: 10/5/2017

2.1 Existing Drainage System Evaluation

The existing conditions assessment involved identifying, analyzing and summarizing the type and extent of drainage issues within the Study Area. The evaluation included a thorough review of system data provided by the City, including CCTV footage review, Operations and Maintenance records, and received public comments. In addition, a hydrologic and hydraulic model of the existing system was developed using XP Software's Storm Water Management Model (XP-SWMM). The model was used to perform a pipe capacity analysis, surface flooding analysis, and to identify system deficiencies. The full Existing Drainage System Evaluation Report is included as Attachment 1.

The Existing Drainage System Evaluation Report led to the identification of both systemic and specific drainage issues within the Awbrey Butte Study Area. Systemic issues are those seen basin wide which negatively impact properties, water quality, water quantity, and/or system performance. Specific drainage issues identified included locations of flooding, non-compliant structures, insufficient pipe capacity, and inlet clogging, among others. These identified issues from the evaluation effort were then mapped, along with reported drainage issues from residents and City staff, to convey the magnitude of drainage problems in the Awbrey Butte drainage Study Area. Figure 2 includes a summary of the identified specific drainage issues, and further mapping efforts are also included in Attachment 1.

Figure 2: Identified Problem Areas



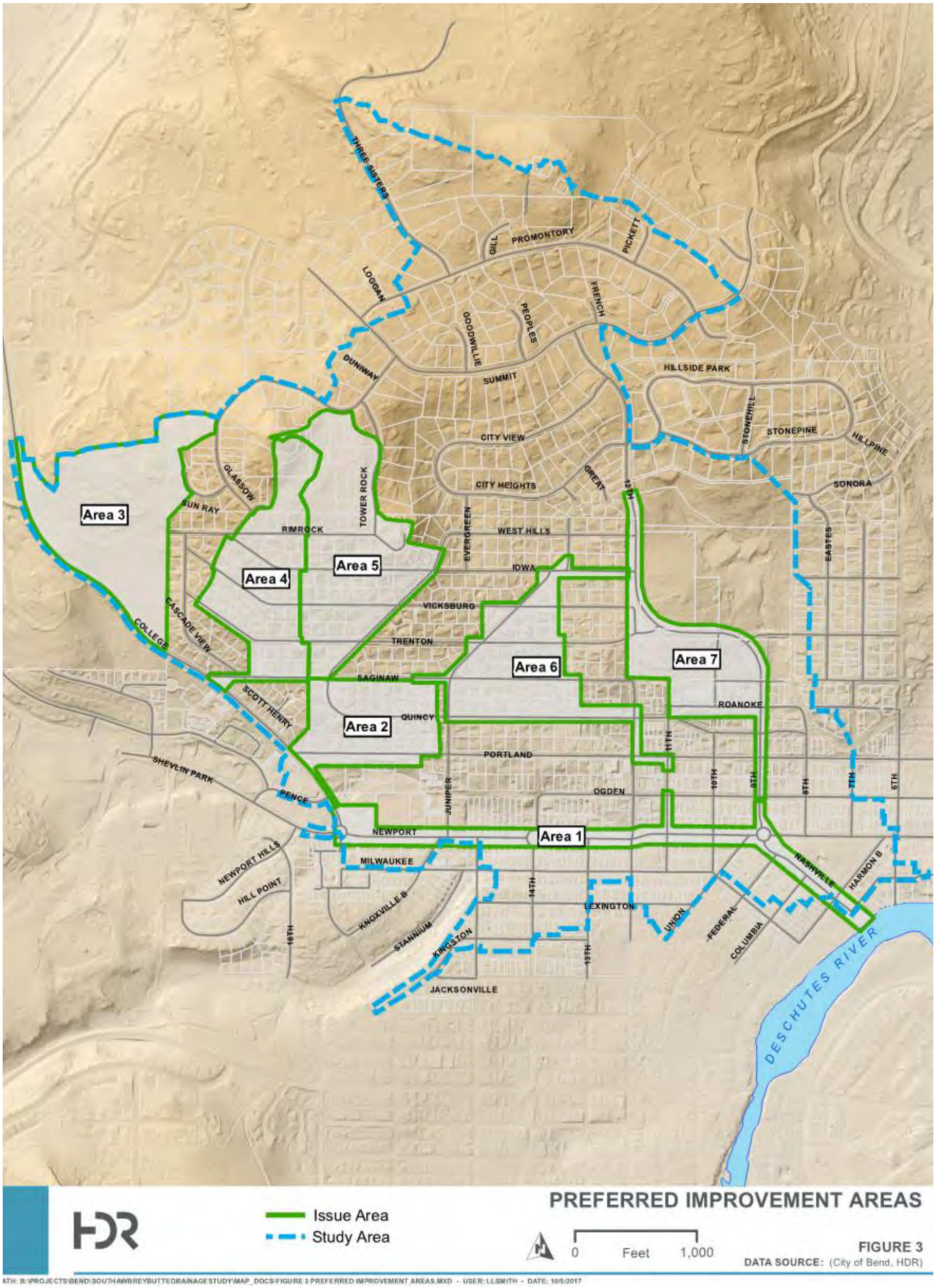
2.2 Preferred Improvement Areas

Preferred Improvements Areas (PIAs) were defined for this project as “a feasible list or set area of drainage problems to be improved, which in the opinion of the City and HDR, will balance future expenditures and benefits.” The identification of PIAs focused on those portions of the system that directly contribute flow via piped or street conveyance to the Newport Avenue Storm System. The areas included the most significant drainage issues that could be addressed at a systems level, or at a level that impacted both directly adjacent areas as well as downstream sections of the storm system.

A total of seven PIAs were developed and carried forward into the Alternatives Analysis and Final Improvement Plan for this project. These areas included portions of College Way, Portland Avenue, Saginaw Avenue, West Hills Avenue, Juniper Avenue, Quincy Avenue and 12th Street, and the basins associated with those streets. The Newport Avenue system, including all conveyance and catch basin structures, was also identified as a PIA; however, it was determined that the entire system on Newport Avenue is in need of replacement, and thus the design of a comprehensive drainage system for Newport Avenue was placed outside the scope of this project. Figure 3 shows the extents of the seven PIA areas.

In addition to those deficiencies identified in the PIAs, there are other specific drainage problems which have been documented throughout the basin. These issues have been documented in the Final Preferred Improvement Area Technical Memorandum provided as Attachment 2. None of the documented issues located outside of the PIAs are included in the final project prioritization list, as these issues may be addressed by City crews or included in future CIP projects.

Figure 3: Preferred Improvement Areas



2.3 Alternatives Development and Evaluation

2.3.1 Alternatives Development

The conceptual design alternatives developed for each of the PIA areas focus on the most significant drainage problems at a systems level. All design alternatives aim to better manage street conveyance and private property flooding, reduce the total amount of runoff discharged to the Deschutes River, improve storm water quality, and replace or repair damaged pipes and structures. The complete set of guidelines and standard design criteria used to develop conceptual designs can be found in the Alternatives Analysis Technical Memorandum provided as Attachment 3.

In general, design alternatives included one base alternative and one comprehensive alternative. The base alternative was developed with the primary objective of managing the water quality storm: a 6-month, 24-hour storm event, or the equivalent of 1.0 inches of rain falling over the entire study area during a 24-hour period. In all cases where applicable, this alternative focused on replacing or repairing ineffective infrastructure, improving overland conveyance to catch basins, and providing UIC facilities to the extent practicable in a given PIA. The comprehensive alternative built upon the base alternative, and had the goal of further reducing street and private property flooding and providing piped conveyance for the 25-year event, which is the equivalent of 2.5 inches of rainwater over the study area in 24 hours. The Central Oregon Stormwater Manual recommends that new storm infiltration and enclosed conveyance systems be designed with capacity for the 25-year event. In two of the areas, only one alternative was developed, as a second alternative was not feasible or practical based on site constraints. These areas included the upstream portion of College Way from Saginaw Avenue to the Central Oregon Community College Campus, and 9th to 12th street, on the eastern border of the study area. A description and map of each of the conceptual designs can also be found in the Alternatives Analysis Technical Memorandum, Attachment 3.

2.3.2 Alternatives Evaluation

The alternatives developed for each PIA area, most often a base and a comprehensive alternative, represent the spectrum of possible improvement projects. As a result of this approach, a typical comparative alternatives analysis was not performed. Instead, HDR selected recommended improvement alternatives which in its opinion best met the following criteria:

- Direct benefit to Newport Avenue Storm System (Newport Avenue pipe replacement, flow reduction, or water quality improvement)
- Reduced flooding of documented areas
- Improved water quality

In the Alternative Analysis memo, a preferred alternative is provided for each of the PIAs. However, it is recognized that a phased approach for the implementation of these recommendations may be required. The following Final Improvement Plan provides an outline for this approach.

3 Final Improvement Plan

3.1 Methodology

This final improvement plan presents a prioritized list of drainage improvements which attempts to balances future expenditures and benefits. The proposed projects are grouped into three (3) priority tiers with Tier 1 representing the highest priority projects and Tier 3 representing the lowest priority projects.

Each of the developed alternatives were broken up into schedules, which are defined as "a group of improvements that is reasonably undertaken as a single construction contract." These schedules were designed to maximize targeted benefits within each PIA and took into consideration the location, type, and constructability of improvements. This approach allows for phased implementation of the developed alternatives and provides flexibility to implement portions of the developed alternatives across the Study Area.

The individual projects were prioritized by HDR based on the following criteria:

- Direct benefit to Newport Avenue Storm System (Newport Avenue pipe replacement, flow reduction or water quality improvement)
- Reduction of flooding of key areas documented by the City, HDR, and public comment.
- Provision of water quality treatment infrastructure

Numerous additional factors were considered during project prioritization including the logical phasing of improvements, constructability, cost, collective magnitude of improvement benefit, extent of benefit area, and long term Operations and Maintenance benefits.

3.2 Estimates of Probable Construction Costs

AACE Class 5 estimates of probable construction cost (cost estimate) were prepared for each of the developed alternatives. The cost estimates detail each individual improvement schedule. Individual schedule costs were summed by alternative, with additional cost items, including, but not limited to, mobilization, traffic control, engineering, and contingency, added to the estimates as percentages of the total. The Class 5 estimates are summarized in **Table 1**, which includes the summed schedule costs with the additional cost items applied. The detailed estimates and figures delineating the limits of each construction schedule are located in Appendix A.

Table 1: Estimate of Probable Construction Cost

PIA	Alternative	Estimated Cost
2	2.1	$208,000
2	2.2	$460,000
3	3.1	$379,000
4	4.1	$216,000
4	4.2	$622,000
5	5.1	$669,000
5	5.2	$1,183,000
6	6.1	$930,000
6	6.2	$1,807,000
7	7.1	$379,000

3.3 Prioritized Project List

3.3.1 Tier 1 Projects

The highest priority projects for implementation are summarized in

Table 2.

Table 2: Prioritized Tier 1 Project List

Priority	Improvement	Description	Estimated Cost
1	PIA 1	Replace Newport Trunk Line from outfall to College Way.	Not Estimated
2	Alt 2.2, Schedules A&B	Extend College Way collection system to DCB001020 on Portland Avenue.	$402,220
3	Alt 4.2, Schedules A&E	Extend College Way collection system to DCB001014 on Saginaw Avenue. Install inlets on Cascade View. Requires priority 2.	$436,020
4	Alt 5.2, Schedule E	Extend storm in Saginaw Avenue to intersection of West Hills Avenue. Requires priorities 2 and 3.	$119,990
5	Alt 6.2, Schedule A	Reconstruct storm system from Newport Avenue to Quincy Avenue, extending west on Quincy Avenue to DCB001032	$415,750

6	Alt 6.2,Schedules C,D, &E	Extend Quincy Avenue storm system to Juniper Street, then northeast on Juniper Street to Iowa Avenue. Requires Priority 5.	$1,264,120

3.3.1.1 TIER 1 PRIORITIZATION RATIONALE

Replacement of the Newport Avenue Trunk Line was selected as the highest priority project in the basin. This critical pipeline consists of approximately 4,500 lineal feet (LF) of corrugated metal pipe (CMP) that varies in both size and shape. The storm system is in poor condition: nearly all pipe segments have structural defects including extensive surface corrosion, collapsed pipe segments, visible holes, separated joints, and considerable sediment deposits. In addition, segments of the system have non-compliant structures and insufficient hydraulic capacity. Pipe sizing is discussed in section 3.1 and Appendix B of the Alternatives Analysis Technical Memo. Upstream improvements are expected to add flows to the Newport Avenue system, and thus the pipe should be sized in anticipation of additional improvements in basin. Sizing depends on additional factors selected in design, included detention and infiltration along Newport Avenue.

Priority projects 2, 3, and 4 were selected next to alleviate excessive flows on the street surface originating from upbasins located on Portland Avenue and Saginaw Avenue. Flows from these upbasins result in frequent flooding of properties on Portland Avenue and College Way, and cascade downslope along Newport Avenue to 14th street. Erosion and the resuspension of pollutants on the street surface degrade water quality and are ultimately discharged to the Deschutes River. When compared to projects 5 and 6, these projects have greater potential to improve water quality in the Newport Avenue Storm System, and are relatively easy to plan and implement.

Projects 5 and 6 are included in Tier 1 as they have the potential to benefit the largest number of homeowners in the Study Area. PIA 6 received the highest number of public comment complaints and HDR believes that the majority of homes in PIA 6 are negatively impacted by excessive street surface flows originating from Iowa and Juniper. The addition of curbs and construction of a piped collection system is required to adequately manage and convey flows in this PIA. Upsizing pipe from Portland Avenue to Newport Avenue is included in the cost estimate for PIA 6.2, Schedule A, as it will facilitate conveyance from upstream improvements to the Newport Avenue system. With the exception of Newport Avenue, these projects will be the most difficult to plan and will cost the most to implement.

3.3.2 Tier 2 Projects

The second highest priority projects for implementation are summarized in **Table 3**.

Table 3: Prioritized Tier 2 Project List

Priority	Improvement	Description	Estimated Cost
7	Alt 5.1, Schedule C	Install storm system in Vicksburg Avenue and connect to existing West Hills Avenue system. Replace and add inlets on Iowa Avenue and Rimrock Drive.	$163,930
8	Alt 5.1, Schedule D	Install UICs and inlets on Tower Rock Road, flanking inlets on Rimrock Drive, and replace upbasin DCB000981 on West Hills Avenue with new UIC.	$251,810
9	Alt 5.1, Schedules A&B	Install storm line in Trenton Avenue and connect to existing West Hills System. Add additional inlets and UICs on West Hills Avenue.	$253,500
10	Alt 4.2, Schedules B,C, &D	Repair pipes and add flanking inlets at sag low points along Trenton Avenue, Vicksburg Avenue and Iowa Avenue.	$185,900
11	Alt 7.1, Schedule C	Add inlets and UIC at 10th and Roanoke Avenue.	$67,600

3.3.2.1 TIER 2 PRIORITIZATION RATIONALE

The highest ranked Tier 2 projects focus on managing flows tributary to the West Hills system. In the Alternatives Analysis, HDR recommends implementing Alternative 5.2. HDR continues to believe that Alternative 5.2 is the best long term approach; however given that West Hills Drive has curbs and an existing storm system, Alternative 5.1 provides a lower cost approach to improve the drainage issues in PIA 5.

Project 7 was selected as the highest Tier 2 project as it eliminates upbasin DCB000984 and connects the Rimrock Drive and Iowa Avenue storm line to the West Hills Drive Storm Line. Primary benefits include reduced flooding on Vicksburg Avenue and West Hills Avenue and improved water quality to the Newport Avenue storm system.

Project 8 was selected next to alleviate flooding that results in severe erosion near the Rimrock Avenue cul-de-sac. The additional inlets and UIC added on West Hills Drive are intended to reduce the frequency of flooding downslope at the intersection of West Hills Avenue and Evergreen Street.

Project 9 was selected third to reduce excessive street surface flow from Trenton Avenue onto West Hills Drive. Improved collection and the addition of UIC's are intended to reduce the amount of runoff tributary to Newport Avenue and improve water quality.

Project 10 was prioritized lower than the previous projects because the storm system in this area functions, but is in need of repair and improvements. This project will reduce or eliminate the flood hazard for approximately 6 residential properties, but does not provide infrastructure to improve water quality or significantly reduce flow to the Newport Avenue System.

Project 11 is the lowest ranked Tier 2 project due to its limited benefit area. The project is expected to capture the turbid flows witnessed on 10th Street and reduce the frequency of flooding to the downslope apartment complex. As proposed the facilities are not adequate to manage large storm events due to site constraints, including limited suitable locations for UICs and lack of a piped system within close proximity for connection.

3.3.3 Tier 3 Projects

The lowest priority projects for implementation are summarized in **Table 4**.

Table 4: Prioritized Tier 3 Project List

Priority	Improvement	Description	Estimated Cost
12	Alt 2.2, Schedule C	Install flanking inlets, new UIC, curb and asphalt berm on Saginaw Avenue.	$57,460
13	Alt 6.2, Schedule B	Add flanking inlets and curb at sag low points on Saginaw Avenue and Trenton Avenue.	$126,750
14	Alt 7.1, Schedules A&B	Install new inlets and UICs on 9th Street, 12th Street, and Saginaw Avenue.	$310,960
15	Alt 3.1, Schedule B	Install flanking inlets and new UIC on Sun Ray Court.	$52,390
16	Alt 3.1, Schedule A	Install new inlets and UICs on College Way from Saginaw Avenue to COCC.	$326,170

3.3.3.1 TIER 3 PRIORITIZATION RATIONALE

Projects prioritized in Tier 3 are those with relatively small benefit areas, which directly depend on or connect to higher tier projects, and those projects where flooding could otherwise be addressed.

Project 12 was selected as the highest ranking Tier 3 project as it will eliminate flooding of two residential lots, improve water quality and decrease the amount of flow to Newport Avenue.

Project 13 was selected next as it decreases the flood hazard to 3 residential lots and is relatively cost effective and easy to implement. Construction of Project 6 (Tier 1) is anticipated to significantly reduce the flows to this area, thereby potentially decreasing the need for this project. HDR recommends reevaluating this project once Project 6 is complete.

Project 14 includes replacing existing grated catch basin inlets and UIC facilities on 9th and 12th streets, and providing additional inlet locations and UICs. This project is aimed at decreasing flows to Newport Avenue and improving water quality. The existence of current facilities justifies this project's low priority; if the current facilities are rigorously maintained then they provide some benefit for managing stormwater.

Project 15 is ranked lower than the previous projects based on its small benefit area. This project will eliminate minor flooding onto the COCC campus and associated erosion of the hillside above College Way which contributes to high turbidity of College Way flows.

Project 16 is the lowest ranked Tier 3 project due to its relatively high cost. The project would significantly reduce the total runoff to Newport Avenue and would improve water quality in the basin; however, the majority of flow this project is designed to manage is runoff from the Central Oregon Community College (COCC) campus. HDR recommends that the City work with COCC to develop on-campus stormwater solutions that minimize erosion and flow discharge to College Way. If this effort fails, the City may re-evaluate classification of this project to Tier 2.

4 Next Steps

The information provided in this Final Improvement Plan is the first step to improving the drainage on the south side of Awbrey Butte. Further work, including a geotechnical study of proposed UIC facilities and additional hydrologic and hydraulic analysis to properly locate and design the proposed stormwater facilities, is needed prior to the implementation of the design elements included in this plan. Geotechnical information required will be site specific, but will likely include, at a minimum: infiltration rate, rock fracture percentage, potential for downstream seepage, and slope stability. Additional program planning and budgeting of the proposed improvements is also necessary. This plan provides a foundation for this further work and a prioritization of projects that need to be implemented.

The existing conditions and proposed conditions models will be provided to the city for future use. Model calibration and validation was based on limited data. In many cases, the quality of data was questionable and some timeseries were missing. Negative depths observed in the data may be a result of gauges that were not recently calibrated or maintained. Negative velocities observed in the data may have been physically accurate, resulting from backwatered conditions. However peak flows and volumes taken from timeseries with negative values are more variable and have more uncertainty. Additional data collection is recommended to develop a robust set of baseline data from which to further improve the model.

Appendix A: Estimate of Probable Construction Cost and Cost Estimate Figures

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 2.1
SCHEDULE SUMMARY

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE	DESCRIPTION	COST
2.1A	College Way and Portland Avenue Improvements	$89,000.00
2.1B	Quincy Avenue Improvements	$34,000.00
	SUBTOTAL ALL SCHEDULES	**$123,000.00**
	MOBILIZATION @ 8%	**$9,840.00**
	EROSION CONTROL @ 3%	**$3,690.00**
	CONSTRUCTION SURVEY WORK @ 3%	**$3,690.00**
	TEMPORARY PROTECTION AND DIRECTION OF TRAFFIC @ 3%	**$3,690.00**
	CONSTRUCTION MANAGEMENT @ 5%	**$6,150.00**
	ENGINEERING @ 12%	**$14,760.00**
	CONTINGENCY (35%)	**$43,050.00**
	TOTAL COST	**$207,870.00**

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 2.1

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE "2.1A"- COLLEGE WAY/PORTLAND AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
A-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	200	FT	$70.00	$14,000.00
A-2	Concrete Manholes, Drywell	470	4	EA	$8,000.00	$32,000.00
A-3	Concrete Manholes, Sedimentation	470	4	EA	$6,000.00	$24,000.00
A-4	Manholes over Existing Sewers	470	1	EA	$5,300.00	$5,300.00
A-5	Connection to Existing Structure	470	1	EA	$950.00	$950.00
A-6	Concrete Inlets, Type CG-3	470	4	EA	$2,800.00	$11,200.00
A-7	Removal of Inlets	310	1	EA	$550.00	$550.00
A-8	Asphalt/Concrete Saw Cutting	310	300	LF	$2.00	$600.00
					SCHEDULE "A" SUBTOTAL	$89,000.00

SCHEDULE "2.1B"- QUINCY AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
B-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	90	FT	$70.00	$6,300.00
B-2	Concrete Manholes, Drywell	470	1	EA	$8,000.00	$8,000.00
B-3	Concrete Manholes, Sedimentation	470	1	EA	$6,000.00	$6,000.00
B-4	Connection to Existing Structure	470	1	EA	$950.00	$950.00
B-5	Concrete Inlets, Type CG-3	470	3	EA	$2,800.00	$8,400.00
B-6	Concrete Curbs, Standard Curb	759	200	FT	$10.00	$2,000.00
B-7	Asphalt Berm	749	205	LF	$5.00	$1,025.00
B-8	Removal of Inlets	310	1	EA	$550.00	$550.00
B-9	Asphalt/Concrete Saw Cutting	310	340	LF	$2.00	$680.00
					SCHEDULE "B" SUBTOTAL	$34,000.00

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 2.2
SCHEDULE SUMMARY

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE	DESCRIPTION	COST
2.2A	College Way Improvements	$126,000.00
2.2B	Portland Avenue Improvements	$112,000.00
2.2C	Quincy Avenue Improvements	$34,000.00
	SUBTOTAL ALL SCHEDULES	**$272,000.00**
	MOBILIZATION @ 8%	**$21,760.00**
	EROSION CONTROL @ 3%	**$8,160.00**
	CONSTRUCTION SURVEY WORK @ 3%	**$8,160.00**
	TEMPORARY PROTECTION AND DIRECTION OF TRAFFIC @ 3%	**$8,160.00**
	CONSTRUCTION MANAGEMENT @ 5%	**$13,600.00**
	ENGINEERING @ 12%	**$32,640.00**
	CONTINGENCY (35%)	**$95,200.00**
	TOTAL COST	**$459,680.00**

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 2.2

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE "2.2A"- COLLEGE WAY IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
A-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	80	FT	$70.00	$5,600.00
A-2	24 inch Storm Sewer Pipe, 5 ft Depth	445	550	FT	$120.00	$66,000.00
A-3	Concrete Storm Sewer Manholes	470	4	EA	$3,500.00	$14,000.00
A-4	Concrete Manholes, Drywell	470	2	EA	$8,000.00	$16,000.00
A-5	Concrete Manholes, Sedimentation	470	2	EA	$6,000.00	$12,000.00
A-6	Connection to Existing Structure	470	1	EA	$950.00	$950.00
A-7	Concrete Inlets, Type CG-3	470	3	EA	$2,800.00	$8,400.00
A-8	Asphalt/Concrete Saw Cutting	310	1,240	LF	$2.00	$2,480.00
					SCHEDULE "A" SUBTOTAL	$126,000.00

SCHEDULE "2.2B"- PORTLAND AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
B-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	95	FT	$70.00	$6,650.00
B-2	24 inch Storm Sewer Pipe, 5 ft Depth	445	680	FT	$120.00	$81,600.00
B-3	Concrete Storm Sewer Manholes	470	3	EA	$3,500.00	$10,500.00
B-4	Connection to Existing Structure	470	1	EA	$950.00	$950.00
B-5	Concrete Inlets, Type CG-3	470	3	EA	$2,800.00	$8,400.00
B-6	Removal of Inlets	310	1	EA	$550.00	$550.00
B-7	Asphalt/Concrete Saw Cutting	310	1,540	LF	$2.00	$3,080.00
					SCHEDULE "B" SUBTOTAL	$112,000.00

SCHEDULE "2.2C"- QUINCY AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
C-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	90	FT	$70.00	$6,300.00
C-2	Concrete Manholes, Drywell	470	1	EA	$8,000.00	$8,000.00
C-3	Concrete Manholes, Sedimentation	470	1	EA	$6,000.00	$6,000.00
C-4	Connection to Existing Structure	470	1	EA	$950.00	$950.00
C-5	Concrete Inlets, Type CG-3	470	3	EA	$2,800.00	$8,400.00
C-6	Concrete Curbs, Standard Curb	759	200	FT	$10.00	$2,000.00
C-7	Asphalt Berm	749	205	LF	$5.00	$1,025.00
C-8	Removal of Inlets	310	1	EA	$550.00	$550.00
C-9	Asphalt/Concrete Saw Cutting	310	340	LF	$2.00	$680.00
					SCHEDULE "C" SUBTOTAL	$34,000.00

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 3.1
SCHEDULE SUMMARY

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE	DESCRIPTION	COST
3.1A	College Way Improvements	$193,000.00
3.1B	Sun Ray Court Improvements	$31,000.00
	SUBTOTAL ALL SCHEDULES	**$224,000.00**
	MOBILIZATION @ 8%	**$17,920.00**
	EROSION CONTROL @ 3%	**$6,720.00**
	CONSTRUCTION SURVEY WORK @ 3%	**$6,720.00**
	TEMPORARY PROTECTION AND DIRECTION OF TRAFFIC @ 3%	**$6,720.00**
	CONSTRUCTION MANAGEMENT @ 5%	**$11,200.00**
	ENGINEERING @ 12%	**$26,880.00**
	CONTINGENCY (35%)	**$78,400.00**
	TOTAL COST	**$378,560.00**

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 3.1

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE "3.1A"- COLLEGE WAY IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
A-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	110	FT	$70.00	$7,700.00
A-2	Concrete Manholes, Drywell	470	11	EA	$8,000.00	$88,000.00
A-3	Concrete Manholes, Sedimentation	470	11	EA	$6,000.00	$66,000.00
A-4	Concrete Inlets, Type CG-3	470	11	EA	$2,800.00	$30,800.00
A-5	Asphalt/Concrete Saw Cutting	310	44	LF	$2.00	$88.00
					SCHEDULE "A" SUBTOTAL	$193,000.00

SCHEDULE "3.1B"- SUN RAY COURT IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
B-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	95	FT	$70.00	$6,650.00
B-2	Concrete Manholes, Drywell	470	1	EA	$8,000.00	$8,000.00
B-3	Concrete Manholes, Sedimentation	470	1	EA	$6,000.00	$6,000.00
B-4	Connection to Existing Structure	470	1	EA	$950.00	$950.00
B-5	Concrete Inlets, Type CG-3	470	3	EA	$2,800.00	$8,400.00
B-6	Asphalt/Concrete Saw Cutting	310	170	LF	$2.00	$340.00
					SCHEDULE "B" SUBTOTAL	$31,000.00

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 4.1
SCHEDULE SUMMARY

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE	DESCRIPTION	COST
4.1A	College Way Improvements	$18,000.00
4.1B	Trenton Avenue Improvements	$39,000.00
4.1C	Vicksburg Avenue Improvements	$48,000.00
4.1D	Iowa Avenue Improvements	$23,000.00
	SUBTOTAL ALL SCHEDULES	**$128,000.00**
	MOBILIZATION @ 8%	**$10,240.00**
	EROSION CONTROL @ 3%	**$3,840.00**
	CONSTRUCTION SURVEY WORK @ 3%	**$3,840.00**
	TEMPORARY PROTECTION AND DIRECTION OF TRAFFIC @ 3%	**$3,840.00**
	CONSTRUCTION MANAGEMENT @ 5%	**$6,400.00**
	ENGINEERING @ 12%	**$15,360.00**
	CONTINGENCY (35%)	**$44,800.00**
	TOTAL COST	**$216,320.00**

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 4.1

PROJECT : S. Awbrey Butte Drainage Study
HDR JOB # : 10030242
LOCATION : Bend, OR
ENR CCI :

ESTIMATE CLASS : 5
DATE : DRAFT
BY : KH
REVIEWED : BW

SCHEDULE "4.1A"- COLLEGE WAY IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
A-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	10	FT	$70.00	$700.00
A-2	Concrete Manholes, Drywell	470	1	EA	$8,000.00	$8,000.00
A-3	Concrete Manholes, Sedimentation	470	1	EA	$6,000.00	$6,000.00
A-4	Concrete Inlets, Type CG-3	470	1	EA	$2,800.00	$2,800.00
A-5	Asphalt/Concrete Saw Cutting	310	4	LF	$2.00	$8.00
					SCHEDULE "A" SUBTOTAL	$18,000.00

SCHEDULE "4.1B" - TRENTON AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
B-1	Removal of Pipes	310	90	FT	$30.00	$2,700.00
B-2	12 inch Storm Sewer Pipe, 5 ft Depth	445	160	FT	$70.00	$11,200.00
B-3	Concrete Storm Sewer Manholes	470	2	EA	$3,500.00	$7,000.00
B-4	Connection to Existing Structure	470	2	EA	$950.00	$1,900.00
B-5	Concrete Inlets, Type CG-3	470	5	EA	$2,800.00	$14,000.00
B-6	Removal of Inlets	310	2	EA	$550.00	$1,100.00
B-7	Asphalt/Concrete Saw Cutting	310	315	LF	$2.00	$630.00
					SCHEDULE "B" SUBTOTAL	$39,000.00

SCHEDULE "4.1C"- VICKSBURG AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
C-1	Removal of Pipes	310	80	FT	$30.00	$2,400.00
C-2	12 inch Storm Sewer Pipe, 5 ft Depth	445	210	FT	$70.00	$14,700.00
C-3	Concrete Storm Sewer Manholes	470	3	EA	$3,500.00	$10,500.00
C-4	Connection to Existing Structure	470	2	EA	$950.00	$1,900.00
C-5	Concrete Inlets, Type CG-3	470	5	EA	$2,800.00	$14,000.00
C-6	Concrete Curbs, Standard Curb	759	140	FT	$10.00	$1,400.00
C-7	Removal of Inlets	310	2	EA	$550.00	$1,100.00
C-8	Asphalt/Concrete Saw Cutting	310	560	LF	$2.00	$1,120.00
					SCHEDULE "C" SUBTOTAL	$48,000.00

SCHEDULE "4.1D"- IOWA AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
D-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	110	FT	$70.00	$7,700.00
D-2	Connection to Existing Structure	470	3	EA	$950.00	$2,850.00
D-3	Concrete Inlets, Type CG-3	470	3	EA	$2,800.00	$8,400.00
D-4	Concrete Curbs, Standard Curb	759	265	FT	$10.00	$2,650.00
D-5	Asphalt/Concrete Saw Cutting	310	400	LF	$2.00	$800.00
					SCHEDULE "D" SUBTOTAL	$23,000.00

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 4.2
SCHEDULE SUMMARY

PROJECT : S. Awbrey Butte Drainage Study
HDR JOB # : 10030242
LOCATION : Bend, OR
ENR CCI :

ESTIMATE CLASS : 5
DATE : DRAFT
BY : KH
REVIEWED : BW

SCHEDULE	DESCRIPTION	COST
4.2A	College Way Improvements	$233,000.00
4.2B	Trenton Avenue Improvements	$39,000.00
4.2C	Vicksburg Avenue Improvements	$48,000.00
4.2D	Iowa Avenue Improvements	$23,000.00
4.2E	Cascade View Drive Improvements	$25,000.00
	SUBTOTAL ALL SCHEDULES	**$368,000.00**
	MOBILIZATION @ 8%	**$29,440.00**
	EROSION CONTROL @ 3%	**$11,040.00**
	CONSTRUCTION SURVEY WORK @ 3%	**$11,040.00**
	TEMPORARY PROTECTION AND DIRECTION OF TRAFFIC @ 3%	**$11,040.00**
	CONSTRUCTION MANAGEMENT @ 5%	**$18,400.00**
	ENGINEERING @ 12%	**$44,160.00**
	CONTINGENCY (35%)	**$128,800.00**
	TOTAL COST	**$621,920.00**

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 4.2

PROJECT : S. Awbrey Butte Drainage Study
HDR JOB # : 10030242
LOCATION : Bend, OR
ENR CCI :

ESTIMATE CLASS : 5
DATE : DRAFT
BY : KH
REVIEWED : BW

SCHEDULE "4.2A"- COLLEGE WAY IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
A-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	195	FT	$70.00	$13,650.00
A-2	24 inch Storm Sewer Pipe, 5 ft Depth	445	1,310	FT	$120.00	$157,200.00
A-3	Concrete Storm Sewer Manholes	470	8	EA	$3,500.00	$28,000.00
A-4	Connection to Existing Structure	470	2	EA	$950.00	$1,900.00
A-5	Concrete Inlets, Type CG-3	470	9	EA	$2,800.00	$25,200.00
A-6	Asphalt/Concrete Saw Cutting	310	3,045	LF	$2.00	$6,090.00
					SCHEDULE "A" SUBTOTAL	$233,000.00

SCHEDULE "4.2B" - TRENTON AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
B-1	Removal of Pipes	310	90	FT	$30.00	$2,700.00
B-2	12 inch Storm Sewer Pipe, 5 ft Depth	445	160	FT	$70.00	$11,200.00
B-3	Concrete Storm Sewer Manholes	470	2	EA	$3,500.00	$7,000.00
B-4	Connection to Existing Structure	470	2	EA	$950.00	$1,900.00
B-5	Concrete Inlets, Type CG-3	470	5	EA	$2,800.00	$14,000.00
B-6	Removal of Inlets	310	2	EA	$550.00	$1,100.00
B-7	Asphalt/Concrete Saw Cutting	310	315	LF	$2.00	$630.00
					SCHEDULE "B" SUBTOTAL	$39,000.00

SCHEDULE "4.2C"- VICKSBURG AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
C-1	Removal of Pipes	310	80	FT	$30.00	$2,400.00
C-2	12 inch Storm Sewer Pipe, 5 ft Depth	445	210	FT	$70.00	$14,700.00
C-3	Concrete Storm Sewer Manholes	470	3	EA	$3,500.00	$10,500.00
C-4	Connection to Existing Structure	470	2	EA	$950.00	$1,900.00
C-5	Concrete Inlets, Type CG-3	470	5	EA	$2,800.00	$14,000.00
C-6	Concrete Curbs, Standard Curb	759	140	FT	$10.00	$1,400.00
C-7	Removal of Inlets	310	2	EA	$550.00	$1,100.00
C-8	Asphalt/Concrete Saw Cutting	310	560	LF	$2.00	$1,120.00
					SCHEDULE "C" SUBTOTAL	$48,000.00

SCHEDULE "4.2D"- IOWA AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
D-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	110	FT	$70.00	$7,700.00
D-2	Connection to Existing Structure	470	3	EA	$950.00	$2,850.00
D-3	Concrete Inlets, Type CG-3	470	3	EA	$2,800.00	$8,400.00
D-4	Concrete Curbs, Standard Curb	759	265	FT	$10.00	$2,650.00
D-5	Asphalt/Concrete Saw Cutting	310	400	LF	$2.00	$800.00
					SCHEDULE "D" SUBTOTAL	$23,000.00

SCHEDULE "4.2E"- CASCADE VIEW DRIVE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
E-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	150	FT	$70.00	$10,500.00
E-2	Concrete Storm Sewer Manholes	470	2	EA	$3,500.00	$7,000.00
E-3	Connection to Existing Structure	470	1	EA	$950.00	$950.00
E-4	Concrete Inlets, Type CG-3	470	2	EA	$2,800.00	$5,600.00
E-5	Asphalt/Concrete Saw Cutting	310	300	LF	$2.00	$600.00
					SCHEDULE "E" SUBTOTAL	$25,000.00

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 5.1
SCHEDULE SUMMARY

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE	DESCRIPTION	COST
5.1A	Lower NW West Hills Avenue Improvements	$122,000.00
5.1B	Upper NW West Hills Avenue Improvements	$28,000.00
5.1C	Vicksburg/Iowa Avenue Improvements	$97,000.00
5.1D	Rimrock Drive	$149,000.00
	SUBTOTAL ALL SCHEDULES	**$396,000.00**
	MOBILIZATION @ 8%	**$31,680.00**
	EROSION CONTROL @ 3%	**$11,880.00**
	CONSTRUCTION SURVEY WORK @ 3%	**$11,880.00**
	TEMPORARY PROTECTION AND DIRECTION OF TRAFFIC @ 3%	**$11,880.00**
	CONSTRUCTION MANAGEMENT @ 5%	**$19,800.00**
	ENGINEERING @ 12%	**$47,520.00**
	CONTINGENCY (35%)	**$138,600.00**
	TOTAL COST	**$669,240.00**

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 5.1

PROJECT : S. Awbrey Butte Drainage Study
HDR JOB # : 10030242
LOCATION : Bend, OR
ENR CCI :

ESTIMATE CLASS : 5
DATE : DRAFT
BY : KH
REVIEWED : BW

SCHEDULE "5.1A"- LOWER NW WEST HILLS AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
A-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	480	FT	$70.00	$33,600.00
A-2	Concrete Storm Sewer Manholes	470	4	EA	$3,500.00	$14,000.00
A-3	Concrete Manholes, Drywell	470	4	EA	$8,000.00	$32,000.00
A-4	Concrete Manholes, Sedimentation	470	4	EA	$6,000.00	$24,000.00
A-5	Manholes over Existing Sewers	470	1	EA	$5,300.00	$5,300.00
A-6	Connection to Existing Structure	470	3	EA	$950.00	$2,850.00
A-7	Concrete Inlets, Type CG-3	470	3	EA	$2,800.00	$8,400.00
A-8	Asphalt/Concrete Saw Cutting	310	920	LF	$2.00	$1,840.00
					SCHEDULE "A" SUBTOTAL	$122,000.00

SCHEDULE "5.1B"- UPPER NW WEST HILLS AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
B-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	10	FT	$70.00	$700.00
B-2	Concrete Manholes, Drywell	470	1	EA	$8,000.00	$8,000.00
B-3	Concrete Manholes, Sedimentation	470	1	EA	$6,000.00	$6,000.00
B-4	Connection to Existing Structure	470	4	EA	$950.00	$3,800.00
B-5	Concrete Inlets, Grated	470	4	EA	$2,000.00	$8,000.00
B-6	Removal of Inlets	310	1	EA	$550.00	$550.00
B-7	Asphalt/Concrete Saw Cutting	310	20	LF	$2.00	$40.00
					SCHEDULE "B" SUBTOTAL	$28,000.00

SCHEDULE "5.1C"- VICKSBURG/IOWA AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
C-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	575	FT	$70.00	$40,250.00
C-2	Concrete Storm Sewer Manholes	470	5	EA	$3,500.00	$17,500.00
C-3	Connection to Existing Structure	470	7	EA	$950.00	$6,650.00
C-4	Concrete Inlets, Type CG-3	470	9	EA	$2,800.00	$25,200.00
C-5	Concrete Curbs, Standard Curb	759	200	FT	$10.00	$2,000.00
C-6	Removal of Inlets	310	4	EA	$550.00	$2,200.00
C-7	Asphalt/Concrete Saw Cutting	310	1,285	LF	$2.00	$2,570.00
					SCHEDULE "C" SUBTOTAL	$97,000.00

SCHEDULE "5.1D"- RIMROCK DRIVE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
D-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	65	FT	$70.00	$4,550.00
D-2	Line Existing Pipe	406	1	LS	$75,000.00	$75,000.00
D-3	Concrete Storm Sewer Manholes	470	1	EA	$3,500.00	$3,500.00
D-4	Concrete Manholes, Drywell	470	3	EA	$8,000.00	$24,000.00
D-5	Concrete Manholes, Sedimentation	470	3	EA	$6,000.00	$18,000.00
D-6	Connection to Existing Structure	470	1	EA	$950.00	$950.00
D-7	Concrete Inlets, Type CG-3	470	7	EA	$2,800.00	$19,600.00
D-8	Concrete Curbs, Standard Curb	759	120	FT	$10.00	$1,200.00
D-9	Removal of Inlets	310	2	EA	$550.00	$1,100.00
D-10	Asphalt/Concrete Saw Cutting	310	65	LF	$2.00	$130.00
					SCHEDULE "D" SUBTOTAL	$149,000.00

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 5.2
SCHEDULE SUMMARY

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE	DESCRIPTION	COST
5.2A	Lower NW West Hills Avenue Improvements	$206,000.00
5.2B	Upper NW West Hills Avenue Improvements	$165,000.00
5.2C	Vicksburg/Iowa Avenue Improvements	$97,000.00
5.2D	Rimrock Drive Improvements	$161,000.00
5.2E	Saginaw Avenue Improvements	$71,000.00
	SUBTOTAL ALL SCHEDULES	**$700,000.00**
	MOBILIZATION @ 8%	**$56,000.00**
	EROSION CONTROL @ 3%	**$21,000.00**
	CONSTRUCTION SURVEY WORK @ 3%	**$21,000.00**
	TEMPORARY PROTECTION AND DIRECTION OF TRAFFIC @ 3%	**$21,000.00**
	CONSTRUCTION MANAGEMENT @ 5%	**$35,000.00**
	ENGINEERING @ 12%	**$84,000.00**
	CONTINGENCY (35%)	**$245,000.00**
	TOTAL COST	**$1,183,000.00**

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 5.2

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE "5.2A"- LOWER NW WEST HILLS AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
A-1	Removal of Pipes	310	440	FT	$30.00	$13,200.00
A-2	12 inch Storm Sewer Pipe, 5 ft Depth	445	520	FT	$70.00	$36,400.00
A-3	18 inch Storm Sewer Pipe, 5 ft Depth	445	450	FT	$95.00	$42,750.00
A-4	Concrete Storm Sewer Manholes	470	8	EA	$3,500.00	$28,000.00
A-5	Concrete Manholes, Drywell	470	4	EA	$8,000.00	$32,000.00
A-6	Concrete Manholes, Sedimentation	470	4	EA	$6,000.00	$24,000.00
A-8	Connection to Existing Structure	470	1	EA	$950.00	$950.00
A-9	Concrete Inlets, Type CG-3	470	8	EA	$2,800.00	$22,400.00
A-10	Removal of Inlets	310	3	EA	$550.00	$1,650.00
A-11	Asphalt/Concrete Saw Cutting	310	1,940	LF	$2.00	$3,880.00
					SCHEDULE "A" SUBTOTAL	$206,000.00

SCHEDULE "5.2B"- UPPER NW WEST HILLS AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
B-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	245	FT	$70.00	$17,150.00
B-2	18 inch Storm Sewer Pipe, 5 ft Depth	445	730	FT	$95.00	$69,350.00
B-3	Concrete Storm Sewer Manholes	470	9	EA	$3,500.00	$31,500.00
B-4	Concrete Manholes, Drywell	470	1	EA	$8,000.00	$8,000.00
B-5	Concrete Manholes, Sedimentation	470	1	EA	$6,000.00	$6,000.00
B-6	Connection to Existing Structure	470	1	EA	$950.00	$950.00
B-7	Concrete Inlets, Type CG-3	470	10	EA	$2,800.00	$28,000.00
B-8	Asphalt/Concrete Saw Cutting	310	1,950	LF	$2.00	$3,900.00
					SCHEDULE "B" SUBTOTAL	$165,000.00

SCHEDULE "5.2C"- VICKSBURG AND IOWA AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
C-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	575	FT	$70.00	$40,250.00
C-2	Concrete Storm Sewer Manholes	470	5	EA	$3,500.00	$17,500.00
C-3	Connection to Existing Structure	470	7	EA	$950.00	$6,650.00
C-4	Concrete Inlets, Type CG-3	470	9	EA	$2,800.00	$25,200.00
C-5	Concrete Curbs, Standard Curb	759	200	FT	$10.00	$2,000.00
C-6	Removal of Inlets	310	4	EA	$550.00	$2,200.00
C-7	Asphalt/Concrete Saw Cutting	310	1,285	LF	$2.00	$2,570.00
					SCHEDULE "C" SUBTOTAL	$97,000.00

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 5.2 (continued)

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE "5.2D"- RIMROCK DRIVE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
D-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	230	FT	$70.00	$16,100.00
D-2	Line Existing Pipe	406	1	LS	$75,000.00	$75,000.00
D-3	Concrete Storm Sewer Manholes	470	1	EA	$3,500.00	$3,500.00
D-4	Concrete Manholes, Drywell	470	3	EA	$8,000.00	$24,000.00
D-5	Concrete Manholes, Sedimentation	470	3	EA	$6,000.00	$18,000.00
D-6	Connection to Existing Structure	470	1	EA	$950.00	$950.00
D-7	Concrete Inlets, Type CG-3	470	7	EA	$2,800.00	$19,600.00
D-8	Concrete Curbs, Standard Curb	759	120	FT	$10.00	$1,200.00
D-9	Removal of Inlets	310	2	EA	$550.00	$1,100.00
D-10	Asphalt/Concrete Saw Cutting	310	485	LF	$2.00	$970.00
					SCHEDULE "D" SUBTOTAL	$161,000.00

SCHEDULE "5.2E"- SAGINAW AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
E-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	90	FT	$70.00	$6,300.00
E-2	18 inch Storm Sewer Pipe, 5 ft Depth	445	515	FT	$95.00	$48,925.00
E-3	Concrete Storm Sewer Manholes	470	1	EA	$3,500.00	$3,500.00
E-4	Connection to Existing Structure	470	1	EA	$950.00	$950.00
E-5	Concrete Inlets, Type CG-3	470	3	EA	$2,800.00	$8,400.00
E-6	Removal of Inlets	310	1	EA	$550.00	$550.00
E-7	Asphalt/Concrete Saw Cutting	310	1,090	LF	$2.00	$2,180.00
					SCHEDULE "E" SUBTOTAL	$71,000.00

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 6.1
SCHEDULE SUMMARY

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE	DESCRIPTION	COST
6.1A	Quincy Avenue to Portland Avenue Improvements	$246,000.00
6.1B	Saginaw/Trenton Avenue Improvements	$75,000.00
6.1C	Quincy Avenue Improvements	$63,000.00
6.1D	Juniper Avenue Improvements	$77,000.00
6.1E	Iowa Avenue Improvements	$89,000.00
	SUBTOTAL ALL SCHEDULES	**$550,000.00**
	MOBILIZATION @ 8%	**$44,000.00**
	EROSION CONTROL @ 3%	**$16,500.00**
	CONSTRUCTION SURVEY WORK @ 3%	**$16,500.00**
	TEMPORARY PROTECTION AND DIRECTION OF TRAFFIC @ 3%	**$16,500.00**
	CONSTRUCTION MANAGEMENT @ 5%	**$27,500.00**
	ENGINEERING @ 12%	**$66,000.00**
	CONTINGENCY (35%)	**$192,500.00**
	TOTAL COST	**$929,500.00**

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 6.1

PROJECT : S. Awbrey Butte Drainage Study
HDR JOB # : 10030242
LOCATION : Bend, OR
ENR CCI :

ESTIMATE CLASS : 5
DATE : DRAFT
BY : KH
REVIEWED : BW

SCHEDULE "6.1A"- QUINCY AVENUE TO PORTLAND AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
A-1	Removal of Pipes	310	650	FT	$30.00	$19,500.00
A-2	12 inch Storm Sewer Pipe, 5 ft Depth	445	180	FT	$70.00	$12,600.00
A-3	21 inch Storm Sewer Pipe, 5 ft Depth	445	1,310	FT	$110.00	$144,100.00
A-4	Concrete Storm Sewer Manholes	470	7	EA	$3,500.00	$24,500.00
A-5	Concrete Manholes, Drywell	470	1	EA	$8,000.00	$8,000.00
A-6	Concrete Manholes, Sedimentation	470	1	EA	$6,000.00	$6,000.00
A-7	Concrete Inlets, Type CG-3	470	8	EA	$2,800.00	$22,400.00
A-8	Removal of Inlets	310	7	EA	$550.00	$3,850.00
A-9	Asphalt/Concrete Saw Cutting	310	2,375	LF	$2.00	$4,750.00
					SCHEDULE "A" SUBTOTAL	$246,000.00

SCHEDULE "6.1B"- SAGINAW AND TRENTON AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
B-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	165	FT	$70.00	$11,550.00
B-2	14 inch Storm Sewer Pipe, 5 ft Depth	445	115	FT	$80.00	$9,200.00
B-3	Concrete Storm Sewer Manholes	470	2	EA	$3,500.00	$7,000.00
B-4	Concrete Manholes, Drywell	470	1	EA	$8,000.00	$8,000.00
B-5	Concrete Manholes, Sedimentation	470	1	EA	$6,000.00	$6,000.00
B-6	Connection to Existing Structure	470	6	EA	$950.00	$5,700.00
B-7	Concrete Inlets, Type CG-3	470	7	EA	$2,800.00	$19,600.00
B-8	Concrete Curbs, Standard Curb	759	445	FT	$10.00	$4,450.00
B-9	Removal of Inlets	310	3	EA	$550.00	$1,650.00
B-10	Asphalt/Concrete Saw Cutting	310	575	LF	$2.00	$1,150.00
					SCHEDULE "B" SUBTOTAL	$75,000.00

SCHEDULE "6.1C"- QUINCY AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
C-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	120	FT	$70.00	$8,400.00
C-2	Concrete Manholes, Drywell	470	3	EA	$8,000.00	$24,000.00
C-3	Concrete Manholes, Sedimentation	470	3	EA	$6,000.00	$18,000.00
C-4	Concrete Inlets, Type CG-3	470	3	EA	$2,800.00	$8,400.00
C-5	Concrete Curbs, Standard Curb	759	260	FT	$10.00	$2,600.00
C-6	Asphalt/Concrete Saw Cutting	310	470	LF	$2.00	$940.00
					SCHEDULE "C" SUBTOTAL	$63,000.00

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 6.1 (continued)

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE "6.1D"- JUNIPER AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
D-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	90	FT	$70.00	$6,300.00
D-2	Concrete Manholes, Drywell	470	3	EA	$8,000.00	$24,000.00
D-3	Concrete Manholes, Sedimentation	470	3	EA	$6,000.00	$18,000.00
D-4	Concrete Inlets, Type CG-3	470	6	EA	$2,800.00	$16,800.00
D-5	Concrete Curbs, Standard Curb	759	945	FT	$10.00	$9,450.00
D-6	Asphalt/Concrete Saw Cutting	310	970	LF	$2.00	$1,940.00
					SCHEDULE "D" SUBTOTAL	$77,000.00

SCHEDULE "6.1E"- IOWA AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
E-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	110	FT	$70.00	$7,700.00
E-2	Concrete Manholes, Drywell	470	3	EA	$8,000.00	$24,000.00
E-3	Concrete Manholes, Sedimentation	470	3	EA	$6,000.00	$18,000.00
E-4	Connection to Existing Structure	470	4	EA	$950.00	$3,800.00
E-5	Concrete Inlets, Type CG-3	470	8	EA	$2,800.00	$22,400.00
E-6	Concrete Curbs, Standard Curb	759	1,035	FT	$10.00	$10,350.00
E-7	Asphalt/Concrete Saw Cutting	310	1,205	LF	$2.00	$2,410.00
					SCHEDULE "E" SUBTOTAL	$89,000.00

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 6.2
SCHEDULE SUMMARY

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE	DESCRIPTION	COST
6.2A	Quincy Avenue to Newport Avenue Improvements	$246,000.00
6.2B	Saginaw/Trenton Avenue Improvements	$75,000.00
6.2C	Quincy Avenue Improvements	$222,000.00
6.2D	Juniper Avenue Improvements	$283,000.00
6.2E	Iowa Avenue Improvements	$243,000.00
	SUBTOTAL ALL SCHEDULES	**$1,069,000.00**
	MOBILIZATION @ 8%	**$85,520.00**
	EROSION CONTROL @ 3%	**$32,070.00**
	CONSTRUCTION SURVEY WORK @ 3%	**$32,070.00**
	TEMPORARY PROTECTION AND DIRECTION OF TRAFFIC @ 3%	**$32,070.00**
	CONSTRUCTION MANAGEMENT @ 5%	**$53,450.00**
	ENGINEERING @ 12%	**$128,280.00**
	CONTINGENCY (35%)	**$374,150.00**
	TOTAL COST	**$1,806,610.00**

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 6.2

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE "6.2A"- QUINCY AVENUE TO NEWPORT AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
A-1	Removal of Pipes	310	650	FT	$30.00	$19,500.00
A-2	12 inch Storm Sewer Pipe, 5 ft Depth	445	180	FT	$70.00	$12,600.00
A-3	21 inch Storm Sewer Pipe, 5 ft Depth	445	1,310	FT	$110.00	$144,100.00
A-4	Concrete Storm Sewer Manholes	470	7	EA	$3,500.00	$24,500.00
A-5	Concrete Manholes, Drywell	470	1	EA	$8,000.00	$8,000.00
A-6	Concrete Manholes, Sedimentation	470	1	EA	$6,000.00	$6,000.00
A-7	Concrete Inlets, Type CG-3	470	8	EA	$2,800.00	$22,400.00
A-8	Removal of Inlets	310	7	EA	$550.00	$3,850.00
A-9	Asphalt/Concrete Saw Cutting	310	2,375	LF	$2.00	$4,750.00
					SCHEDULE "A" SUBTOTAL	$246,000.00

SCHEDULE "6.2B"- SAGINAW AND TRENTON AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
B-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	165	FT	$70.00	$11,550.00
B-2	14 inch Storm Sewer Pipe, 5 ft Depth	445	115	FT	$80.00	$9,200.00
B-3	Concrete Storm Sewer Manholes	470	2	EA	$3,500.00	$7,000.00
B-4	Concrete Manholes, Drywell	470	1	EA	$8,000.00	$8,000.00
B-5	Concrete Manholes, Sedimentation	470	1	EA	$6,000.00	$6,000.00
B-6	Connection to Existing Structure	470	6	EA	$950.00	$5,700.00
B-7	Concrete Inlets, Type CG-3	470	7	EA	$2,800.00	$19,600.00
B-8	Concrete Curbs, Standard Curb	759	445	FT	$10.00	$4,450.00
B-9	Removal of Inlets	310	3	EA	$550.00	$1,650.00
B-10	Asphalt/Concrete Saw Cutting	310	575	LF	$2.00	$1,150.00
					SCHEDULE "B" SUBTOTAL	$75,000.00

SCHEDULE "6.2C"- QUINCY AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
C-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	145	FT	$70.00	$10,150.00
C-2	21 inch Storm Sewer Pipe, 5 ft Depth	445	1,120	FT	$110.00	$123,200.00
C-3	Concrete Storm Sewer Manholes	470	6	EA	$3,500.00	$21,000.00
C-4	Concrete Manholes, Drywell	470	3	EA	$8,000.00	$24,000.00
C-5	Concrete Manholes, Sedimentation	470	3	EA	$6,000.00	$18,000.00
C-6	Concrete Inlets, Type CG-3	470	6	EA	$2,800.00	$16,800.00
C-7	Concrete Curbs, Standard Curb	759	285	FT	$10.00	$2,850.00
C-8	Asphalt/Concrete Saw Cutting	310	2,790	LF	$2.00	$5,580.00
					SCHEDULE "C" SUBTOTAL	$222,000.00

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 6.2 (continued)

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE "6.2D"- JUNIPER AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
D-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	365	FT	$70.00	$25,550.00
D-2	21 inch Storm Sewer Pipe, 5 ft Depth	445	1,085	FT	$110.00	$119,350.00
D-3	Concrete Storm Sewer Manholes	470	11	EA	$3,500.00	$38,500.00
D-4	Concrete Manholes, Drywell	470	3	EA	$8,000.00	$24,000.00
D-5	Concrete Manholes, Sedimentation	470	3	EA	$6,000.00	$18,000.00
D-6	Concrete Inlets, Type CG-3	470	14	EA	$2,800.00	$39,200.00
D-7	Concrete Curbs, Standard Curb	759	1,010	FT	$10.00	$10,100.00
D-8	Asphalt/Concrete Saw Cutting	310	3,900	LF	$2.00	$7,800.00
					SCHEDULE "D" SUBTOTAL	$283,000.00

SCHEDULE "6.2E"- AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
E-1	Removal of Pipes	310	570	FT	$30.00	$17,100.00
E-2	12 inch Storm Sewer Pipe, 5 ft Depth	445	445	FT	$70.00	$31,150.00
E-3	14 inch Storm Sewer Pipe, 5 ft Depth	445	745	FT	$80.00	$59,600.00
E-4	Concrete Storm Sewer Manholes	470	8	EA	$3,500.00	$28,000.00
E-5	Concrete Manholes, Drywell	470	3	EA	$8,000.00	$24,000.00
E-6	Concrete Manholes, Sedimentation	470	3	EA	$6,000.00	$18,000.00
E-7	Connection to Existing Structure	470	1	EA	$950.00	$950.00
E-8	Concrete Inlets, Type CG-3	470	15	EA	$2,800.00	$42,000.00
E-9	Concrete Curbs, Standard Curb	759	1,035	FT	$10.00	$10,350.00
E-10	Removal of Inlets	310	8	EA	$550.00	$4,400.00
E-11	Asphalt/Concrete Saw Cutting	310	3,355	LF	$2.00	$6,710.00
					SCHEDULE "E" SUBTOTAL	$243,000.00

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 7.1
SCHEDULE SUMMARY

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE	DESCRIPTION	COST
7.1A	12th and 9th Street Improvements	$154,000.00
7.1B	Saginaw Avenue Improvements	$30,000.00
7.1C	Roanoke Avenue Improvements	$40,000.00
	SUBTOTAL ALL SCHEDULES	**$224,000.00**
	MOBILIZATION @ 8%	**$17,920.00**
	EROSION CONTROL @ 3%	**$6,720.00**
	CONSTRUCTION SURVEY WORK @ 3%	**$6,720.00**
	TEMPORARY PROTECTION AND DIRECTION OF TRAFFIC @ 3%	**$6,720.00**
	CONSTRUCTION MANAGEMENT @ 5%	**$11,200.00**
	ENGINEERING @ 12%	**$26,880.00**
	CONTINGENCY (35%)	**$78,400.00**
	TOTAL COST	**$378,560.00**

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.

ENGINEERS OPINION OF PROBABLE COST
ALTERNATIVE 7.1

PROJECT :	S. Awbrey Butte Drainage Study	**ESTIMATE CLASS :**	5
HDR JOB # :	10030242	**DATE :**	DRAFT
LOCATION :	Bend, OR	**BY :**	KH
ENR CCI :		**REVIEWED :**	BW

SCHEDULE "7.1A" - 12th AND 9th AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
A-1	Removal of Pipes	310	100	FT	$30.00	$3,000.00
A-2	12 inch Storm Sewer Pipe, 5 ft Depth	445	245	FT	$70.00	$17,150.00
A-3	Concrete Manholes, Drywell	470	7	EA	$8,000.00	$56,000.00
A-4	Concrete Manholes, Sedimentation	470	7	EA	$6,000.00	$42,000.00
A-5	Connection to Existing Structure	470	4	EA	$950.00	$3,800.00
A-6	Concrete Inlets, Type CG-3	470	10	EA	$2,800.00	$28,000.00
A-7	Removal of Inlets	310	4	EA	$550.00	$2,200.00
A-8	Asphalt/Concrete Saw Cutting	310	485	LF	$2.00	$970.00
					SCHEDULE "A" SUBTOTAL	$154,000.00

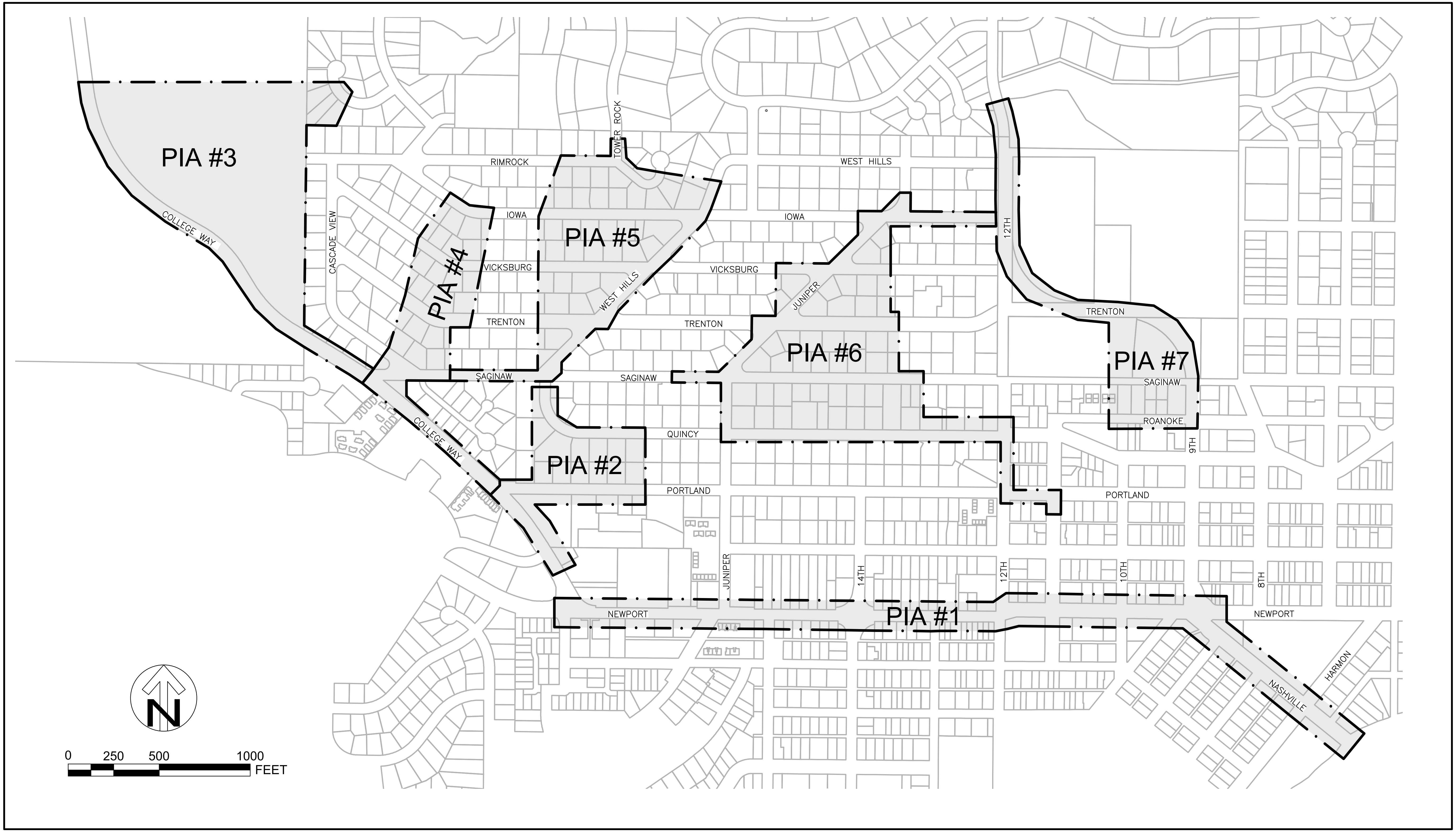
SCHEDULE "7.1B" - SAGINAW AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
B-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	140	FT	$70.00	$9,800.00
B-2	Concrete Manholes, Drywell	470	1	EA	$8,000.00	$8,000.00
B-3	Concrete Manholes, Sedimentation	470	1	EA	$6,000.00	$6,000.00
B-4	Concrete Inlets, Type CG-3	470	2	EA	$2,800.00	$5,600.00
B-5	Asphalt/Concrete Saw Cutting	310	280	LF	$2.00	$560.00
					SCHEDULE "B" SUBTOTAL	$30,000.00

SCHEDULE "7.1C" - ROANOKE AVENUE IMPROVEMENTS

NO.	DESCRIPTION	SECTION	QTY	UNIT	UNIT PRICE	COST
C-1	12 inch Storm Sewer Pipe, 5 ft Depth	445	145	FT	$70.00	$10,150.00
C-2	Concrete Storm Sewer Manholes	470	1	EA	$3,500.00	$3,500.00
C-3	Concrete Manholes, Drywell	470	1	EA	$8,000.00	$8,000.00
C-4	Concrete Manholes, Sedimentation	470	1	EA	$6,000.00	$6,000.00
C-5	Concrete Inlets, Type CG-3	470	4	EA	$2,800.00	$11,200.00
C-6	Asphalt/Concrete Saw Cutting	310	290	LF	$2.00	$580.00
					SCHEDULE "C" SUBTOTAL	$40,000.00

This estimate of probable cost reflects our professional opinion of accurate costs at this time based on current conditions at the project location. This estimate is subject to change through the project planning and design process. Actual construction cost will depend on the cost of labor, materials, equipment, and services provided by others, contractor's methods of determining prices, competitive bidding and market conditions.



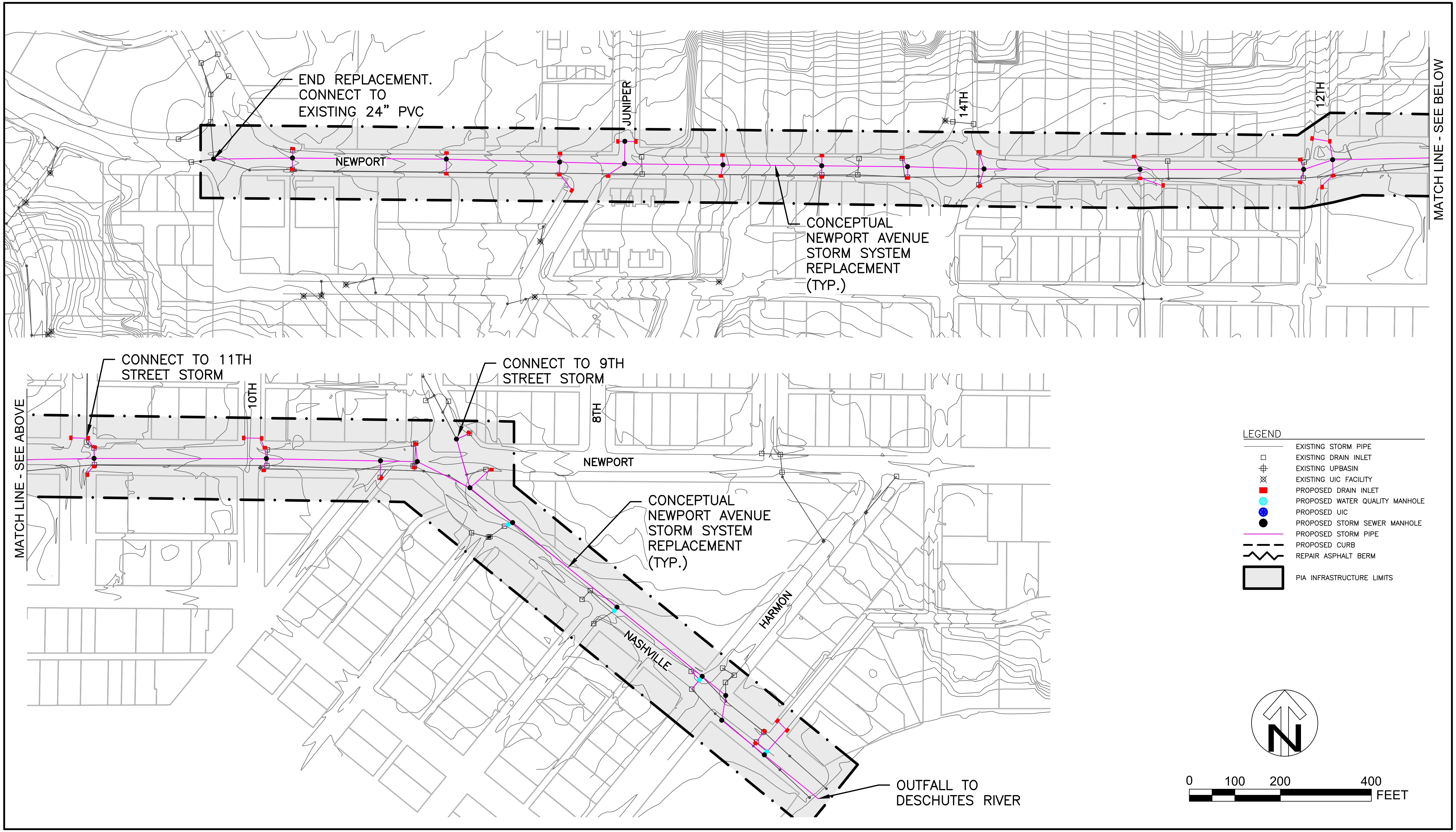
HDR

SOUTH AWBREY BUTTE DRAINAGE STUDY
ALTERNATIVE ANALYSIS

PIA KEYMAP

DATE
5/15/2017

FIGURE
KEYMAP



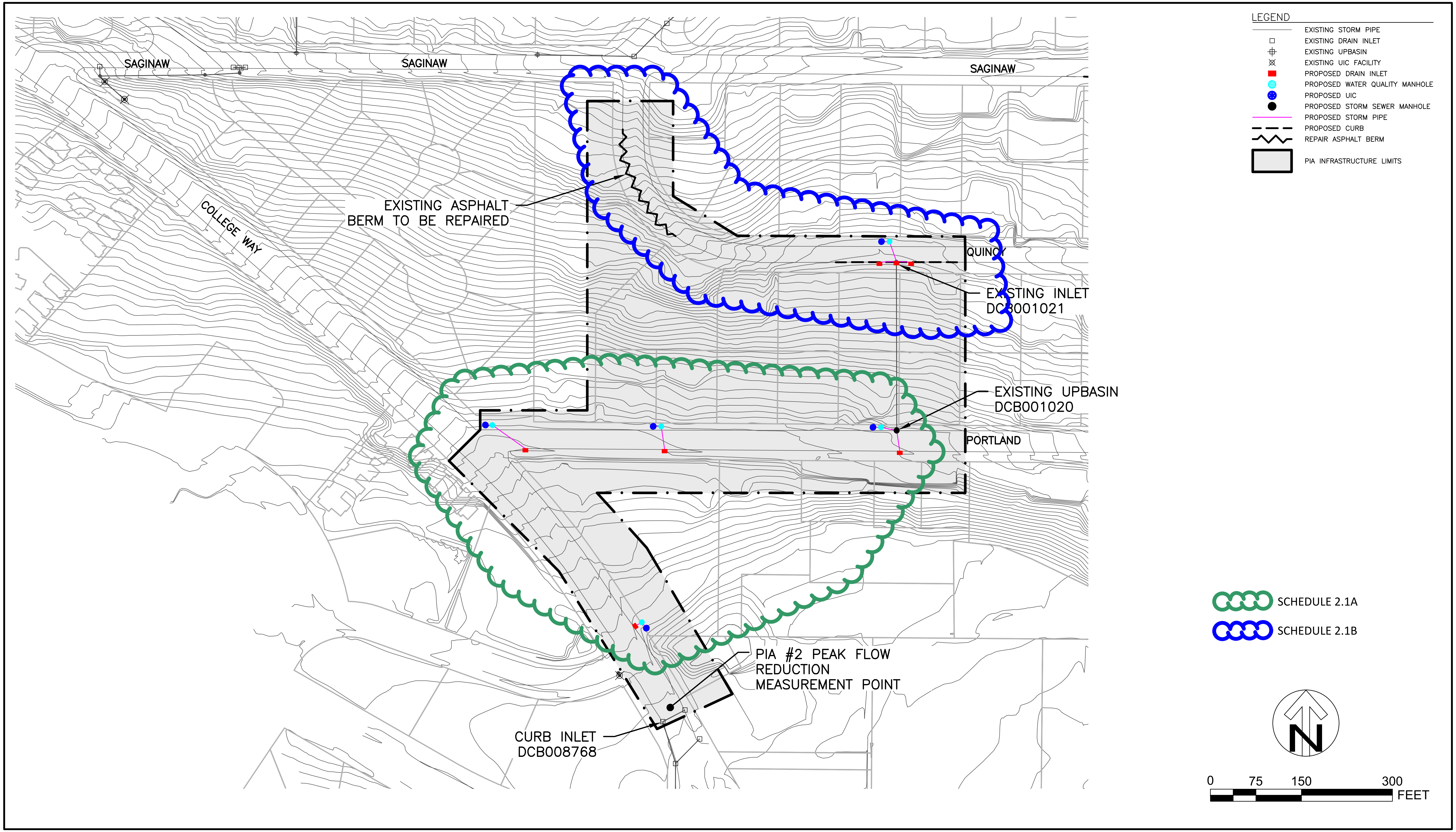
HDR

SOUTH AWBREY BUTTE DRAINAGE STUDY
ALTERNATIVE ANALYSIS

CONCEPTUAL NEWPORT AVENUE REPLACEMENT SYSTEM

DATE
5/15/2017

FIGURE
1.1

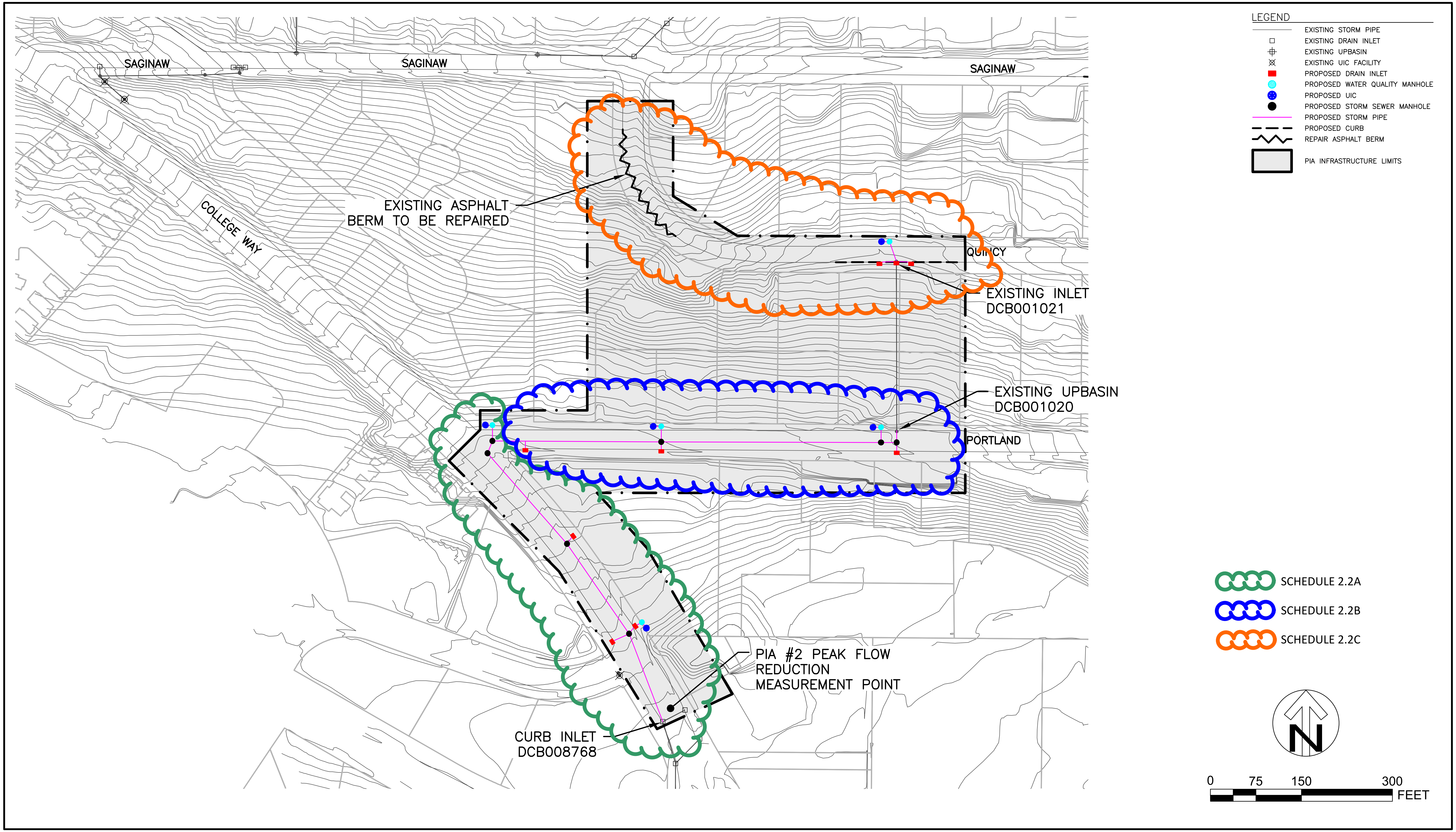


SOUTH AWBREY BUTTE DRAINAGE STUDY
ALTERNATIVE ANALYSIS

PIA #2- ALTERNATIVE 2.1

DATE
5/15/2017

FIGURE
2.1



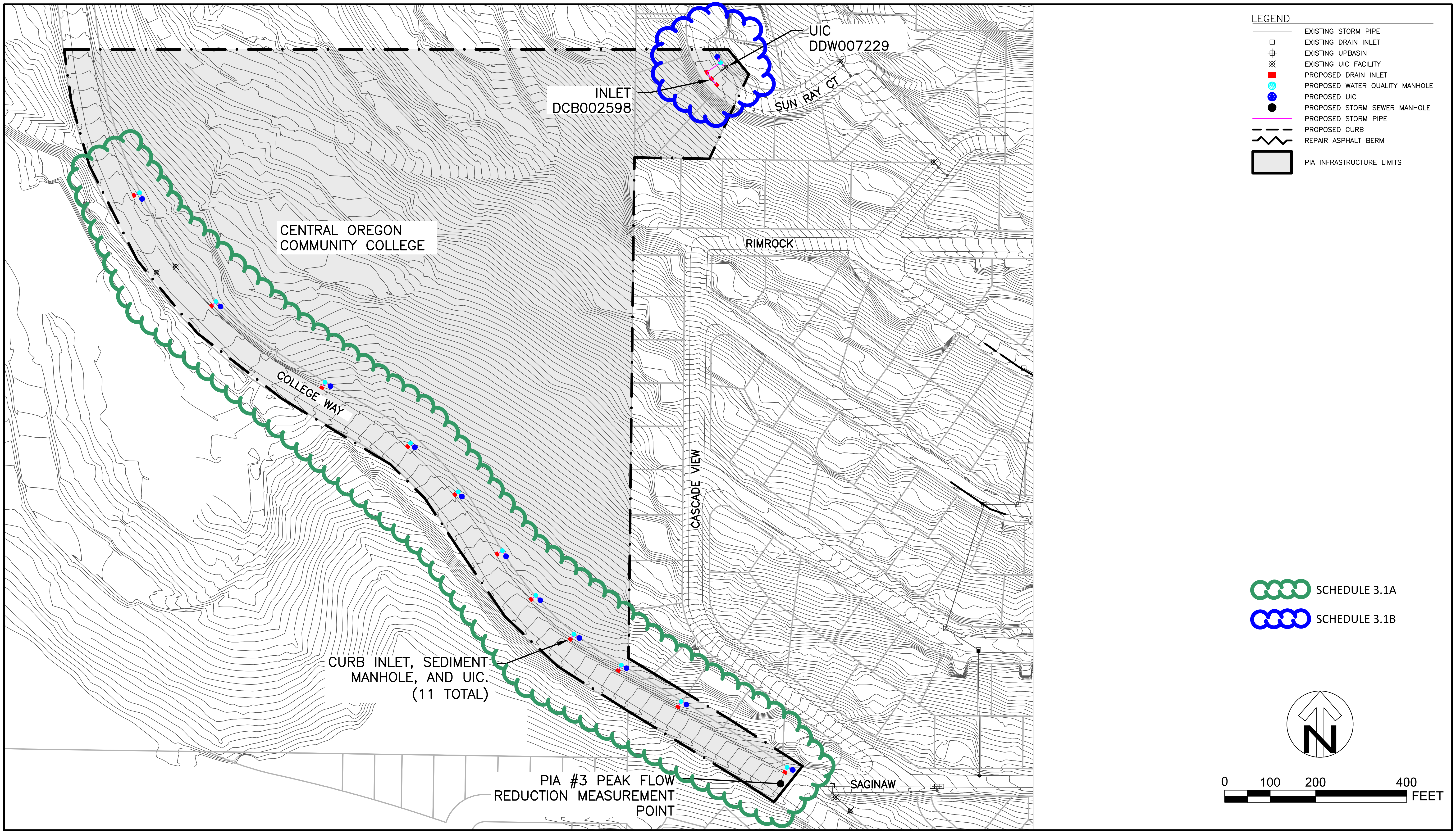
HDR

SOUTH AWBREY BUTTE DRAINAGE STUDY
ALTERNATIVE ANALYSIS

PIA #2- ALTERNATIVE 2.2

DATE
5/15/2017

FIGURE
2.2

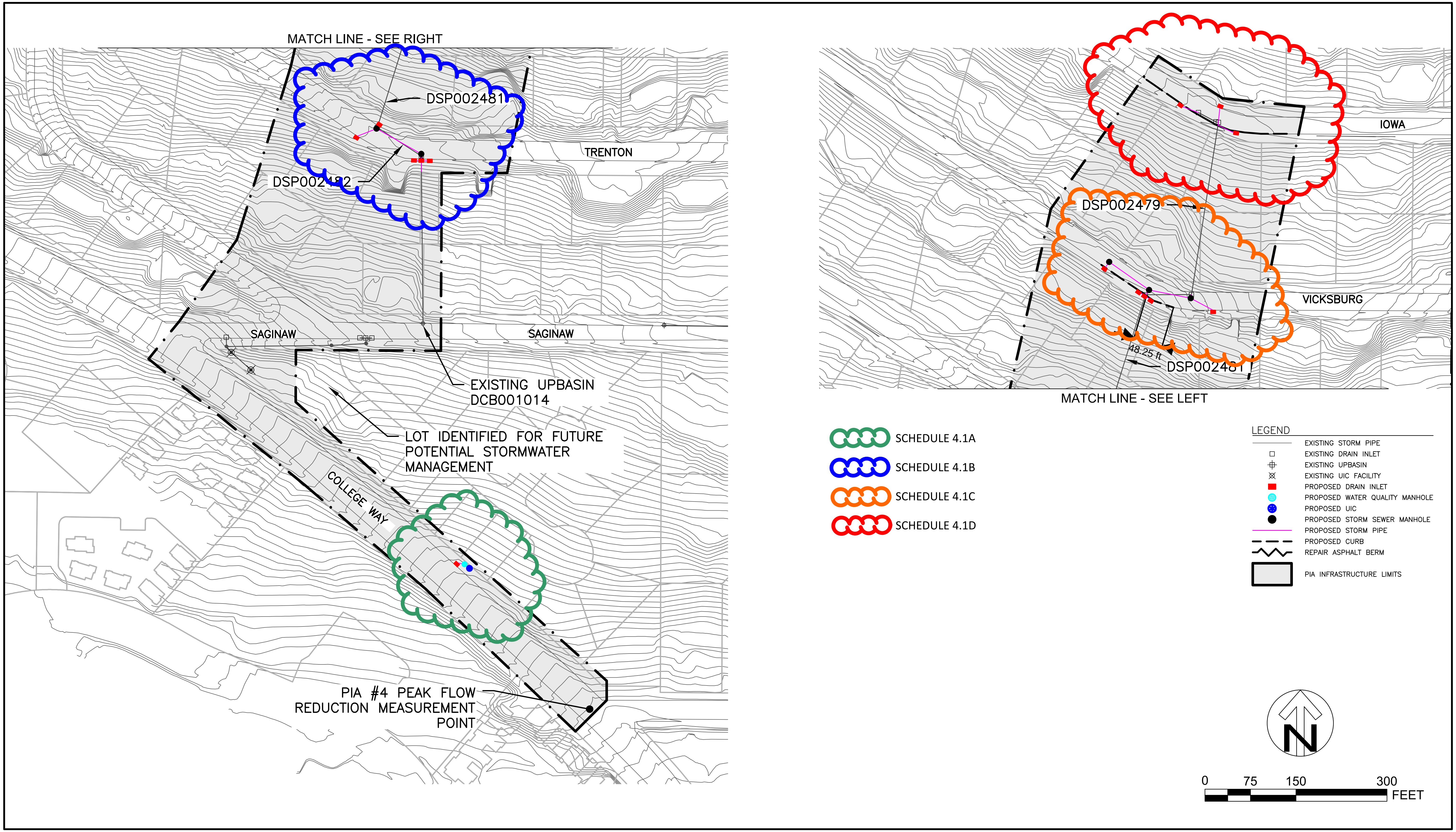


SOUTH AWBREY BUTTE DRAINAGE STUDY
ALTERNATIVE ANALYSIS

PIA #3- ALTERNATIVE 3.1

DATE
5/15/2017

FIGURE
3.1



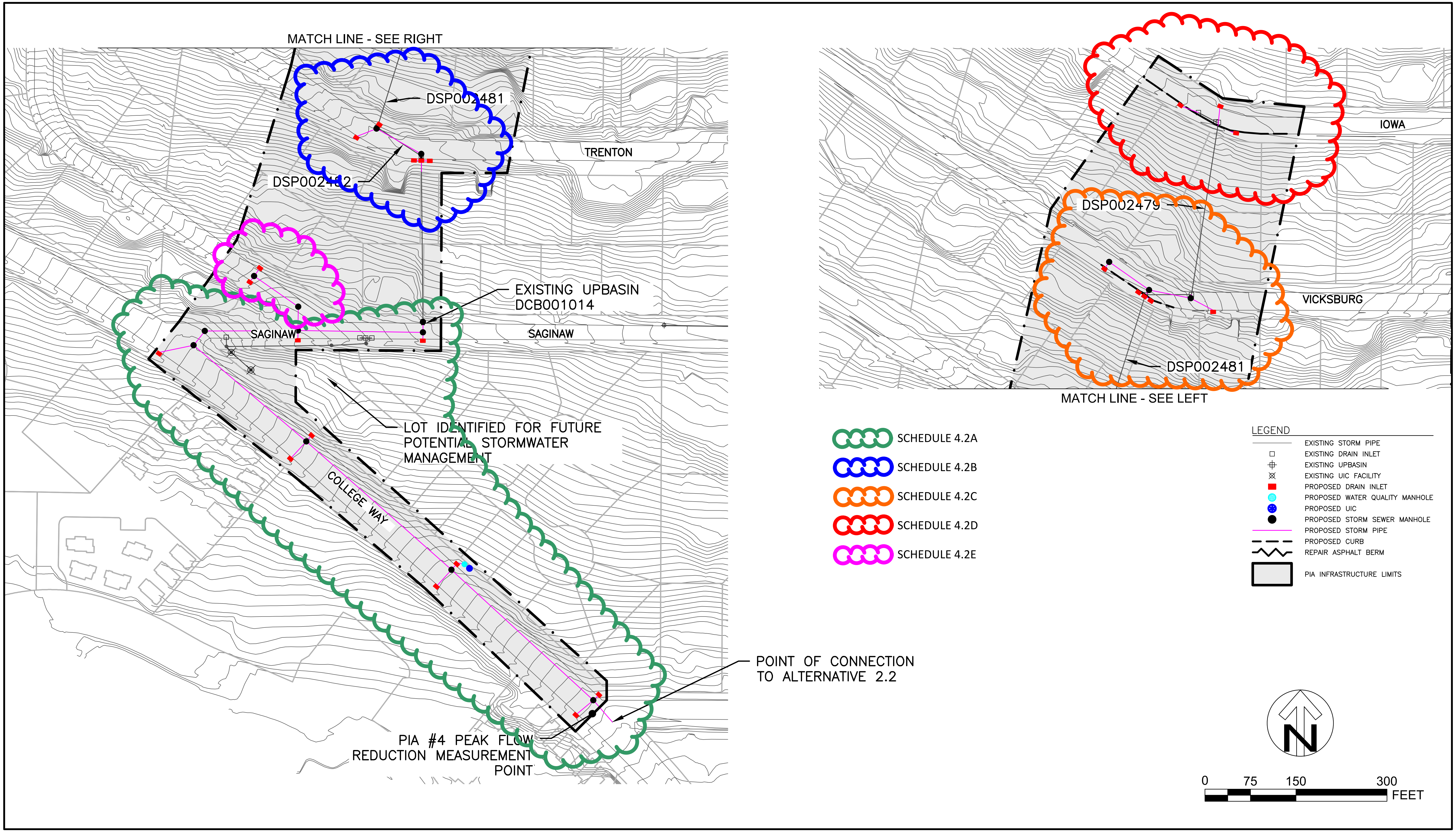
HDR

SOUTH AWBREY BUTTE DRAINAGE STUDY
ALTERNATIVE ANALYSIS

PIA #4- ALTERNATIVE 4.1

DATE
5/15/2017

FIGURE
4.1



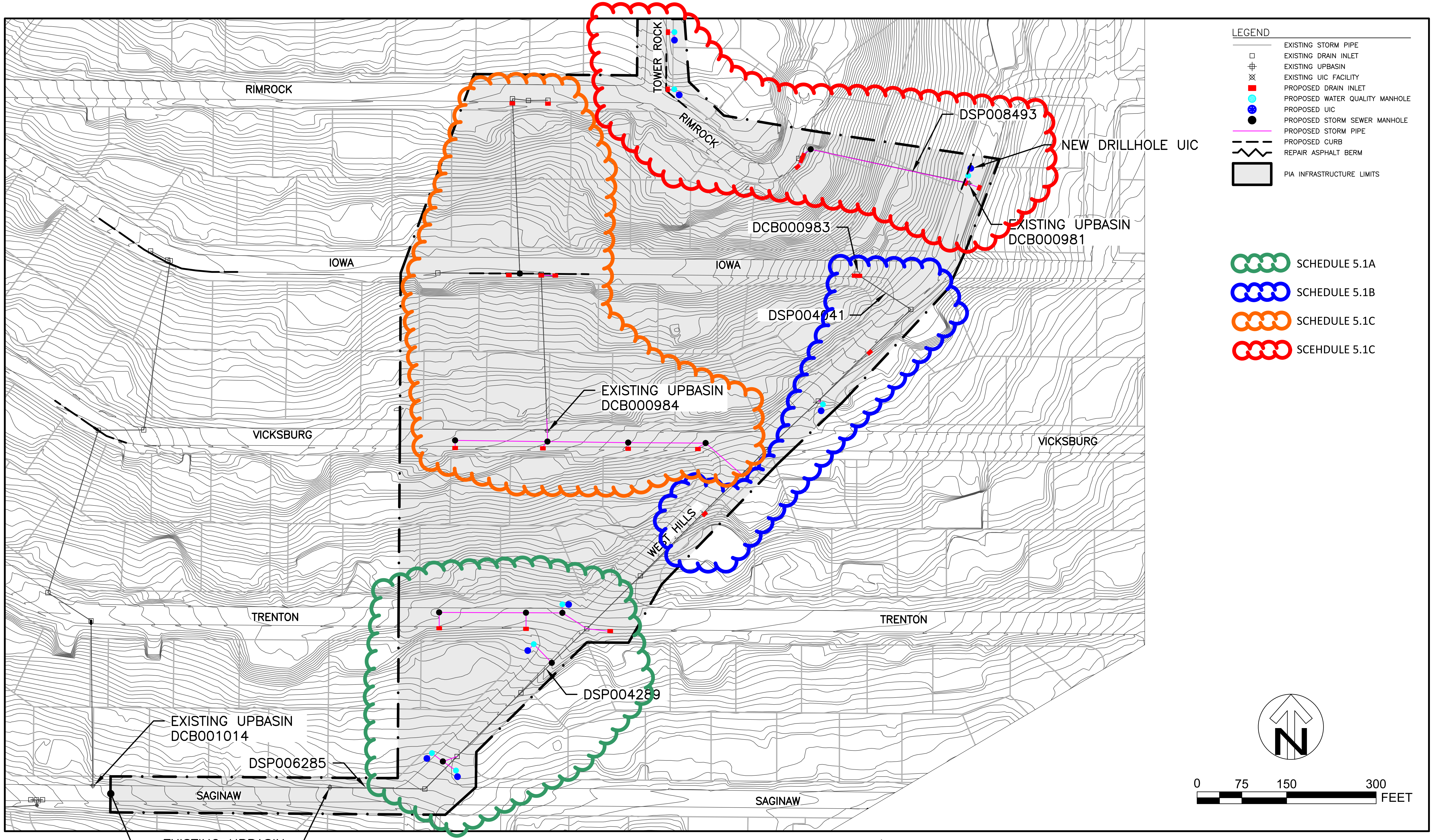
HDR

SOUTH AWBREY BUTTE DRAINAGE STUDY
ALTERNATIVE ANALYSIS

PIA #4- ALTERNATIVE 4.2

DATE
5/15/2017

FIGURE
4.2

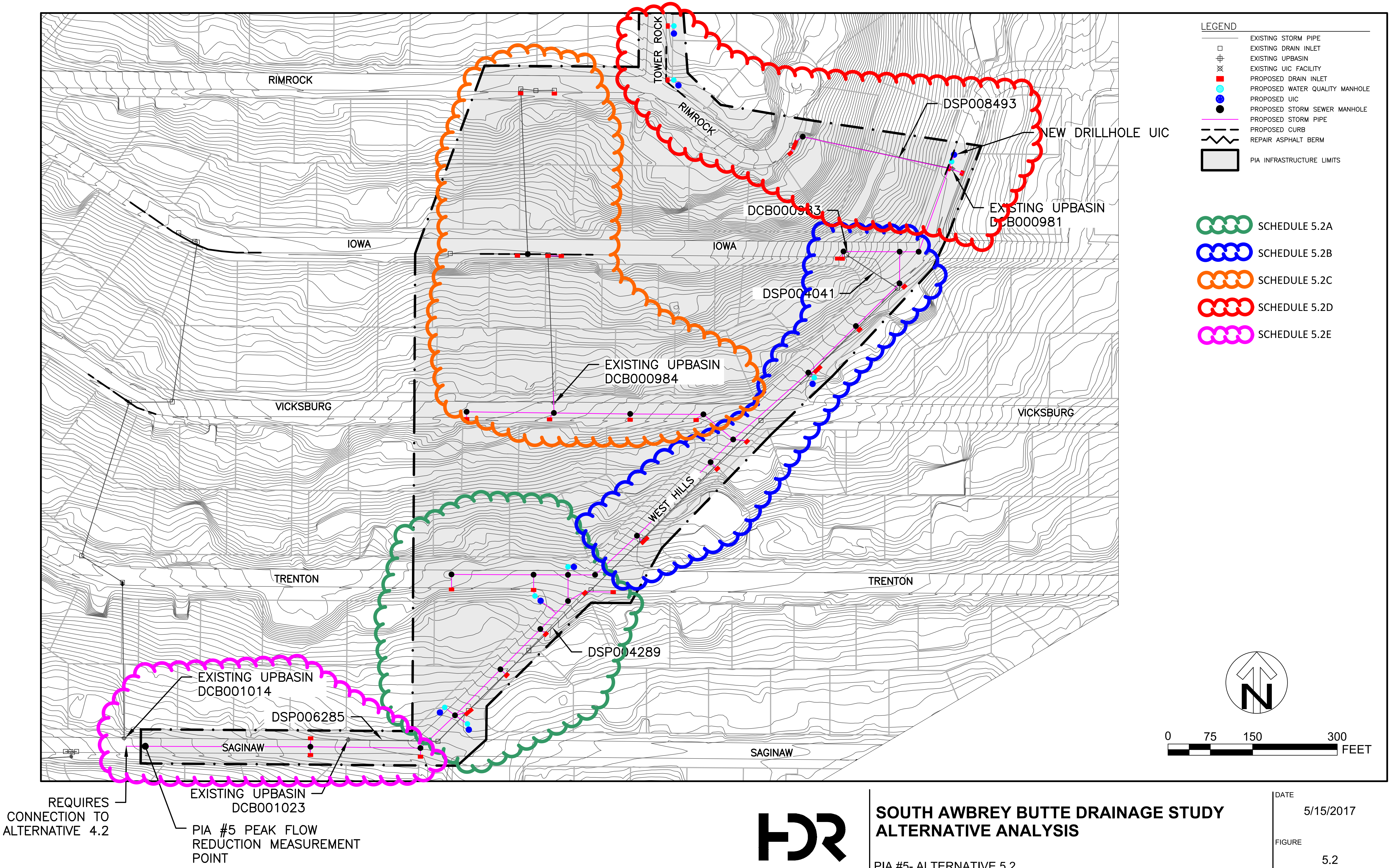


SOUTH AWBREY BUTTE DRAINAGE STUDY
ALTERNATIVE ANALYSIS

PIA #5- ALTERNATIVE 5.1

DATE
5/15/2017

FIGURE
5.1



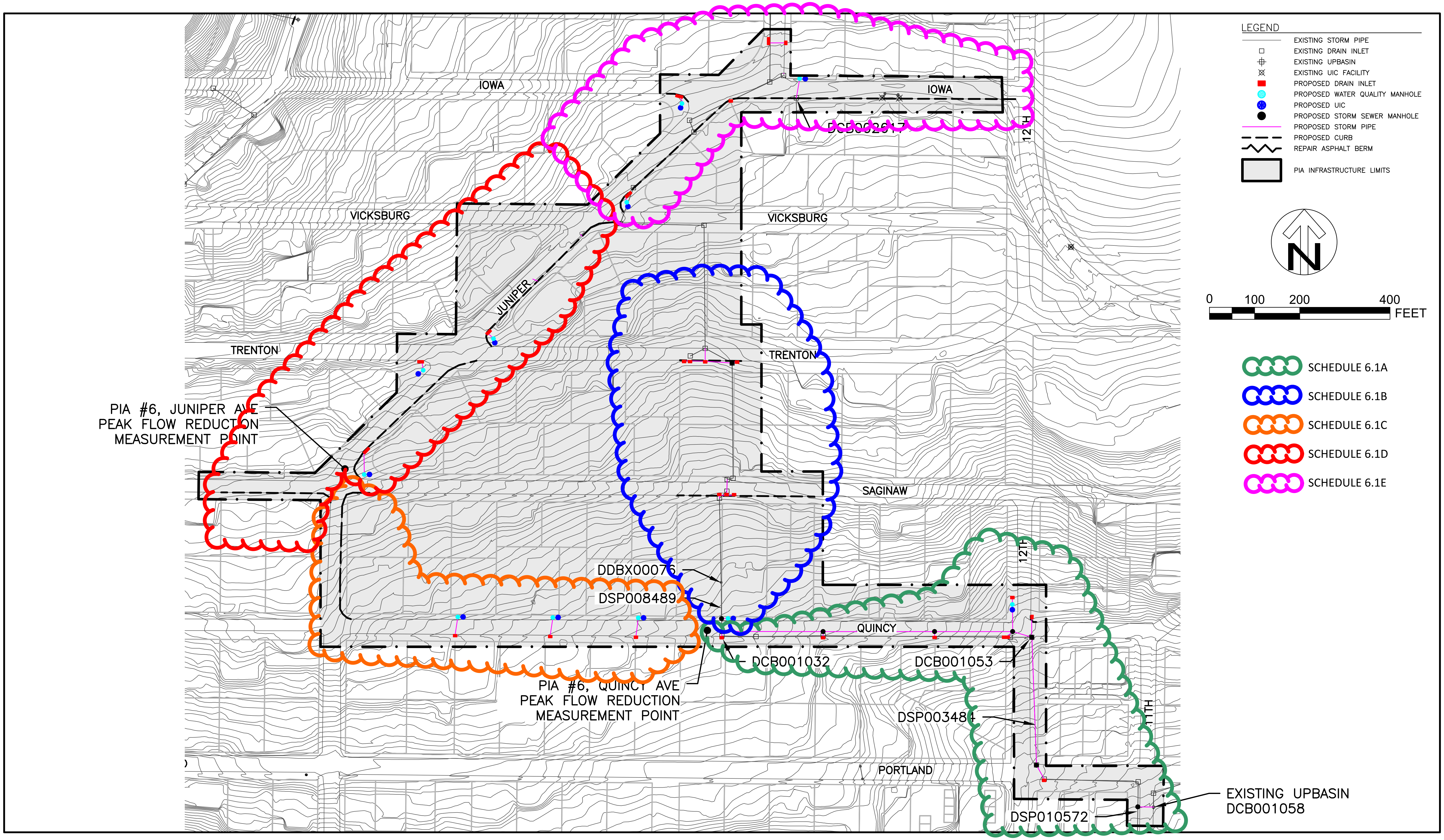
HDR

SOUTH AWBREY BUTTE DRAINAGE STUDY
ALTERNATIVE ANALYSIS

PIA #5- ALTERNATIVE 5.2

DATE
5/15/2017

FIGURE
5.2



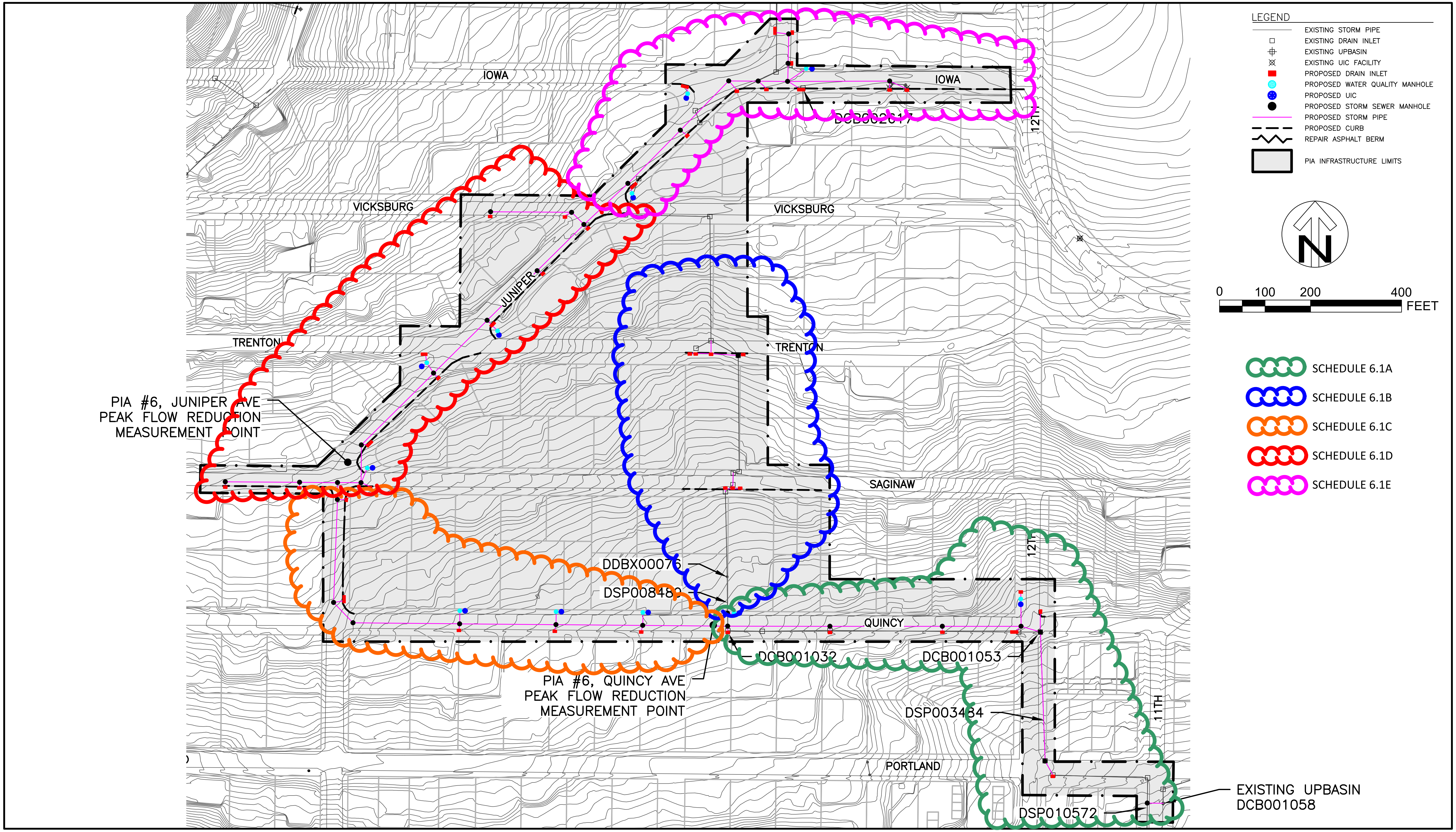
HDR

SOUTH AWBREY BUTTE DRAINAGE STUDY
ALTERNATIVE ANALYSIS

PIA #6- ALTERNATIVE 6.1

DATE
5/15/2017

FIGURE
6.1



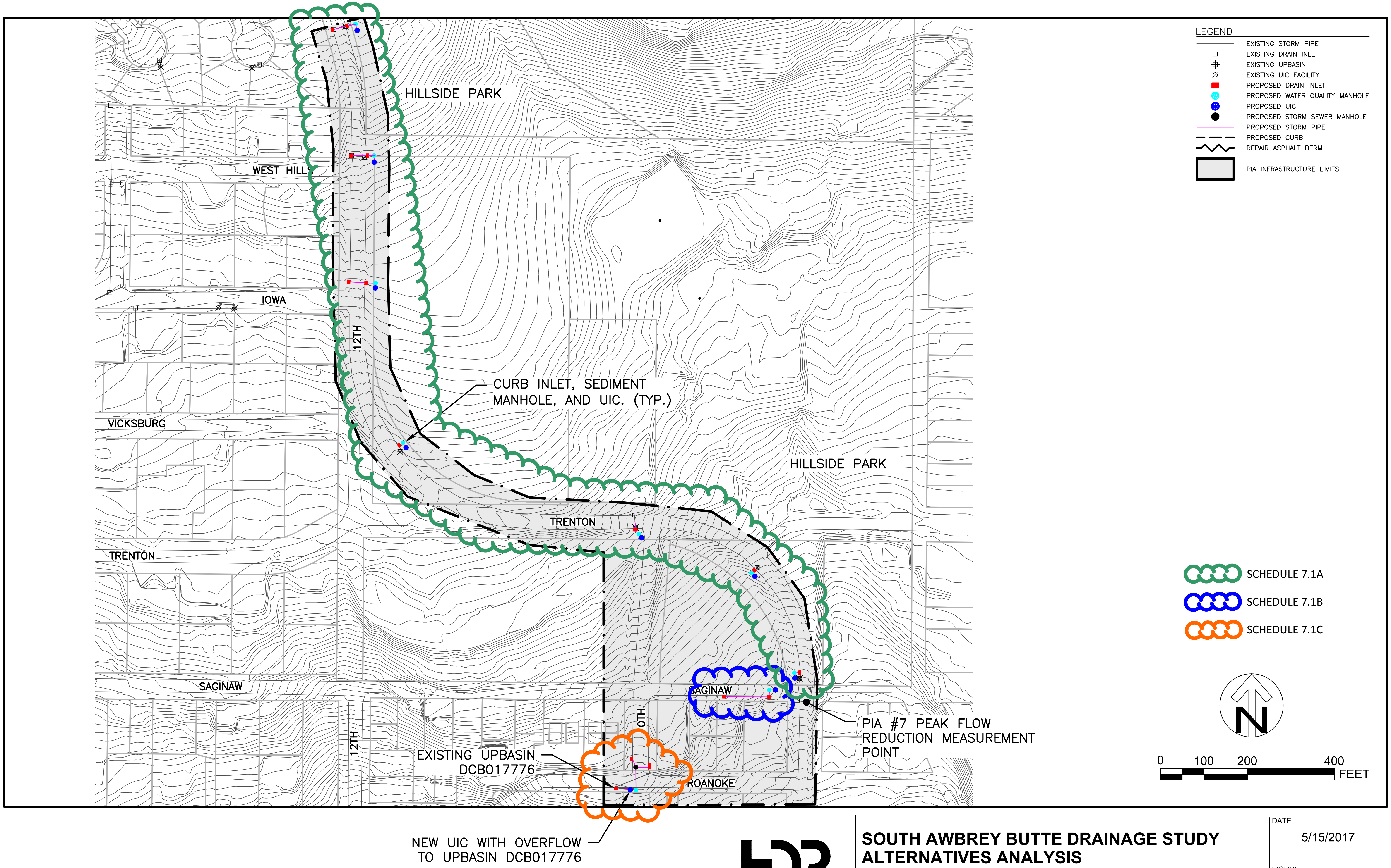
HDR

SOUTH AWBREY BUTTE DRAINAGE STUDY
ALTERNATIVE ANALYSIS

PIA #6- ALTERNATIVE 6.2

DATE
5/15/2017

FIGURE
6.2



SOUTH AWBREY BUTTE DRAINAGE STUDY
ALTERNATIVES ANALYSIS

PIA #7- ALTERNATIVE 7.1

DATE
5/15/2017

FIGURE
7.1

CITY OF BEND MIDTOWN STORMWATER IMPROVEMENTS

Midtown Multimodal Crossings and Streetscape

1GHAO

Prepared for:

City of Bend
710 NW Wall Street
Bend, Oregon 97703

DECEMBER 2024

Prepared by:

DOWL

DOWL, LLC
963 SW Simpson Ave
Bend, OR 97702

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

EXECUTIVE SUMMARY

This report outlines strategies to mitigate flooding at the undercrossings of Franklin Avenue and Greenwood Avenue with Burlington Northern Santa-Fe Rail (BNSF) and US Highway 97. The study covers existing conditions, basin delineation, upstream basin improvements, and various flood management options. Key findings and recommendations are provided and include options ranging from the installation of alternative stormwater management such as deep drywells, more traditional management such as the use of current City standard drywells, and more complex systems to pump water away from low points and discharge it to other locations such as the river, drywells, or existing regional stormwater facilities.

Implementing strategies, which may include individually or some combination of deep drywells, pumping, and upstream basin improvements, will improve flood resilience at the Franklin Avenue and Greenwood Avenue undercrossings. Selecting an option that meets City requirements will involve balancing risk, cost-benefit analysis, the selected alternative’s future resilience, stakeholder engagement, environmental impacts, operational efficiency, public health and safety, and regulatory compliance.

1.0 INTRODUCTION

The purpose of this report is to present the hydrological analysis performed for the Midtown Crossings (1GHAO) Project (project), and provide conveyance, treatment, and disposal recommendations for long-term solutions to the current drainage issues at the NE Franklin Avenue (Franklin) and NE Greenwood Avenue (Greenwood) undercrossings. These analyses and recommendations aim to reduce or eliminate the frequency and severity of flood events while minimizing impacts to existing infrastructure. See Appendix 1 for class V cost estimates – the overall budget is presented with each option.

The Greenwood and Franklin undercrossings are located at the grade separation of each avenue with the BNSF Railway and US Highway 97, providing critical east-west movement in the City of Bend (City). Due to the grade separated crossings being lowered to go under the rail, a low point is created at each crossing. Historical flooding at these locations has caused mobility issues due to road closures, damage to property, and interrupted emergency response routes during heavy rain and snow melt events. The current City response to flooding is to use trailer mounted pumps to move water out of the undercrossings.

These areas of Bend have seen development in the past few years and consist of a portion of downtown including the Deschutes County Courthouse, office spaces, restaurants and bars, and several historic buildings. Greenwood is an arterial street from Bond Street through 27th Street and serves as a major connection for motorists, cyclists, and pedestrians as part of the corridor from the town of Tumalo to the northwest of Bend and to the eastern Bend City limits as Highway 20. Franklin Avenue is an arterial street, connecting east and west Bend from Skyliners Road to Bear Creek Road. Greenwood turns into Highway 20 at 3rd Street where the Oregon Department of Transportation takes ownership. Greenwood and Franklin Avenues are critical connections for Bend Fire and EMS. Interruptions to these crossings cause major issues for motorists. Temporary closures at the Greenwood undercrossing can have disproportionally negative effects on larger trucks which may not be able to cross at Franklin.

As discussed above, this report summarizes the existing conditions, documents the field investigations, identifies stormwater improvement alternatives to minimize flooding events, provides cost estimates for the alternatives, summarizes operation and maintenance, and provides recommendations for the preferred solution.

The Franklin Avenue stormwater improvements proposed in this report are planned to occur with current Midtown Crossings progressive design build project. Design of this segment is underway with construction planned in 2025.

The preferred Greenwood improvements identified in this report will be constructed as part of upcoming projects, both through City funding and private development. The study area encompasses portions of the Bend Core Area – an area planned for future multi use and high-density housing consisting of low to no setback development, narrow rights-of-way, and little opportunity for the installation of storm infrastructure. These constraints may pose challenges for developers and require out-of-the-box thinking for how storm water is disposed of within this area. Stormwater improvements identified in this area should be considered during future development.

2.0 EXISTING CONDITIONS

2.1 General Conditions and Considerations

2.1.1 Existing Soil Conditions

The online soil mapping tool was available from the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) as Web Soil Survey (WSS) to identify the soil types within the project. An area of interest (AOI) was created using this online mapping tool and follows roughly the delineation of the two combined basins. The generated report (see Appendix 2) has identified two soil types within the AOI. The first is Wanoga sandy loam, 0 to 15 percent slopes which accounts for 75% of the total area. The second is Wanoga-Fremkle-Rock outcrop complex, 0 to 15 percent slopes which accounts for 25% of the area. Table 1 summarizes the soil report data.

Table 1. Summary of Web Soil Survey Report.

Soil Type	Transmissivity (inches/hour)	Depth to Bedrock (inches)	Hydrologic Soil Group
Wanoga sandy loam	1.98-5.95	25-35 (weathered) 35-45 (unweathered)	B
Wanoga-Fremkle-Rock outcrop complex	1.98-5.95	25-35 (weathered) 35-45 (unweathered)	B

2.1.2 Existing Basins Development

The analysis area of this project starts at each undercrossing at Franklin Avenue and Greenwood Avenue, resulting in two existing drainage basins, see sections 2.1.4 and 2.1.5. A LiDAR ground surface was used to analyze and develop the Greenwood and Franklin Basins. These were then reviewed against the City of Bend GIS data for verification and consistency. Each existing drainage basin, Greenwood Basin and Franklin Basin, is defined by grades and features at the upper reaches that would prohibit flows from entering the basins. These overall basins ignored existing collection and disposal systems for the initial basin analysis to evaluate potential flows. These systems were added to each basin through refinement of the subbasin areas.

The overall Franklin and Greenwood Basins are characterized by large catchment areas east and west of the roadway low points, made up primarily of developed, to varying degrees, commercial properties and City rights of way.

2.1.3 Existing Stormwater Facilities

The existing public stormwater systems in these basins are primarily made up of catch basins that either have drillhole underground injection control (UICs) in them or are piped to UICs for disposal. These are historic systems that have been in place and maintained to varying degrees throughout the years.

The Oregon Department of Transportation recently completed improvements to 3rd Street, from Greenwood Avenue to the north, including stormwater upgrades. These systems utilize catch basins with sedimentation treatment and drywell disposal.

Private property drainage patterns and existing drainage systems vary throughout the basins. DOWL conducted a desktop survey of aerial imaging to identify onsite systems, as well as field visits to review existing drainage patterns. The effectiveness of the systems were not tested. It is assumed that if a storm drain system exists on private property it is being maintained and is effectively functioning to prevent the movement of private stormwater into the public right-of-way.

Performance testing was completed on a sampling of the existing stormwater infrastructure. There are areas of paving in poor condition, resulting in bypass flows which can contribute to the ultimate low points at Franklin and Greenwood.

Drywells and drillholes are considered UIC facilities and are regulated by the Oregon Department of Environmental Quality (DEQ), their associated rules, and the City's Water Pollution Control Facilities (WPCF) permit. The City has two stormwater permits; the WPCF which allows for and permits the disposal of stormwater by recirculation, evaporation, and/or controlled seepage with no discharge to surface waters and a Municipal Separate Storm Sewer System (MS4) permit which allows for stormwater discharge to waters of the state. The City generally no longer allows the construction of drillholes in the right-of-way, and typically requires the closure of these facilities (in cooperation with both the DEQ and City closure requirements) with projects that impact them.

If flood conditions can reach the existing sewer manhole east of the undercrossing (±18" flood depth) it may cause sudden large inflows into the sewer system by way of a manhole located on the west side of the undercrossing at Greenwood which creates unexpected load on the wastewater treatment facility, reducing treatment capacity and adding expense to City operations.

2.1.4 Franklin Avenue Basin

The Franklin Avenue Basin is bounded roughly by NW Hill Street to the west, 3rd Street to the east, a small portion of 1st Street to roughly NE Greely Avenue to the north, and a larger swath south to NE Dekalb Avenue. The existing overall drainage basin's potential to contribute to the undercrossing is approximately 18.6 acres, primarily made up of developed commercial property.

City development standards require the inclusion of the full right of way width plus an additional 20 feet into private lots. Per City standards this additional 20 feet may only be reduced if topography would prevent the movement of stormwater from private lots back into the right of way. As noted above, DOWL did a high-level review of existing properties and utilized the right of way plus 20 feet of private property to develop these basins, unless an obvious, large drainage pattern was found to be flowing, uncontrolled into right of way. If this was found, the estimated private property drainage pattern was included in the basin. The total area, when considering right of way plus 20 feet, with potential to drain to the underpass is calculated to be ±10.21 acres. This area is illustrated as basins F1-F7 in Figure 1 below.

DOWL further analyzed the overall basin to account for existing facilities to determine the existing pattern to the undercrossing, developing contributing and non-contributing areas within the overall basin. These areas were developed considering locations of existing stormwater facilities, localize low points, and existing flow patterns. A final contribution basin was delineated based on this information. The contribution area is calculated to be ±2.03 acres. See Figure 1 for the delineated contribution area.

A new development (Project Platform, PRINF#202306851) is planned at the old Les Schwab building (105 NE Franklin Avenue). This project will improve the existing storm system on NE 1st Street south of Franklin. Figure 2 below shows the delineated Franklin basin, existing storm facilities, and proposed storm facility locations. The basin delineation accounts for the proposed stormwater improvements with Project Platform.

Current City development code requires privately owned property to retain all drainage on site, however many of the properties adjacent to the study area were developed decades ago and have no, to limited infrastructure to retain their stormwater discharges.

The Franklin Avenue Undercrossing project is identified in the 2014 Stormwater Master Plan (SMP) as Project 8, priority number 2. The solution proposed in the SWMP is to pump to the Deschutes River.

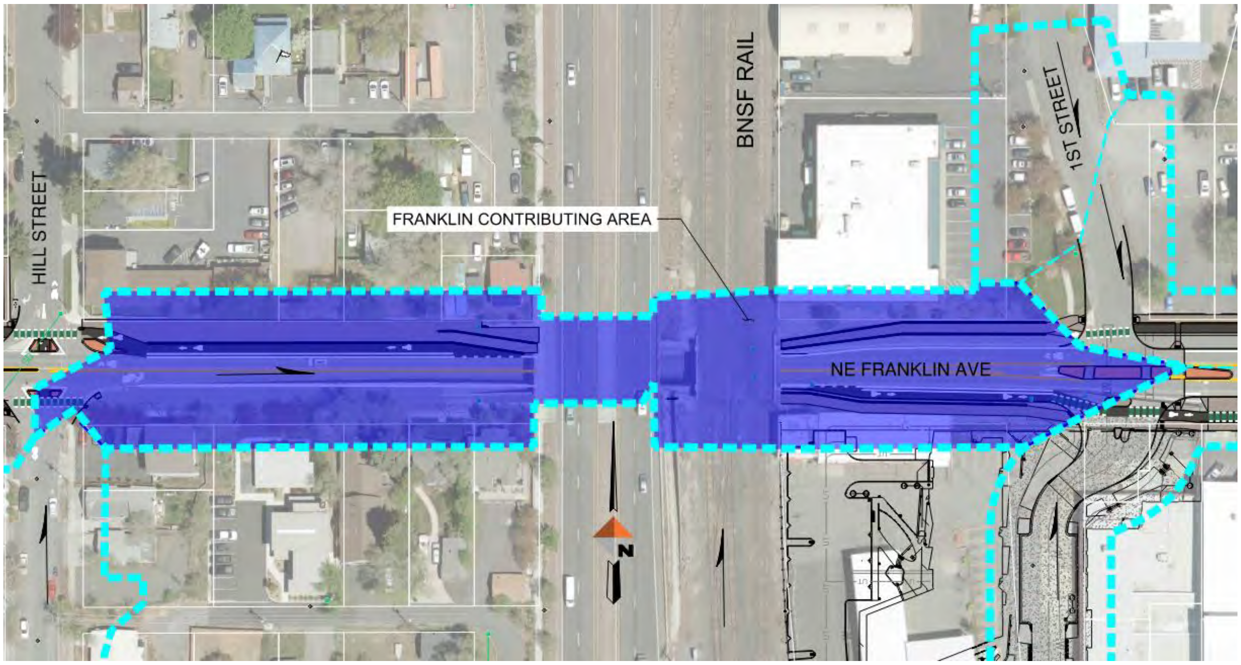
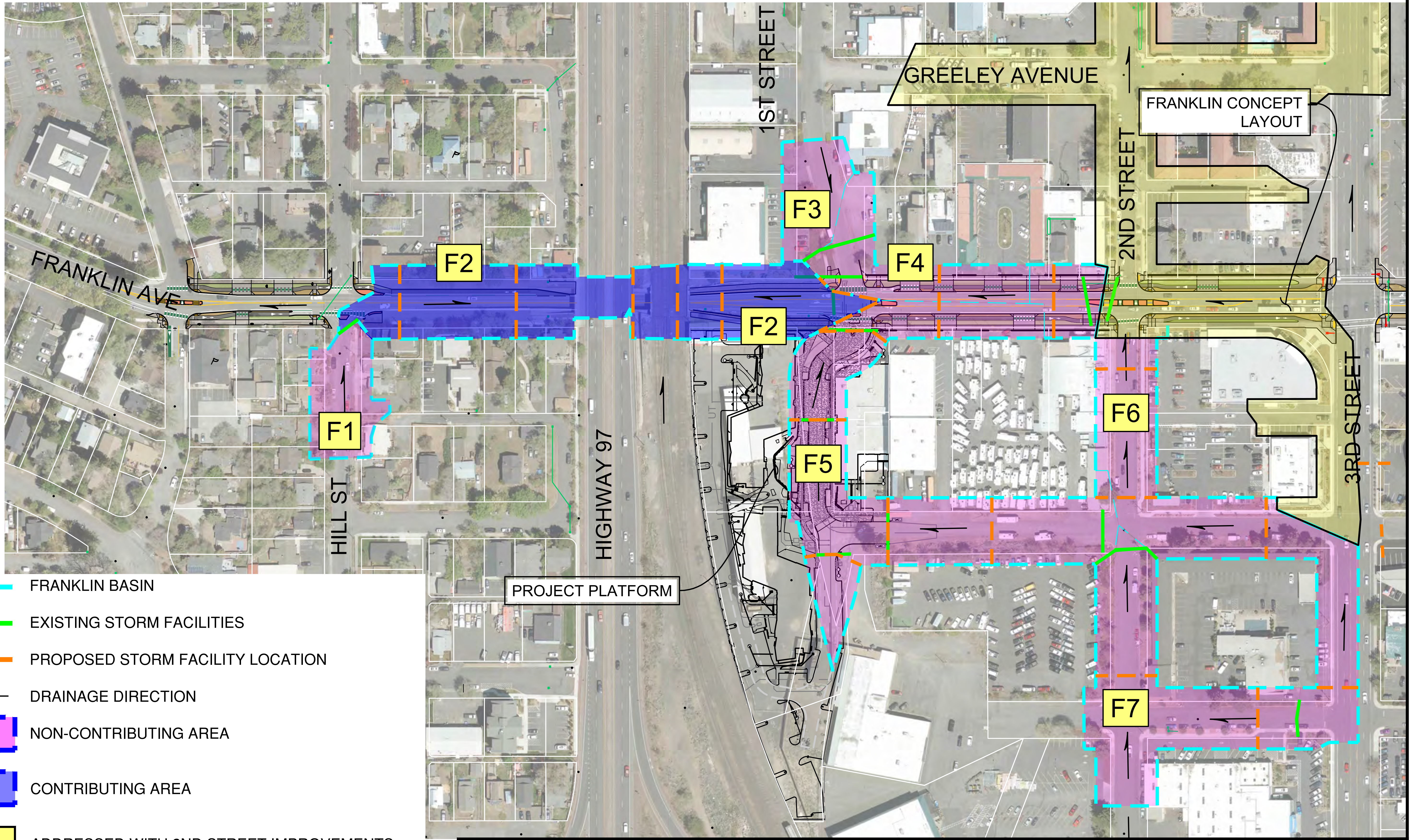


Figure 1. Franklin contribution area.



- - - FRANKLIN BASIN
- - - EXISTING STORM FACILITIES
- - - PROPOSED STORM FACILITY LOCATION
↼ DRAINAGE DIRECTION
🟪 NON-CONTRIBUTING AREA
🟦 CONTRIBUTING AREA
🟨 ADDRESSED WITH 2ND STREET IMPROVEMENTS
F# BASIN IDENTIFIER

DOWL
WWW.DOWL.COM
963 SW Simpson Avenue, #200
Bend, Oregon 97702
541-385-4772

FIGURE 2

PROJECT	1GHAO
DATE	10/18/2024

FRANKLIN BASINS

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2.1.5 Greenwood Avenue Basin

The Greenwood Avenue Basin catchment encompasses an area of ±88.0 acres bounded roughly by Bond Street to the west, 5th Street to the east, Kearney Avenue to the north, and Franklin Avenue to the south.

As noted above, DOWL did a high-level review of existing properties and utilized the right of way plus 20 feet of private property to develop these basins, unless an obvious, large drainage pattern was found to be flowing, uncontrolled into right of way. If this was found, the estimated private property drainage pattern was included in the basin. The total area, when considering right of way plus 20 feet, with potential to drain to the underpass is calculated to be ±47.1 acres.

The existing basin has an extensive system of stormwater facilities ranging from drywells and swales to drillholes. However, examination of the existing basins and facilities shows there are large portions of the basin which may contribute directly to the low point with little to no potential for capture. This may be due to the condition of existing asphalt or placement of existing catch basins and other storm infrastructure. Figure 3 shows the detailed contribution area. Figure 4 shows the delineated Greenwood basin and existing storm facilities. The basin is further reduced by considering low points and existing or proposed storm facilities to develop contributing and non-contributing areas. These locations, low points, and flow patterns were then analyzed to create an expectation of the current capture of stormwater provided by each basin's respective storm facilities. A final contribution basin was then delineated based on this information. The total contribution area is calculated to be ±8.25 acres.

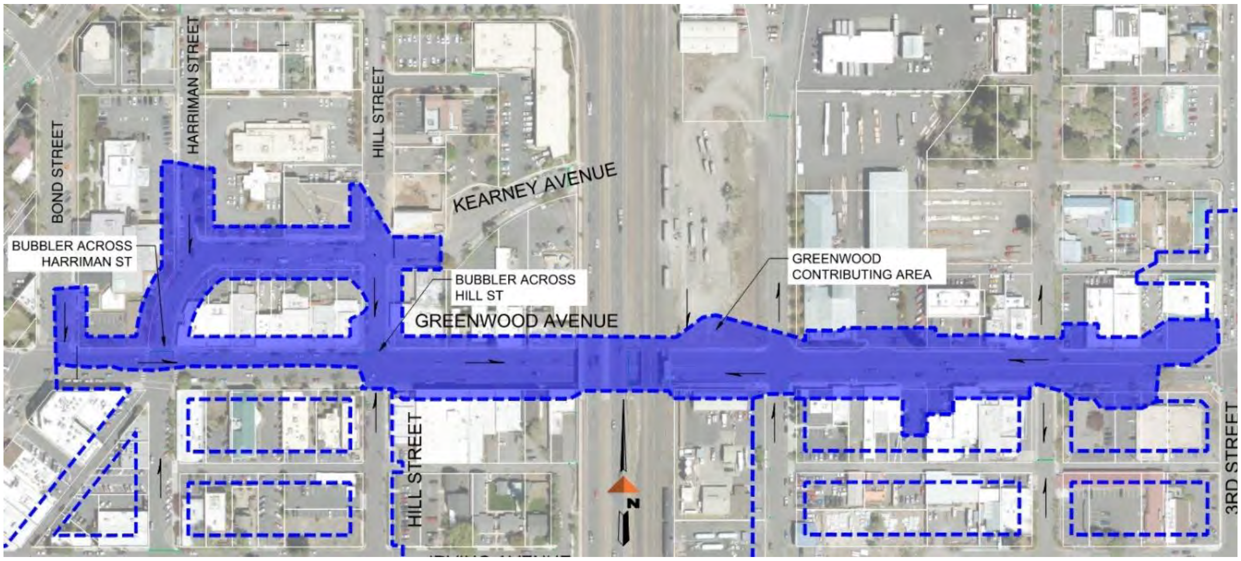
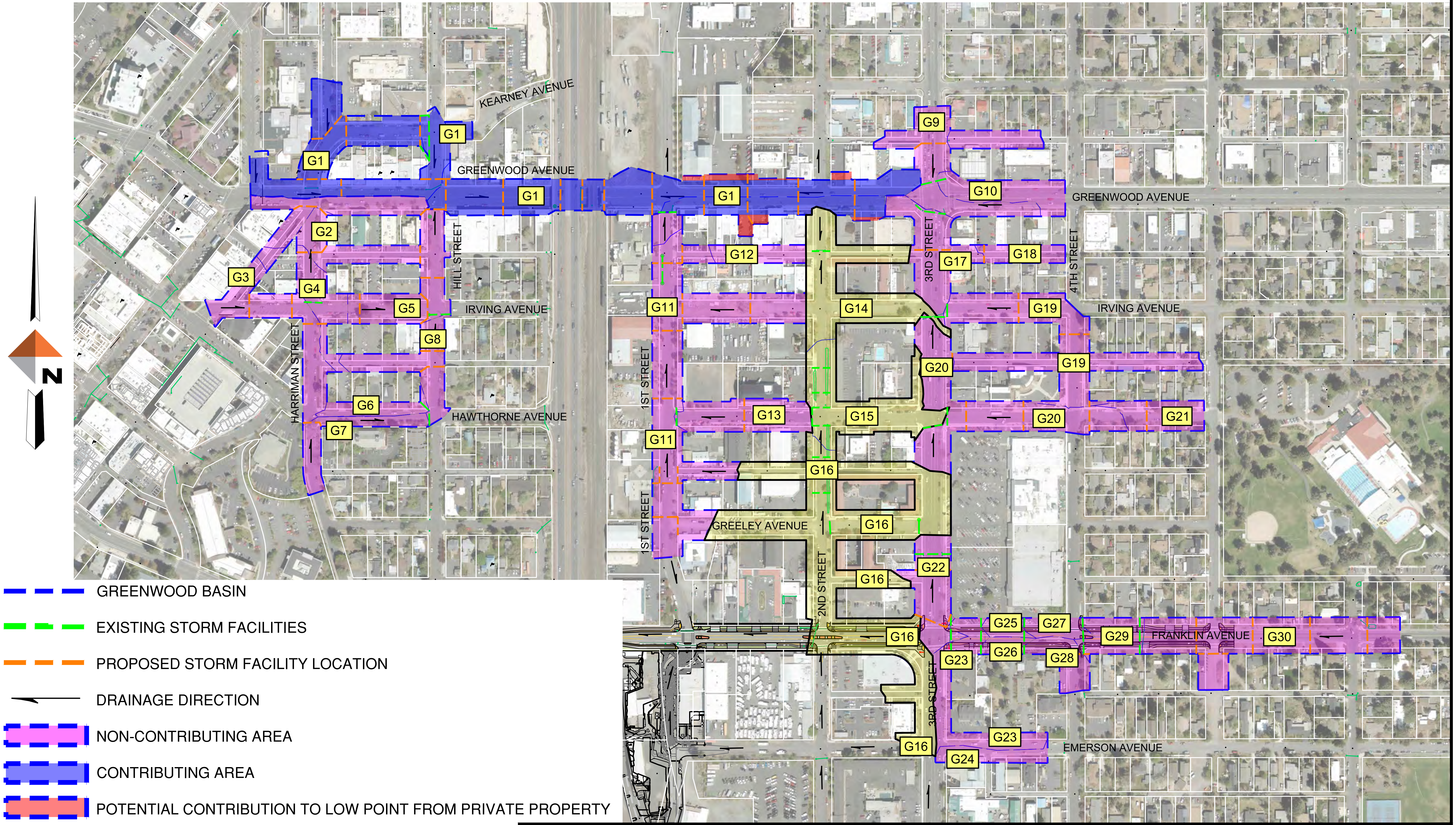


Figure 3. Greenwood contribution area.



— — — GREENWOOD BASIN

— — — EXISTING STORM FACILITIES

— — — PROPOSED STORM FACILITY LOCATION

← DRAINAGE DIRECTION

🟪 NON-CONTRIBUTING AREA

🟦 CONTRIBUTING AREA

🟥 POTENTIAL CONTRIBUTION TO LOW POINT FROM PRIVATE PROPERTY

🟨 ADDRESSED WITH 2ND STREET IMPROVEMENTS

G# BASIN IDENTIFIER

DOWL
WWW.DOWL.COM
963 SW Simpson Avenue, #200
Bend, Oregon 97702
541-385-4772

FIGURE 4

PROJECT	1GHAO
DATE	10/18/2024

GREENWOOD BASINS

C:\dowl_pw\d0413199\MA-CT-DR-EX-14953_1.dwg PLOT DATE 2024-12-13 16:16 SAVED DATE 2024-12-13 16:32 USER: jpugh

2.2 Infiltration Testing of Existing Facilities

Infiltration testing was conducted on two separate dates by DOWL and K&E in the early morning to cause minimal impacts to traffic. The structures tested were found to be drillholes in catch basins with debris screens installed over the top of the drillhole casings in perforated PVC pipe, see Figure 5 for a typical drillhole found along the Franklin Avenue corridor. A Vactor truck was used to jet and vacuum sediment and other debris from the structures prior to beginning testing. K&E Excavating provided two 4,000-gallon water trucks for testing.

Figure 5. A typical drillhole in catch basin.

The first tests were conducted on DDH010016 and DDH009491 on March 9, 2024, a second round of testing was performed on DDH9493 and DDH009492 April 12, 2024. Water truck operators were directed to empty the trucks as quickly as possible without overtopping the catch basins. The goal of testing was to discard 10,000 gallons of water within an hour. If crews were unable to get that full volume into the drillholes in an hour, then the goal was to maintain flows long enough to establish a maximum flow rate that the drillholes could control without overtopping.

Figure 6. Existing drillhole facilities and locations.

DDH010016 is the drillhole that exists at the low point of the Franklin undercrossing. This drillhole is a special case as it is in a non-standard catch basin. A photo of this drillhole with two 4-inch hoses during testing may be seen in Figure 7 below.

Figure 7. DDH010016.

DDH009492 was not able to be tested due to snow melt conditions that morning. The basin was observed to be completely full and not draining. K&E crews attempted to vactor and jet the drillhole, however when testing was commenced water immediately overtopped the catch basin. It is recommended that this drillhole be decommissioned per City and DEQ requirements with the Franklin corridor improvements.

Additional testing was also completed on several drywells and drillholes on 2nd Street by Hickman Williams and Associates (HWA). The data from their drywell testing was used to establish a factored (FS=2.5) infiltration rate of 16 inches per hour when developing a unit drywell for the unit basins as described in 4.0 Proposed Improvement Options. The reasoning behind using this data instead of testing data from the drillholes was threefold; for one, HWA was able to establish, maintain, and measure a drawdown rate (per testing requirements established by the Central Oregon Stormwater Manual (COSM)) in the drywells that they tested which is typically not possible with drillholes, for two it provides an in situ measurement of drywell facilities in the same area and similar soil conditions, and for three it increases the accuracy and dependability of drywell models in HydroCAD versus using a constant exfiltration rate. See Appendix 4 for HWA testing data.

A summary of DOWL drillhole testing results may be seen in Tables 1 through 4 below.

No infiltration testing has been completed on Greenwood Avenue to date.

Table 2 DDH010016 Testing Results. Note approximate max flow rate is 0.83CFS.

DDH010016 – Assumed construction with bridge 1936 – Pretreatment: None					
Truck 1 Volume=	1300 gal	Truck 2 Volume=	4000 gal	Truck 3 Volume=	4000 gal
Truck 1 start/end:	6:02/6:09	Truck 2 start/end:	6:02/6:24	Truck 3 start/end:	6:17/6:37
Truck 1 flow rate (GPM)=	190	Truck 2 flow rate (GPM)=	182	Truck 3 Flow Rate (GPM)=	200
Average test flow rate (GPM)=	191				
Average test flow rate (CFS)=	0.42				
Appx. Peak test flow rate (GPM) =	372				
Appx. Peak test flow rate (CFS) =	0.83				

Table 3 DDH009491 Testing Results. Note approximate max flow rate is 0.75CFS.

DDH009491 – Constructed 8/2006 – Pretreatment: Perforated pipe with screen					
Truck 1 Volume=	3700 gal	Truck 2 Volume=	3700 gal	Truck 3 Volume=	3700 gal
Truck 1 start/end:	4:46/5:01	Truck 2 start/end:	5:04/5:15	Truck 3 start/end:	5:21/5:36
Truck 1 flow rate (GPM)=	247	Truck 2 flow rate (GPM)=	336	Truck 3 Flow Rate (GPM)=	129
Average test flow rate (GPM)=	237				
Average test flow rate (CFS)=	0.53				
Appx. Peak test flow rate (GPM) =	336				
Appx. Peak test flow rate (CFS) =	0.75				

Table 4 DDH009493 Testing Results. Note approximate max flow rate is 0.64CFS.

DDH009493 – Constructed 8/2006 – Pretreatment: Perforated pipe with screen					
Truck 1 Volume=	1300	Truck 2 Volume=	4000	Truck 3 Volume=	4000
Truck 1 start/end:	4:53/5:07	Truck 2 start/end:	5:09/5:34	Truck 3 start/end:	5:36/5:49
Truck 1 flow rate (GPM)=	274	Truck 2 flow rate (GPM)=	151	Truck 3 Flow Rate (GPM)=	288
Average test flow rate (GPM)=	238				
Average test flow rate (CFS)=	0.53				
Appx. Peak test flow rate (GPM) =	288				
Appx. Peak test flow rate (CFS) =	0.64				

Table 5 DDH009492 Testing Results. Drillhole has failed.

DDH009492 – Constructed 8/2006 – Pretreatment: Perforated pipe with screen
COMPLETE FAILURE. IMMEDIATE OVERFLOW AND NO DRAWDOWN OVER NEXT 20MIN.

3.0 HYDROLOGIC MODELING

3.1 Basis of Model

All modeling was completed in HydroCAD software using the Santa Barbara Urban Hydrograph (SBUH) hydrologic method, SCS TR-55 with a minimum time of concentration (TC) of 5 minutes. The link routing method used was storage-indication (SI). The storm type used was the Type I 24-hour storm. The antecedent moisture condition was 2.

Based on drainage basins including only right-of-way and paved roads with curb and storm facilities, a curve number of 98 was used. Rainfall is based on Table 5-5 available in COSM and is presented in Table 6.

Table 6. 24-Hour Storm Depths for Bend (inches)

Rainfall Event	6-month	2-year	10-year	25-year	50-year	100-year
Rainfall Depth (inches)	1.0	1.5	2.0	2.5	2.8	3.0

3.2 Model Results

3.2.1 Proposed Basins

The existing drainage basins developed in Section 2 were reviewed and analyzed based upon current City standards, requirements, and methods of collection and disposal to determine proposed sub-basin sizes. The approach to this is the same for the Franklin and Greenwood Basins. Maximize the collection of stormwater outside of the undercrossing influence areas and minimize the basin size into the undercrossing. This is done to alleviate flooding risks and efficiently use City funds as collection, treatment, and disposal of the water in the upper basins is more cost effective. Alternatives for collection, treatment and disposal are discussed in Section 4.

Each sub-basin of the overall catchment is modeled as identified above, based on basins areas generated in AutoCAD. Areas were based on right-of-way plus 20-feet and areas of private property that seem to currently drain into right-of-way. Each sub-catchment was modeled using HydroCAD to generate hydrographs including peak discharge rate and runoff volume based on each storm evaluated (Appendix 1) An overview of the results from the delineated basins for Franklin Avenue is shown in Table 7, Table 8, Table 9, and Table 10. Results from Greenwood Avenue are shown in Table 11, Table 12, Table 13, and Table 14 below. The 50-year 24-hour storm will serve as the hydrologic basis for design of each single pump at the duplex pump stations. See 4.0 for more details. The 100-year 24-hour storm will serve as the hydrologic basis of design for any drywells or other UIC facilities receiving stormwater at a low point. Per City standards, any inlets on grade will be designed to the 25-year 24-hour storm. Section 4.0 outlines some alternative options when considering drywell and catch basin designs.

A table legend is shown below. Gradients are relative to each table and aid interpretation of flows or volumes represented in the tables to more easily identify potential problem areas.

Low → High

🟩🟩🟩🟨🟨🟧🟧🟥🟥

Table 7. Franklin basin data – peak flows.

Franklin Basin Data				PEAK FLOW (Q) (CFS)		
Franklin Basins	**AREA (SF)**	**CN**	**TC (MIN)**	**6-MO 1.0IN/HR**	**25-YR 2.5IN/HR**	**100-YR 3.0IN/HR**
F1	20,210	98	5.0	0.27	0.74	0.9
F2	88,510	98	11.4	0.92	2.54	3.07
F3	18,180	98	8.1	0.21	0.59	0.71
F4	29,470	98	5.0	0.39	1.09	1.31
F5	111,901	98	26.7	0.78	2.18	2.64
F6	108,950	98	10.4	1.17	3.23	3.91
F7	66,861	98	12.2	0.67	1.87	2.26
Total Area	809,033		Total Q =	4.41	12.24	14.80

Table 8. Franklin basin data – total runoff volume.

Franklin Basin Data				Total Runoff Volume (Cubic Feet)		
Franklin Basins	**AREA (SF)**	**CN**	**TC (MIN)**	**6-MO 1.0IN/HR**	**25-YR 2.5IN/HR**	**100-YR 3.0IN/HR**
F1	20,210	98	5.0	1,332	3,824	4,662
F2	88,510	98	11.4	5,834	16,749	20,418
F3	18,180	98	8.1	1,198	3,440	4,194
F4	29,470	98	5.0	1,942	5,577	6,798
F5	111,901	98	26.7	7,375	21,175	25,814
F6	108,950	98	10.4	7,181	20,616	25,134
F7	66,861	98	12.2	4,407	12,652	15,424
Total Area	809,033		Total Q =	29,269	84,033	102,444

Table 9 Franklin contributing area basin data – peak flows.

Franklin Basin Data				PEAK FLOW (Q) (CFS)		
Franklin Basins	AREA (SF)	CN	TC (MIN)	**6-MO 1.0IN/HR**	**25-YR 2.5IN/HR**	**100-YR 3.0IN/HR**
Contributing Area	88,510	98	11.4	0.92	2.54	3.07

Table 10. Franklin contributing area basin data – total runoff volume.

Franklin Basin Data				**Total Runoff Volume (Cubic Feet)**		
Franklin Basins	AREA (SF)	CN	TC (MIN)	**6-MO 1.0IN/HR**	**25-YR 2.5IN/HR**	**100-YR 3.0IN/HR**
Contributing Area (F2)	88,510	98	5.0	5,834	16,749	20,418

Table 11 Greenwood basin data – peak flows. Table continues to next page.

Greenwood Basin Data				**PEAK FLOW (Q) (CFS)**		
Greenwood Basins	**AREA (SF)**	**CN**	**TC (MIN)**	**6-MO 1.0IN/HR**	**25-YR 2.5IN/HR**	**100-YR 3.0IN/HR**
G1	359,720	98	8.1	3.84	10.62	12.84
G2	39,900	98	5.0	0.46	1.28	1.55
G3	57,524	98	8.1	0.57	1.58	1.91
G4	33,212	98	12.8	0.46	1.27	1.54
G5	87,020	98	19.7	0.96	2.66	3.22
G6	16,301	98	6.4	0.19	0.53	0.65
G7	26,966	98	14.8	0.33	0.9	1.09
G8	41,054	98	12.0	0.56	1.55	1.87
G9	77,413	98	11.2	1.12	3.08	3.72
G10	34,931	98	6.9	0.46	1.26	1.53
G11	179,175	98	26.6	1.81	5.01	6.06
G12	18,775	98	5.1	0.19	0.53	0.64
G13	43,553	98	8.3	0.53	1.45	1.76
G14	88,806	98	17.8	1.18	3.26	3.94
G15	72,917	98	18.9	0.59	1.65	2
G16	253,088	98	18.2	3.29	9.08	10.98
G17	52,120	98	11.3	0.73	2.03	2.45
G18	16,852	98	7.8	0.18	0.49	0.59
G19	115,812	98	30.4	1.11	3.09	3.74
G20	103,496	98	8.6	1.27	3.5	4.23
G21	27,832	98	5.9	0.39	1.07	1.29
G22	46,321	98	17.2	0.63	1.73	2.09
G23	46,984	98	21.2	0.63	1.73	2.09
G24	17,838	98	10.7	0.24	0.66	0.79
G25	8,625	98	6.3	0.12	0.32	0.38
G26	8,250	98	7.2	0.11	0.3	0.37
G27	13,306	98	5.0	0.18	0.49	0.59
G28	21,504	98	5.0	0.23	0.64	0.78
G29	24,271	98	5.0	0.26	0.72	0.88

G30	114,132	98	5.0	1.23	3.4	4.12
Total Area	2,047,698		Totals =	23.85	65.88	79.69

Table 12 Greenwood basin data – total runoff.

Greenwood Basin Data				**Total Runoff Volume (Cubic Feet)**		
Greenwood Basins	**AREA (SF)**	**CN**	**TC (MIN)**	**6-MO 1.0IN/HR**	**25-YR 2.5IN/HR**	**100-YR 3.0IN/HR**
G1	359,720	98	8.1	21,628	62,094	75,700
G2	39,900	98	NA	2,630	7,550	9,204
G3	57,524	98	8.1	3,791	10,885	13,270
G4	33,212	98	12.8	2,189	6,285	7,662
G5	87,020	98	19.7	5,735	16,467	20,075
G6	16,301	98	6.4	1,074	3,085	3,760
G7	26,966	98	14.8	1,777	5,103	6,221
G8	41,054	98	12.0	2,706	7,769	9,471
G9	77,413	98	11.2	5,102	14,649	17,858
G10	34,931	98	6.9	2,302	6,610	8,058
G11	179,175	98	26.6	11,809	33,905	41,334
G12	18,775	98	5.1	1,237	3,553	4,331
G13	43,553	98	8.3	2,871	8,241	10,047
G14	88,806	98	17.8	5,853	16,805	20,487
G15	72,917	98	18.9	4,806	13,798	16,821
G16	253,088	98	18.2	16,681	47,891	58,385
G17	52,120	98	11.3	3,435	9,863	12,024
G18	16,852	98	7.8	1,111	3,189	3,888
G19	115,812	98	30.4	7,633	21,915	26,717
G20	103,496	98	8.6	6,821	19,584	23,875
G21	27,832	98	5.9	1,834	5,267	6,421
G22	46,321	98	17.2	3,053	8,765	10,686
G23	46,984	98	21.2	3,097	8,891	10,839
G24	17,838	98	10.7	1,176	3,375	4,115
G25	8,625	98	6.3	568	1,632	1,990
G26	8,250	98	7.2	544	1,561	1,903
G27	13,306	98	5.0	877	2,518	3,070
G28	21,504	98	5.0	1,417	4,069	4,961
G29	24,271	98	5.0	1,600	4,593	5,599
G30	114,132	98	5.0	7,522	21,597	26,329
Total Area	2,047,698		Totals =	132,879	381,509	465,101

Table 13. Greenwood contributing basin data – peak flows.

Greenwood Basin Data				**PEAK FLOW (Q) (CFS)**		
Greenwood Basins	AREA (SF)	CN	TC (MIN)	**6-MO 1.0IN/HR**	**25-YR 2.5IN/HR**	**100-YR 3.0IN/HR**
Contributing Area (G1)	359,720	98	8.1	3.84	10.62	12.84

Table 14. Greenwood contributing basin data – total runoff.

Greenwood Basin Data				**Total Runoff Volume (Cubic Feet)**		
Greenwood Basins	AREA (SF)	CN	TC (MIN)	**6-MO 1.0IN/HR**	**25-YR 2.5IN/HR**	**100-YR 3.0IN/HR**
Contributing Area (G1)	359,720	98	8.1	21,628	62,094	75,700

4.0 PROPOSED IMPROVEMENT OPTIONS

Both the Franklin and Greenwood Basin's proposed improvements are developed based upon their locations, whether in the Upper Basin Improvement or Undercrossing Improvement areas. The intent is to maximize the collection, treatment, and disposal of stormwater in the Upper Basin area and provide systems in the undercrossings to manage design storms, or more considering operation and maintenance, public impacts, and costs.

4.1 Upper Basin Improvements

The intent is to maximize the collection, treatment, and disposal of stormwater in the Upper Basin area, utilizing standard City of Bend methods (catch basin, sedimentation treatment, drywell disposal) or City approved Best Management Practices where space is available. Many of these upgrades and improvements will be triggered, designed, and constructed as part of future development.

4.1.1 Hydrologic Design

City of Bend standards currently do not allow for any one UIC to take more than 25,000 gallons. This volume is based on the applicable design storm for the inlet location. Inlets on grade are designed for the 25-year 24-hour storm, while inlets at sag/low points are designed for the 100-year 24-hour storm. See Table 6 for corresponding rainfall depths. Based on this and the HydroCAD model settings outlined in 3.0 Hydrologic Modeling, a "unit" basin was created. This unit basin is based on the right-of-way width plus 40 feet of private property width and applicable design storm. The unit basin was developed using a runoff curve number (CN) of 93 which corresponds to an urban industrial district with a class 'D' soil condition. Higher or lower CNs will return different results and spacing may be increased or decreased. CNs typically range from 30 to 98. The CN represents the potential for an area to produce runoff, with higher numbers (up to an absolute maximum CN of 100) representing increasingly impervious surfaces such as a paved area that has little to no infiltration.

For inlets on grade and considering the 25-year storm, the following maximum length and corresponding maximum area for basins was developed:

Table 15. Unit basins for 25-year storm.

ROW Width	Maximum Area (Square Feet)	Maximum Length Between Inlets
60 Feet	22,500 ft^2	225 feet
80 Feet	22,500 ft^2	190 feet
100 Feet	22,500 ft^2	160 feet

For inlets located at a sag/low point and considering the 100-year storm, the following maximum length and corresponding maximum area for basins was developed:

Table 16. Unit basins for 100-year storm.

ROW Width	Maximum Area (Square Feet)	Maximum Length of Low Point Basin
60 Feet	17,500 ft^2	175 feet
80 Feet	17,500 ft^2	145 feet
100 Feet	17,500 ft^2	125 feet

To develop contributing areas (see Figure 2 and Figure 4) meeting City standards and to limit the amount of runoff that can reach each low point it is suggested that inlets be installed on intervals equal to or less than the developed maximum lengths between inlets. For low points the reported length is the total length of the low point basin.

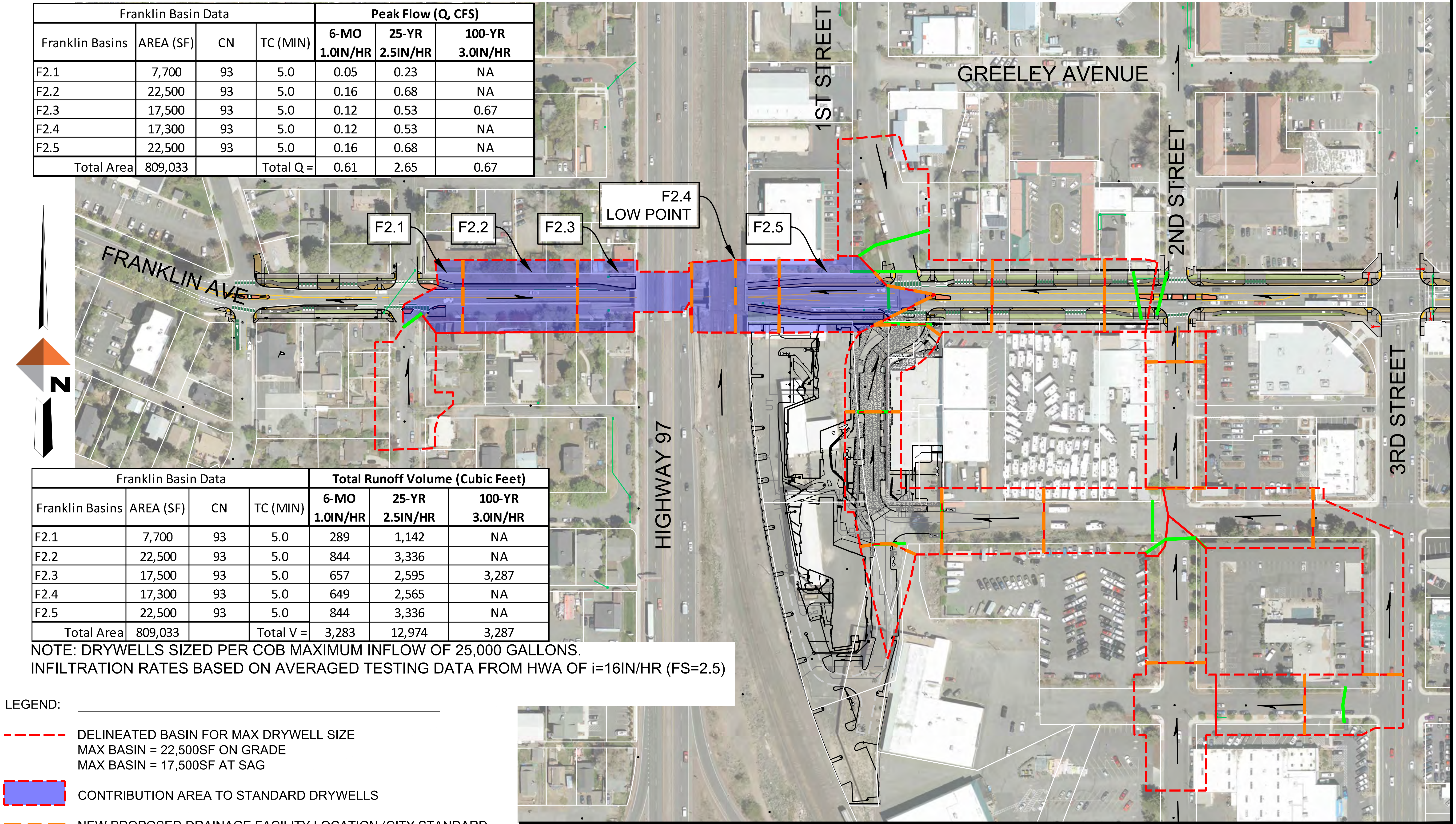
Using the basin areas in the above tables, the rainfall depths from Table 6, and the factored infiltration rate calculated for drywells in 2.2 Infiltration Testing of Existing Facilities (i=16in/hr), a unit drywell was modeled in HydroCAD. The drywell is based on an excavation with a total depth of 14.5 feet, 9 feet of drain rock (40% voids), and vertical sides to simulate an excavation in fractured bedrock. Through iteration it was found that a bottom area of 225 square feet will be required to discard inflows which results in a 75 cubic yard drywell. Peak water elevations in the drywells are 8.27 feet (25-year) and 8.06 feet (100-year) allowing for a reasonable amount of extra storage with the top of rock gallery being at 9 feet. Since the maximum amount of runoff into each drywell is limited to 25,000 gallons, the sizing for both the 25-year and 100-year design storms is the same. The results of the model are summarized in Table 17.

Table 17. Unit drywell summary.

Design Storm	Maximum Basin Area (Square Feet)	Drywell Size – Minimum Area and Drain Rock Volume
25-Year 24-Hour P=2.5in	22,500 ft^2	225 square feet 75 cubic yards
100-Year 24-Hour P=3.0in	17,500 ft^2	225 square feet 75 cubic yards

The spacing and maximum basin area above were used to develop proposed basins and new storm facility locations for both Greenwood and Franklin overall basins.

Franklin Basin Data				Peak Flow (Q, CFS)		
Franklin Basins	AREA (SF)	CN	TC (MIN)	6-MO 1.0IN/HR	25-YR 2.5IN/HR	100-YR 3.0IN/HR
F2.1	7,700	93	5.0	0.05	0.23	NA
F2.2	22,500	93	5.0	0.16	0.68	NA
F2.3	17,500	93	5.0	0.12	0.53	0.67
F2.4	17,300	93	5.0	0.12	0.53	NA
F2.5	22,500	93	5.0	0.16	0.68	NA
Total Area	809,033		Total Q =	0.61	2.65	0.67



Franklin Basin Data				Total Runoff Volume (Cubic Feet)		
Franklin Basins	AREA (SF)	CN	TC (MIN)	6-MO 1.0IN/HR	25-YR 2.5IN/HR	100-YR 3.0IN/HR
F2.1	7,700	93	5.0	289	1,142	NA
F2.2	22,500	93	5.0	844	3,336	NA
F2.3	17,500	93	5.0	657	2,595	3,287
F2.4	17,300	93	5.0	649	2,565	NA
F2.5	22,500	93	5.0	844	3,336	NA
Total Area	809,033		Total V =	3,283	12,974	3,287

NOTE: DRYWELLS SIZED PER COB MAXIMUM INFLOW OF 25,000 GALLONS.
INFILTRATION RATES BASED ON AVERAGED TESTING DATA FROM HWA OF i=16IN/HR (FS=2.5)

LEGEND:

🟥	DELINEATED BASIN FOR MAX DRYWELL SIZE MAX BASIN = 22,500SF ON GRADE MAX BASIN = 17,500SF AT SAG
🟦	CONTRIBUTION AREA TO STANDARD DRYWELLS
🟧	NEW PROPOSED DRAINAGE FACILITY LOCATION (CITY STANDARD CATCH BASIN, SED MANHOLE, DRYWELL)
🟩	EXISTING CITY FACILITY TO REMAIN

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FIGURE 8

PROJECT 1GHAO
DATE 10/18/2024

FRANKLIN BASINS

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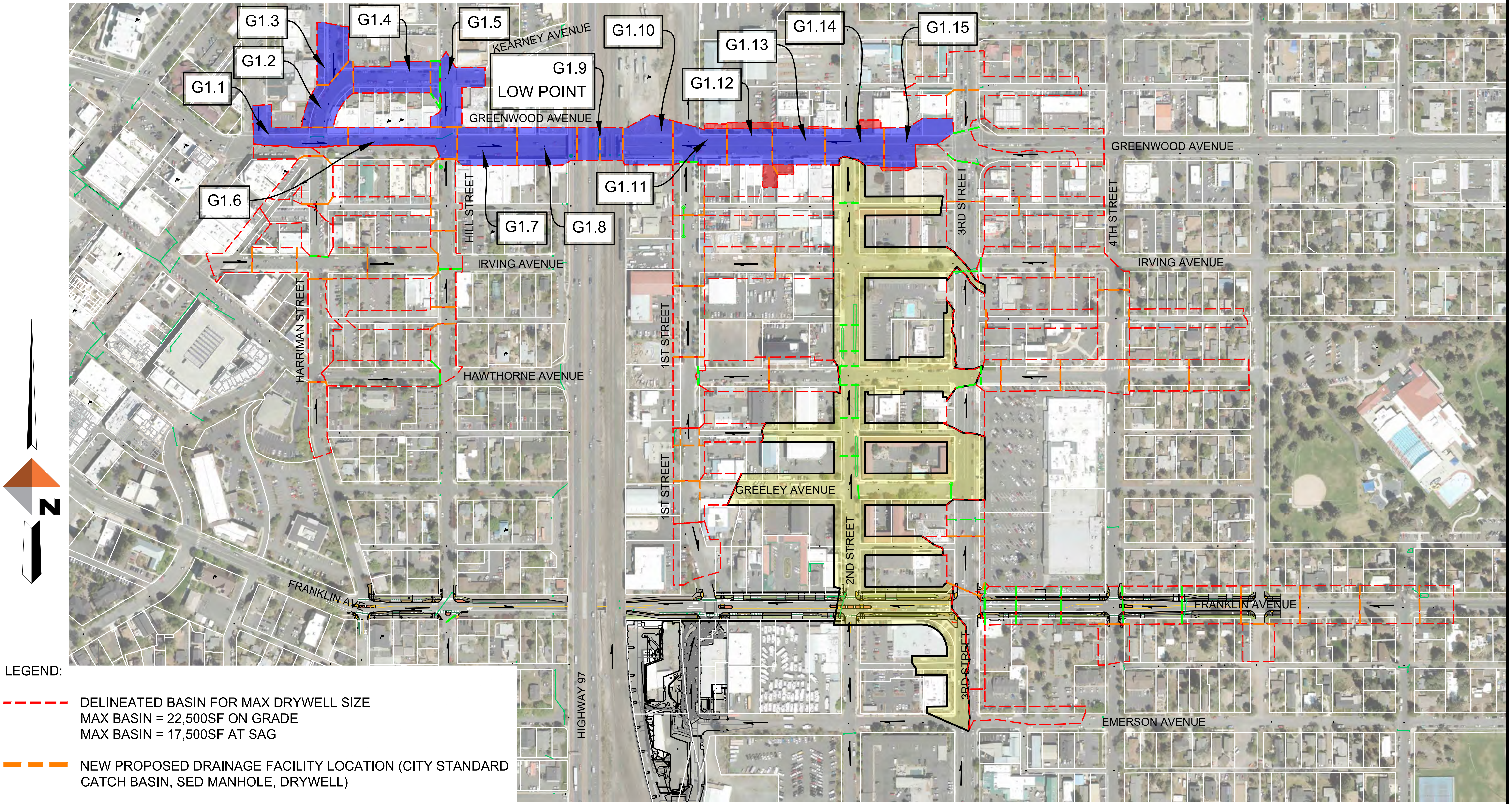

LEGEND:

- - - - DELINEATED BASIN FOR MAX DRYWELL SIZE
MAX BASIN = 22,500SF ON GRADE
MAX BASIN = 17,500SF AT SAG

— — — NEW PROPOSED DRAINAGE FACILITY LOCATION (CITY STANDARD CATCH BASIN, SED MANHOLE, DRYWELL)

— — — EXISTING CITY FACILITY TO REMAIN

🟨 2ND STREET UPDATED WITH GMP1

🟦 CONTRIBUTION AREA

🟥 POTENTIAL CONTRIBUTION FROM PRIVATE PROPERTY

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FIGURE 9

PROJECT 1GHAO
DATE 9/10/2024

GREENWOOD BASINS

Greenwood Basin Data				**Total Runoff Volume (Cubic Feet)**		
Greenwood Basins	AREA (SF)	CN	TC (MIN)	**6-MO 1.0IN/HR**	**25-YR 2.5IN/HR**	**100-YR 3.0IN/HR**
G1.1	22,447	93	5.0	842	3,329	NA
G1.2	18,682	93	5.0	701	2,770	NA
G1.3	16,897	93	5.0	634	2,506	NA
G1.4	22,500	93	5.0	844	3,336	NA
G1.5	20,304	93	5.0	762	3,011	NA
G1.6	22,500	93	5.0	846	3,344	NA
G1.7	22,550	93	5.0	846	3,344	NA
G1.8	22,297	93	5.0	837	3,306	NA
G1.9	15,004	93	5.0	563	2,225	2,818
G1.10	22,500	93	5.0	844	3,336	NA
G1.11	21,434	93	5.0	804	3,336	NA
G1.12	22,500	93	5.0	844	3,336	NA
G1.13	22,500	93	5.0	844	3,336	NA
G1.14	22,500	93	5.0	844	3,336	NA
G1.15	22,500	93	5.0	844	3,336	NA
Total Area	317,115		Totals =	11,899	47,187	2,818

Greenwood Basin Data				**PEAK FLOW (Q) (CFS)**		
Greenwood Basins	AREA (SF)	CN	TC (MIN)	**6-MO 1.0IN/HR**	**25-YR 2.5IN/HR**	**100-YR 3.0IN/HR**
G1.1	22,447	93	5.0	0.16	0.68	NA
G1.2	18,682	93	5.0	0.13	0.56	NA
G1.3	16,897	93	5.0	0.12	0.51	NA
G1.4	22,500	93	5.0	0.16	0.80	NA
G1.5	20,304	93	5.0	0.15	0.61	NA
G1.6	22,500	93	5.0	0.16	0.68	NA
G1.7	22,550	93	5.0	0.16	0.68	NA
G1.8	22,297	93	5.0	0.16	0.67	NA
G1.9	15,004	93	5.0	0.11	0.45	0.57
G1.10	22,500	93	5.0	0.16	0.68	NA
G1.11	21,434	93	5.0	0.15	0.65	NA
G1.12	22,500	93	5.0	0.16	0.68	NA
G1.13	22,500	93	5.0	0.16	0.68	NA
G1.14	22,500	93	5.0	0.16	0.68	NA
G1.15	22,500	93	5.0	0.16	0.68	NA
Total Area	317,115		Totals =	2.26	9.69	0.57

NOTE: DRYWELLS SIZED PER COB MAXIMUM INFLOW OF 25,000 GALLONS.
INFILTRATION RATES BASED ON AVERAGED TESTING DATA FROM HWA OF i=16IN/HR (FS=2.5)

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FIGURE 10

PROJECT 1GHAO
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GREENWOOD BASINS

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4.1.2 Corridor Improvements

Through the alternative analysis conducted with the Franklin Corridor Study a preferred cross section was developed (Figure 11). This cross section is unique as it proposes separated vehicle, bike, and pedestrian facilities. Note that the vehicle to curb buffer width in the cross section is 2 feet from fog line to face of curb. If standard G2 catch basins (see Figure 12) are used, they will protrude into the traveled way. Curb inlets (CG3 inlet, see Figure 13) could be used along the corridor, however they are not as efficient as a G2 and do not efficiently capture gutter flows when compared to the other City standard options. While the combination inlet (see Figure 14) is only marginally more efficient than a G2 and typically not cost effective on grade, to maximize the amount of runoff captured and increase driver comfort along the corridor combination catch basin inlets in series could be used. They strike a balance between space efficiency by not protruding into the roadway, gutter flow captures due to the curb inlet, easy maintenance due to the removable grate, and the ability to continue to capture water if the grate becomes blocked or frozen.

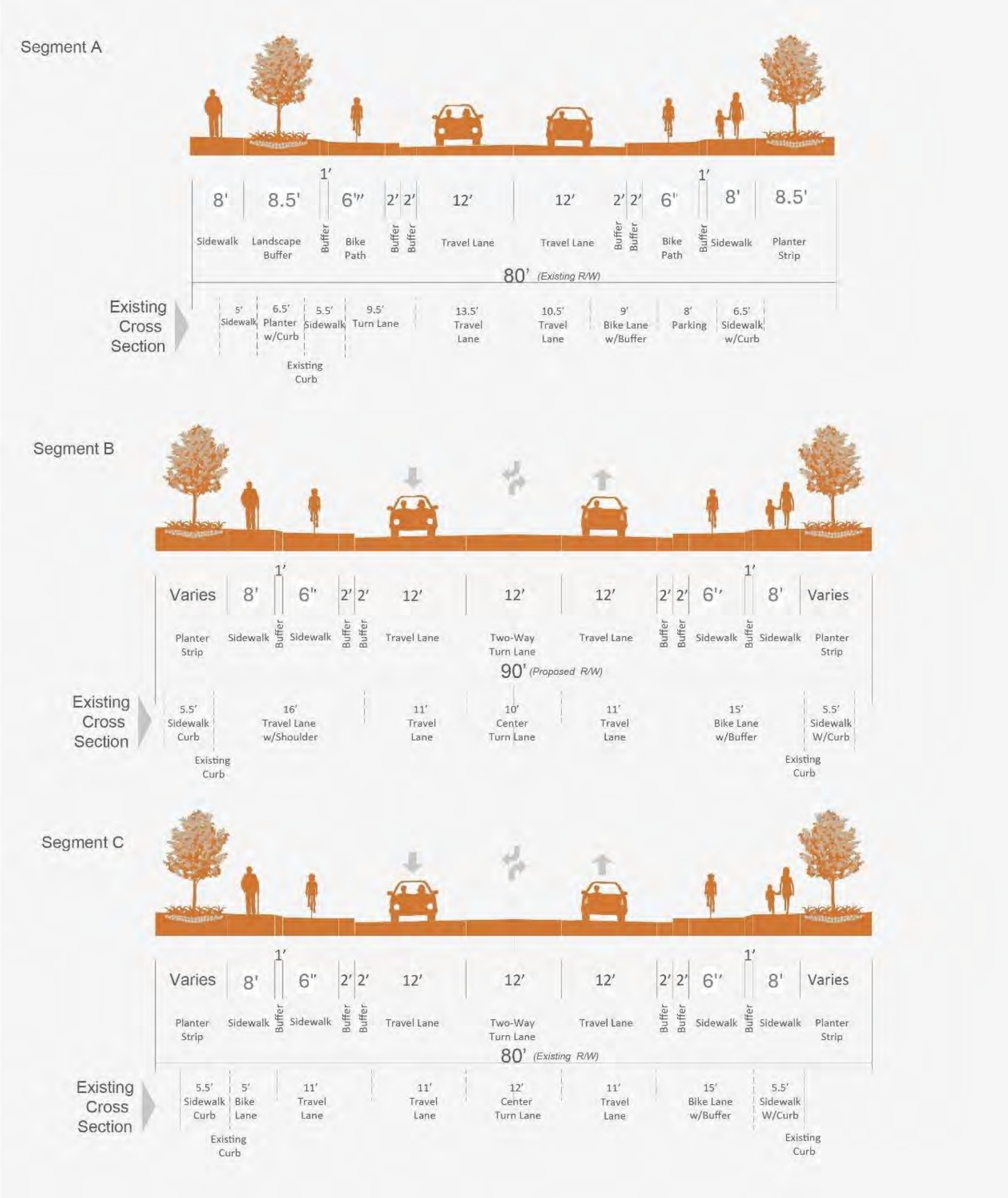

Figure 11. Franklin Avenue preferred alternative cross sections.

4.1.3 Catch Basins

Catch basins play a critical role in effective stormwater management by capturing the runoff that has been directed to gutters and low points. However, not all flow that is directed to a catch basin is able to be captured by the inlet. This generally happens during high flow events where gutter spread and flow rate begin to outpace the effective capture rate of each individual inlet, with improper grading that directs flows to bypass, or when blockages prevent the flow of stormwater to the inlet. Proper installation of inlets and inlet grates, routine maintenance, and inlets installed in series can help to mitigate how much water will bypass from each sub-basin and enter the next basin downstream. Different inlet types and the road grade can also impact efficiency. G2 inlets (a double grate style inlet, see Figure 12) are more efficient than a CG3 inlet (a reinforced inlet in the curb and typically with depressed concrete gutter, see Figure 13) but the grate in the bike lane is not a preferred option for the bike community. Current City standards require a combination catch basin inlet (a single grate typically with recessed curb, see Figure 14) where roadway grade is greater than or equal to 6%, however these may not be able to be installed in curb tight sidewalk, near bridge abutments, or with other site constraints. Inlet efficiency should be considered as roadway alternatives and stormwater designs are developed. To most effectively reduce the amount of flooding at the undercrossings, bypass flows should be modeled (efficiency versus gutter flow) and cost/benefit considered. Chapter 7 of HEC-22 4th Edition is an invaluable resource for inlet design. A series of inlets may prevent any bypass flows from upper reaches from reaching the undercrossings, but there will be increased costs for construction of catch basins, piping, and future maintenance.

Figure 12. An Example of a G2 Style Catch Basin.

Figure 13. An Example of a CG3 Curb Inlet Catch Basin.

Figure 14. An Example of a Combination Curb Inlet Catch Basin.

4.1.4 Cost Estimates

The upper basins (considered to be areas outside of the undercrossing contribution areas) for both Franklin and Greenwood could be updated to the extents possible with the Midtown Crossings project. Basins adjacent to each respective corridor should be prioritized to most effectively limit the amount of storm water to the undercrossings. Class five cost estimates for upgrading the basins outside of the contribution area in the case of Greenwood and outside of the Franklin corridor in the case of Franklin are provided below in Table 18 and Table 19. These cost estimates assume that standard catch basin/sedimentation manhole/drywell systems (10 for Franklin and 46 for Greenwood) will be utilized to create basins that meet the maximum basin sizes as outlined in 4.1.1. Along with the storm improvements, costs for trenching, 8-inch piping, and restoration of curbs, pavement, and sidewalks are included. See Appendix 1 for cost estimates and specific quantities included.

4.1.4.1 Franklin Upper Basin

Table 18. Franklin upper basin cost estimate.

-50%	Class V Cost Estimate	+100%
$425,000	$850,000	$1,700,000

4.1.4.2 Greenwood Upper Basin

Table 19. Greenwood upper basin cost estimate.

-50%	Class V Cost Estimate	+100%
$1,914,000	$3,835,000	$7,670,000

4.2 Undercrossing Improvements

In general, this area has four alternatives for disposal of collected stormwater water; pumping to underground injection, pumping to surface infiltration, pumping to the Deschutes River, or in-place underground injection.

All options require treatment prior to disposal to varying degrees. Treatment will be achieved via inlets with sumps, sedimentation manholes with sumps and snouts, or trash racks all installed prior to the wet well for surface and/or UIC disposal. Additional pretreatment is required for disposal to the Deschutes River.

To most effectively limit runoff to the low points standard catch basin/sedimentation manhole/drywell facilities should be prioritized as close as possible to the low points on either side of the undercrossings.

4.2.1 Special Considerations

Due to BNSF Rail and US 97 being over top of these undercrossings and the potential for vehicular accidents in the low points, spill prevention and flow control in each undercrossing will be included. This will include a system of standard sedimentation manholes and manually operated valves in the case of a spill. The location of the valves should be located far enough from the low point to keep accessible in the case of a spill and to allow staff to safely operate and exercise valves during standard maintenance. These valves will allow City staff to isolate inflows to UICs or pump systems in the event a spill occurs near the underpass. It is anticipated that either a resilient wedge gate valve or butterfly valve will be proposed and will be operated using valve extensions and surface mounted valve cans. Sedimentation manholes also provide storage for spills. Their 4-foot-diameter, 4-foot-deep sump provide ~50ft^3 or 375-gallons of storage, with the ability to oversize (diameter or depth) for additional capacity. (For additional consideration semi tanker trucks typically contain a volume between 3,000 and 11,000 gallons, whereas a rail tank car may have a volume between 6,500 to more than 31,000 gallons of liquid).

Discharge to the Deschutes River will require additional permitting and coordination for a new point discharge location, or capacity verification at the existing outfall in Drake Park. All options require collection, treatment, and movement to a disposal location. The pump station options have several different alternatives as to where and how water is discharged. These options are discussed in more detail in the following sections.

4.2.2 Deep Drywells

Deep drywells represent an emerging stormwater management solution in the City of Bend. While they offer certain advantages, their implementation has resulted in mixed outcomes across City projects. They consist of a vertical drilled shaft which is backfilled with drain rock allowing for storage volume and infiltration into the surrounding soils. Figure 15 details a conceptual deep drywell installation. details a conceptual deep drywell installation.

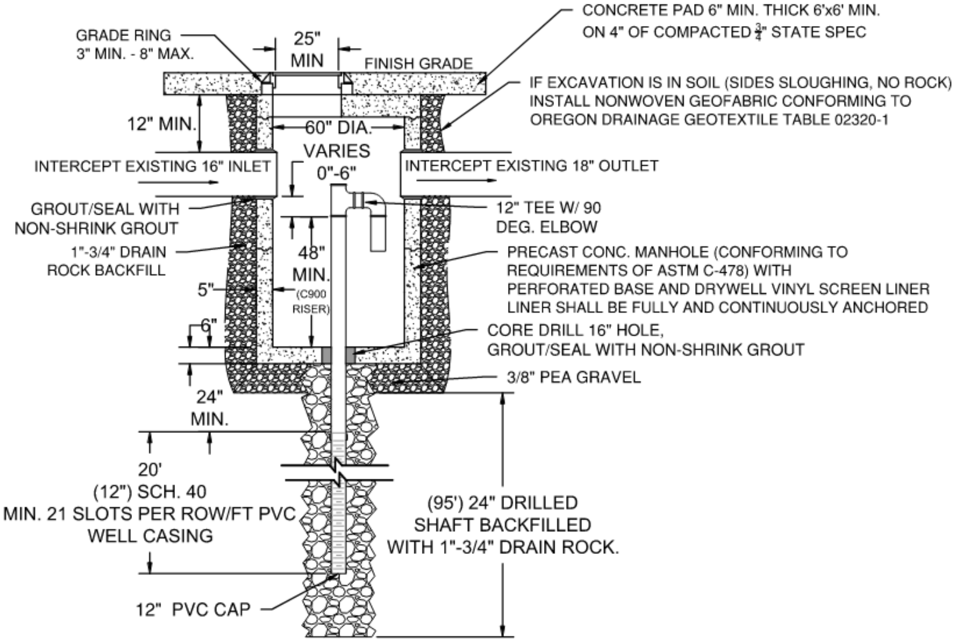

Figure 15. A conceptual deep drywell Installation. This project specified a 24" 95ft shaft.

Current research into the implementation and siting of deep drywells suggest that they only be allowed on local streets with average daily traffic (ADT) under 1000 vehicles and in residential areas, neither of which would be met by installations on Franklin Avenue or Greenwood Avenue. Based on the above information it is not anticipated that the new Stormwater Master Plan update project would support the construction of deep drywells in either location.

Deep drywells offer several advantages but can also face changes unique to them during and after installation. The largest advantage is their space efficiency and contained treatment system. Deep drywells require a small fraction of the footprint that a traditional drywell does. Challenges faced installing deep drywells include soil and drainage conditions, high costs when compared to traditional installations, a lack of storage volume and dependency on extremely high exfiltration rates, an inability to perform pre-infiltration testing like traditional drywell installations, injection of pollutants deep underground if a spill or contamination was to ever occur, and no backup system if they were to ever fail. See Figure 16 below. Two sets of flanking catch basins are used to capture stormwater and limit the total inflow to the ultimate low point. Three sets of catch basins are installed at the low point to provide some redundancy to the system in the case a blockage ever occurs. A series of deep drywells is shown from the low point and would provide multiplied exfiltration by increasing the total area offered to water entering the low point.

Deep drywells have not yet been formally incorporated into City standards, and their implementation would require approval from City engineers on a case-by-case basis.

Based on the 100-year peak flows which will control the system seen in Table 9 and Table 13, a modeled 95-foot-deep deep drywell, and constant flow rate from averaged test data (Q=0.74cfs), it is estimated that five deep drywell will be needed at the Franklin undercrossing and 17 would be needed at the Greenwood undercrossing. When considering the reduced basins sizes as are proposed in Figure 8 and Figure 9, a modeled 95-foot-deep deep drywell, and constant flow rate from averaged test data (Q=0.74cfs), each low point needs only one deep drywell to discard of the 100-year storm flows. Extensive geotechnical explorations should be performed to measure in situ drainage capacity of the deep drywells prior to acceptance of the new facilities. Based on HydroCAD modeling a minimum constant flow rate of 0.66cfs should be obtained.

It is not anticipated that based on the siting criteria outlined above that deep drywells will be permitted with this project, however Figure 16 below shows a conceptual layout on the western side of Franklin Avenue.

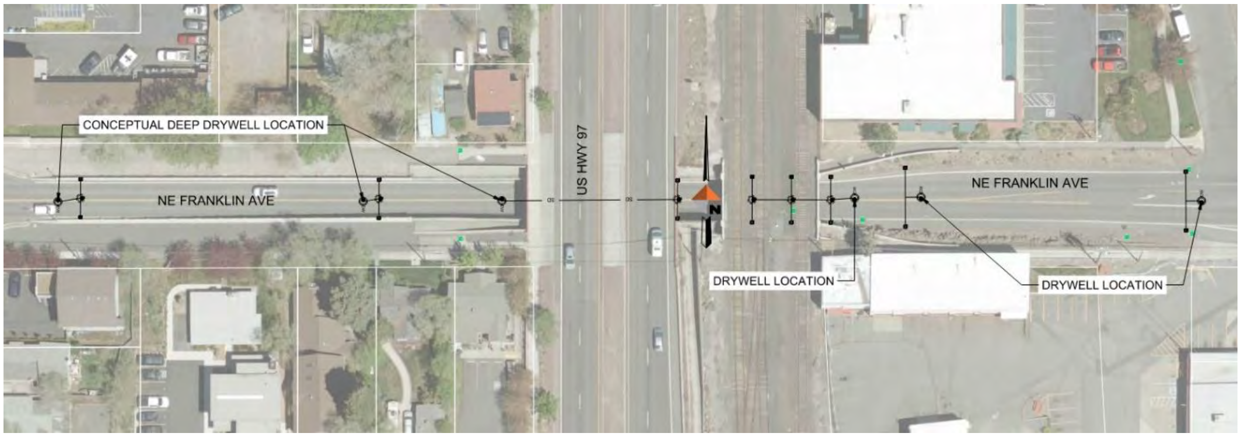

Figure 16. Concept deep drywell installation on Franklin Avenue.

4.2.3 Standard Drywells

A system of City standard drywells is currently planned to control storm water in the upstream basins, however, if properly designed and implemented, drywells could be a viable solution to mitigate flooding at the undercrossings.

The performance of drywells is determined mainly by the soil or rock conditions that they are installed in. Performance testing in accordance with COSM guidelines must be performed and recorded. Pre-tests are highly valuable and recommended to be completed prior to stacking out structures and backfilling with drain rock.

Drywells offer several pros but do face several cons as well. A major advantage to the installation of drywells versus any other system is that City Utility staff is familiar with the operation and maintenance associated with them. No new equipment or training would be required for these systems outside of the use of an isolation valve as suggested in 4.0 Proposed Improvement Options during spill events at the underpass. A few other advantages include established City standards that support their construction and use, they are a much cheaper alternative to deep drywells and pump stations, they provide storage for excess storm water underground versus in the roadway, they recharge ground water, their overall footprint is relatively minimal compared to a pump station, and they are highly versatile (location, soil conditions, site conditions). Some limitations of drywells include soil suitability, maintenance requirements, groundwater contamination risk (though lower risk than deep drywells), capacity limitations, size (when compared to deep drywells), and lifecycle limitations if routine maintenance is not performed or there was improper initial installation.

Per City standards (section 6.4.4) “drywells and sedimentation manholes, when used as part of the drainage design, are to be placed in landscape strips per City Standard drawings, unless otherwise approved by the City Engineer. Drywells and sedimentation manholes must not be placed within sidewalks/shared-use paths or driveways." Placement of drywells, especially within the envelope of the undercrossings will likely require them to be located under the roadway. This is typically not desirable due to the potential impacts to existing or future locations of City and franchise utilities, potential long-term settlement, and increased maintenance complexity however, placement out of the low points would require the drywells and associated piping to be unreasonably deep.

As mentioned above, drywells can be extremely versatile if properly designed and implemented. For example, to further decrease the risk of future flooding, drywells in the upper reaches of the Franklin and Greenwood basins could be sized to manage a larger design storm than the 25-year while remaining reasonably sized. 25-year drywells in the upper reaches could be designed to manage the 100-year storm by increasing their footprint by ~50ft^2 and drain rock volume from ~75yds^3 to ~90yds^3. The low point drywells could be sized to fully store the 100-year event below ground by increasing the volume of drain rock in the gallery requiring a larger volume and footprint of ~310yds^3 and ~930ft^2. To ensure that this increase in drywell cost is worthwhile, catch basin efficiency should be evaluated to verify that 100-year level flows in the upper reaches are captured by facilities on grade. Refer to 4.1.3 for more information on catch basin efficiency.

Figure 17. A large drywell installation at Caldera High School.

Figure 18. 6-mil plastic sheeting installed prior to concrete pour.

Figure 19. Concrete cap poured over plastic sheeting.

4.2.3.1 Franklin Avenue Standard Drywell Option

The utilization of standard City drywells a feasible option to mitigate storm water at the Franklin undercrossing. It will however require some deviation from City standards to construct facilities at this location. The proximity to existing and proposed structural elements will likely require the placement of drywells in the roadway. This option will require piping from the low point to locations outside of BNSF right-of-way, or regrading of the roadway to move the low point east of the bridge. These facilities will limit basins to their respective maximum size and reduce runoff to the low point. Another option would be to forego drainage structures on the western approach through a design deviation and oversize the low point drywell to take more than the current City standard 25,000-gallons. See Figure 20 below for a conceptual layout.

4.2.3.1.1 Franklin Avenue Cost Estimate

The contribution area to Franklin is expected to be updated with this project. Class five cost estimates to upgrade the contribution basin of Franklin is provided below. This cost estimate aligns with the layout of Figure 2. It is anticipated that standard catch basin/sedimentation manhole/drywell systems will be utilized to create basins that meet the maximum basin sizes as outlined in 4.1.1. Refer also to the Franklin Alternatives Analysis Report (AA) for more information on the overall anticipated project costs. The below table is assumed to be in addition to the Franklin cost estimate found in the AA report. Other installation costs like demolition, curb, paving, etc. are captured in the AA cost estimate.

Table 20. Contribution Area Cost Estimate.

-50%	Class V Cost Estimate	+100%
$310,000	$620,000	$1,240,000

4.2.3.2 Greenwood Avenue Standard Drywell Option

The utilization of standard City drywells a feasible option to mitigate storm water at the Greenwood undercrossing. It will however require some deviation from City standards to construct facilities at this location. The proximity to existing and proposed structural elements will likely require the placement of drywells in the roadway and non-standard pipe routing to the drywells and sedimentation manholes. This option will require piping from the low point to locations outside of BNSF right-of-way, or an agreement with BNSF to retrofit the existing structures in the low point. See Figure 21 below for a conceptual layout.

4.2.3.2.1 Greenwood Avenue Cost Estimate

The contribution area to Greenwood was evaluated with this report. High level (class five) cost estimates to upgrade the contribution basin is provided below. This cost estimate aligns with the layout of Figure 4. It is anticipated that standard catch basin/sedimentation manhole/drywell systems will be utilized to create basins that meet the maximum basin sizes as outlined in 4.1.1.

This estimate captures costs associated to inlets, piping, sedimentation manholes, drywells, surface restoration, and engineering costs among others.

Table 21. Contribution Area Cost Estimate.

Class V Cost Estimate	-50%	+100%
$932,000	$1,863,000	$3,726,000

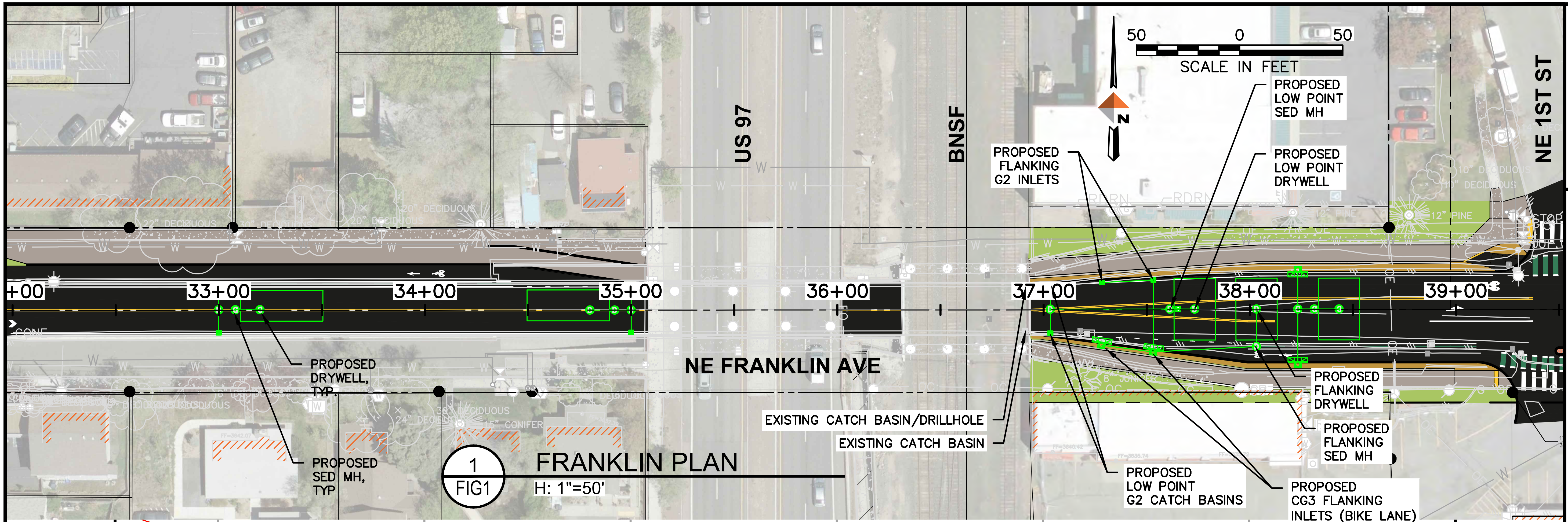

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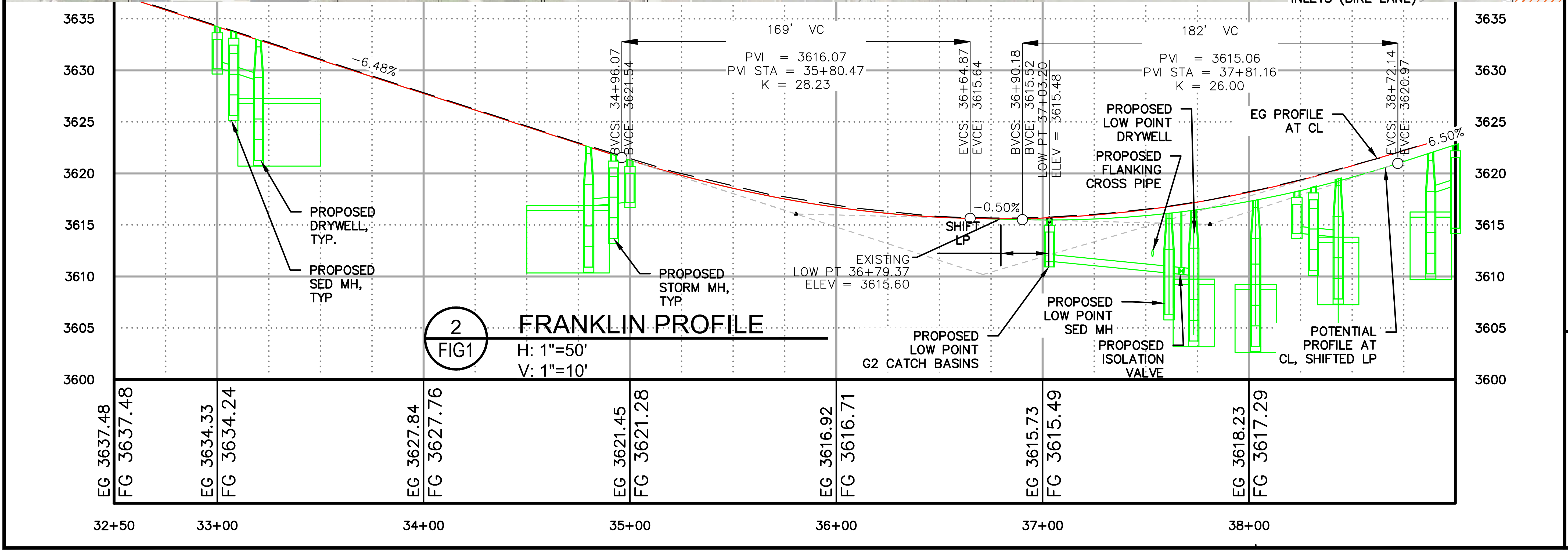
FIG1
FRANKLIN PLAN
H: 1"=50'



2
FIG1
FRANKLIN PROFILE
H: 1"=50'
V: 1"=10'

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FIGURE 20

MIDTOWN CROSSINGS
FRANKLIN AVENUE CORRIDOR
STORMWATER UPGRADE - ALT

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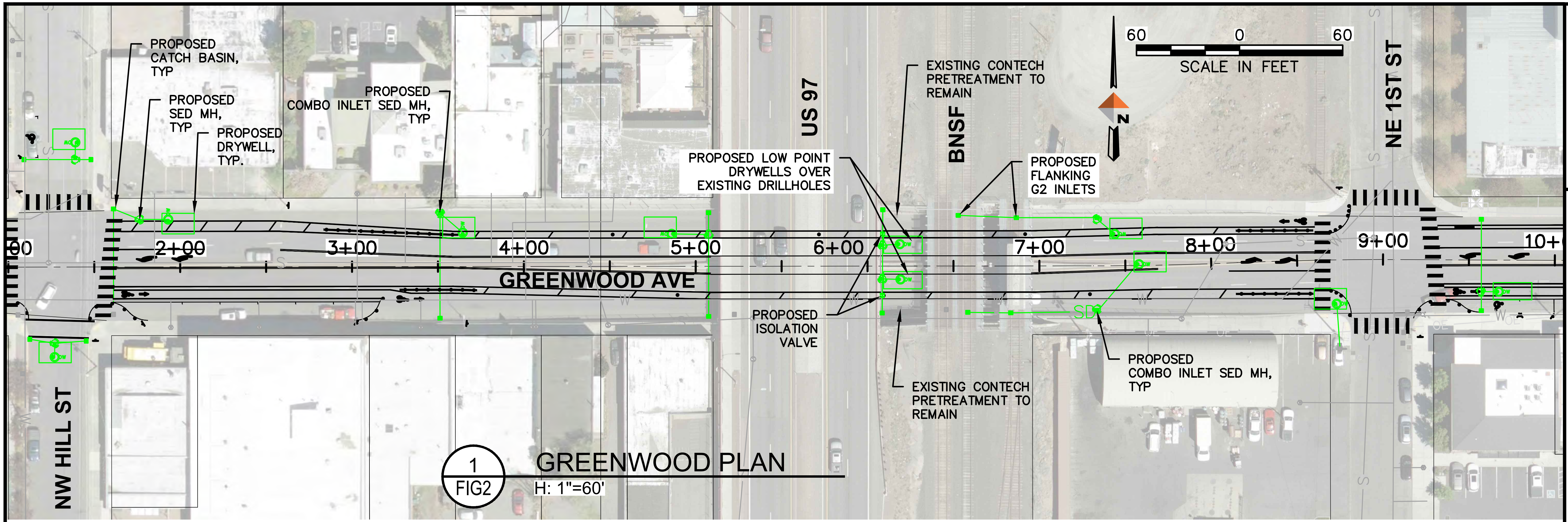
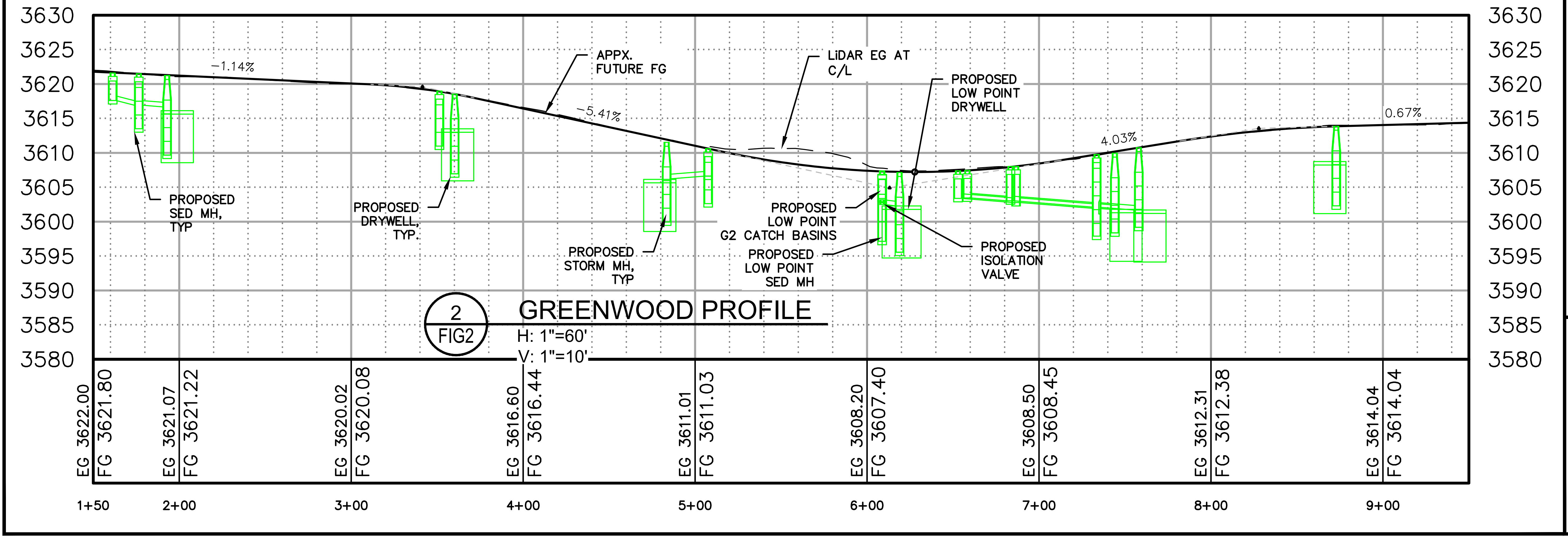


1 FIG2 GREENWOOD PLAN

H: 1"=60'



2 FIG2 GREENWOOD PROFILE

H: 1"=60'
V: 1"=10'

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FIGURE 21

MIDTOWN CROSSINGS
GREENWOOD AVENUE CORRIDOR
STORMWATER UPGRADE - ALT

DOWL
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4.2.4 Pumping Options

DOWL has identified with City staff several options for pumping collected stormwater from each undercrossing. A duplex pump station like the current system installed with the Third Street undercrossing is recommended. Each pump station will consist of a gravity system from catch basins and sedimentation manholes that flows to a large wet well that is sized for the 100-year event, a pair of submersible, rail mounted variable frequency drive (VFD) pumps, a vault containing required valving, instrumentation, and controls to integrate these into the City SCADA system, and piping to the final discharge location. See Figure 22 and Figure 23.

The pump system will provide full redundancy by providing a pair of pumps that are identical. Each single pump will be sized to convey the 50-year design storm, and 100-year flows will be conveyed by pumping in tandem, utilizing both pumps.

Through initial design development based on the total inflows into each undercrossing and assuming a maximum water velocity in the pipe systems of 5 feet per second (fps) it has been calculated that Greenwood ($Q_{50} = 8cfs$) will require 18” pipe and Franklin ($Q_{50} = 4.2cfs$) will require 12” ductile iron pipe (assumed DI for worst case Hazen-Williams coefficients in preliminary calculations). If these options are to be piped together, 24” piping will be required to maintain pipe velocities under 5 feet per second.

Using existing topography from the City LiDAR survey the existing pond along Colorado Avenue was modeled, and with an assumed infiltration rate of 6 inches per hour (taken from an average of values found during infiltration testing for the 3rd Street Undercrossing project – see page 70 of the Preliminary Engineering Report) was found to have capacity for the three pump systems (3rd Street, Franklin, and Greenwood). Infiltration rates should be verified by running a pond flood test as outlined in appendix 4F – Flood Pond Test of COSM. Some challenges faced in connecting to this existing pond are bringing the new pipe under the railroad tracks at the Colorado Street and Highway 97 bridge, minimizing impacts to the bridge embankment, and potential utility conflicts such as the pressure sewer main that currently runs below the Colorado bridge.

Each of these pumping options has advantages and disadvantages. Some disadvantages include added expense for construction of pump stations, regulatory permitting expenses and delays, added expense for piping and associated structures, increased system complexity, increased system construction costs, is not preferred by City operations staff, and more complex and costly maintenance. Some advantages include the ability to handle a wide range of rainfall depths, future resilience of the overall system, using pre-existing stormwater systems, and eliminating the need for deep excavations near existing infrastructure. Pump selection and recommendations for pump systems will be provided as designs are finalized.

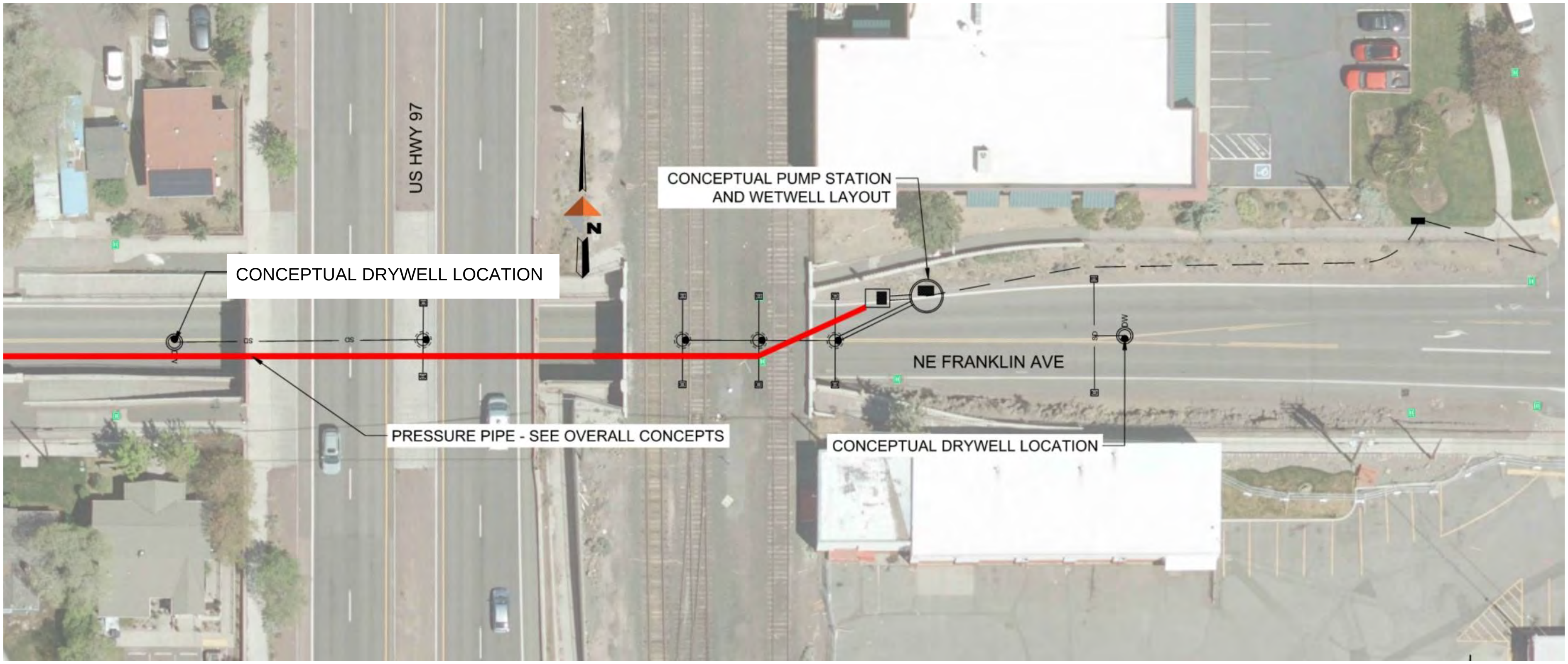


Figure 22. Franklin conceptual pump station.

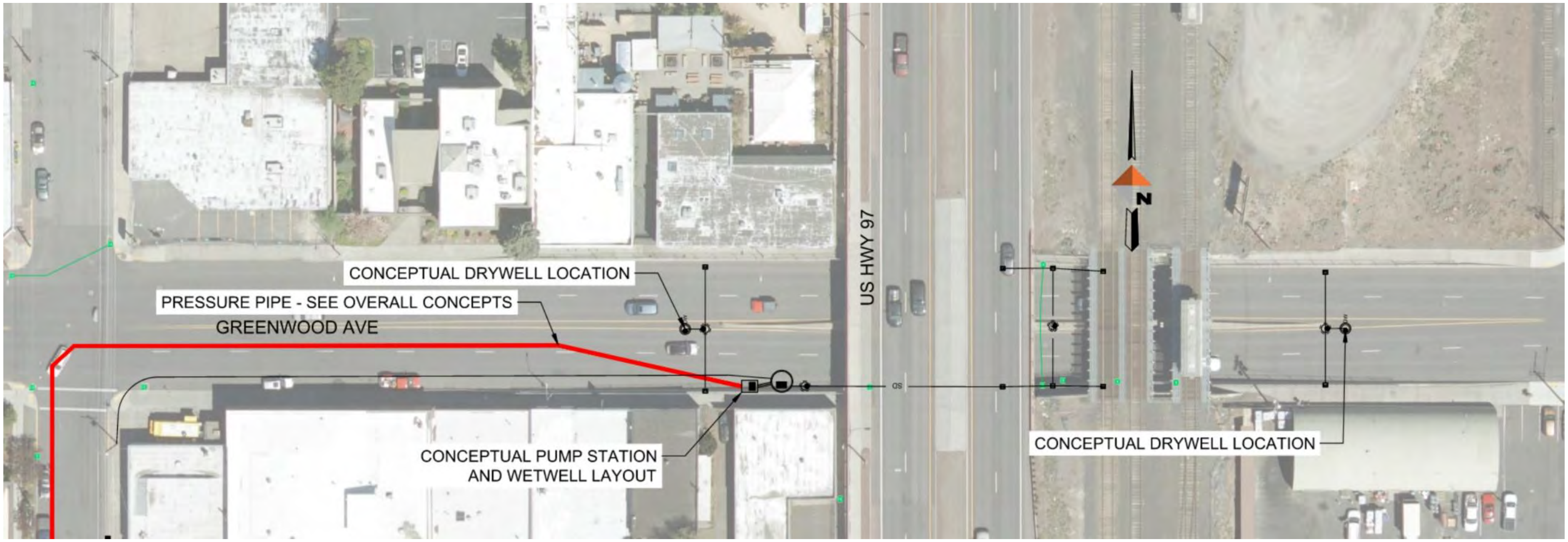


Figure 23. Greenwood conceptual pump station.

Pumps and pressure pipe will be sized to convey water from the bottom of wet wells to high points along the chosen pumping route. Flows may be transitioned at high points from pressure to gravity, however this will potentially increase system costs due to gravity mains requiring manholes. There are multiple discharge locations that have been identified, and several different options for final configuration of each option. These options include:

4.2.5 Undercrossing Pumping Option #1 – Colorado Interchange

A combined system that pumps stormwater from both undercrossings to a combined system that outfalls to the regional stormwater pond near the Colorado Avenue interchange. This option will require stepping up pipe size at the point pressure flows are combined. It will require ±610 feet of 12” pipe from the Franklin pump station, ±1820 feet 16” pipe from the Greenwood pump station, and ±2420 feet of 24” pipe from the point they are combined near the intersection of Hill Street and Franklin Avenue to the stormwater pond. See Figure 24 below.

Figure 24. Combined pressure system from Franklin and Greenwood pump stations.

4.2.5.1 Franklin Avenue Undercrossing

The Franklin undercrossing pump station could be constructed independent from Greenwood but planned for a future combined system with the construction of a pump station at Greenwood.

4.2.5.1.1 Cost Estimate

Table 22. Franklin pump to existing pond cost estimate.

-50%	Class V Cost Estimate	+100%
$1,229,500	$2,459,000	$4,918,000

4.2.5.2 Greenwood Avenue Undercrossing

Through proper pipe sizing, the Greenwood undercrossing could be constructed at a later date and tied into the Franklin Undercrossing pipe network minimizing potential rework in the future.

4.2.5.2.1 Cost Estimate

Table 23. Greenwood pump to existing pond cost estimate.

-50%	Class V Cost Estimate	+100%
$1,172,000	$2,344,000	$4,688,000

4.2.6 Undercrossing Pumping Option #2 – to UICs

Separate systems that pump Greenwood Avenue to drywells located on Kearney Avenue, and Franklin Avenue to drywells located on a City parcel/ROW and the intersection of Georgia Avenue and Harriman Street. This option will require ±950 feet of 16” piping for Greenwood and ±1,350 feet of 12” piping for Franklin. There is potential to switch Franklin to gravity flow at the top of Hill Street. HydroCAD was used to model the drywells for this option and, assuming a 2 inch per hour infiltration rate, complete upstream improvements, and 25,000 gallon per drywell limit, one drywell would be required for Greenwood. Making the same assumptions for Franklin, a total of one drywell will be required.

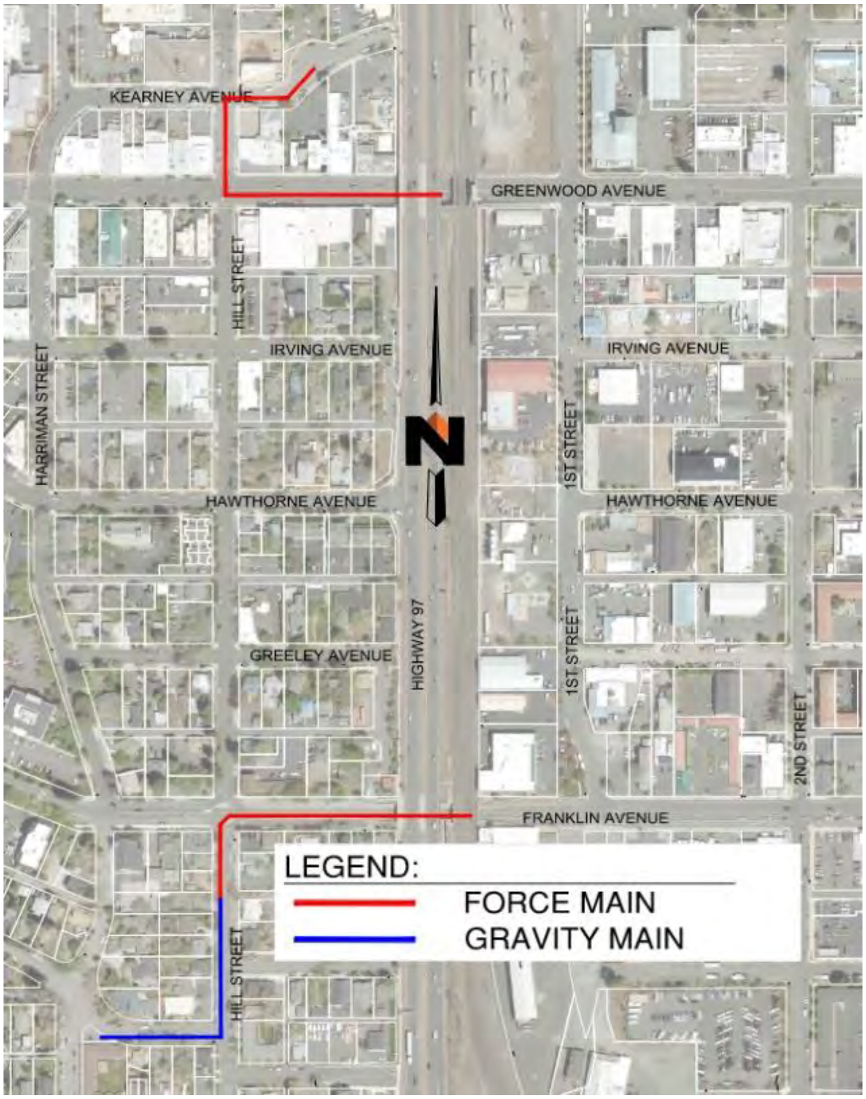


Figure 25. Separate systems to outfall near each undercrossing.

4.2.6.1 Franklin Avenue Undercrossing

Franklin undercrossing could be pumped to Hill Street and transitioned to gravity flows. This option reduces roadway impacts over other pumping options.

4.2.6.1.1 Cost Estimate

Table 24. Franklin discharge to UICs cost estimate.

-50%	Class V Cost Estimate	+100%
$1,060,000	$2,120,000	$4,240,000

4.2.6.2 Greenwood Avenue Undercrossing

Greenwood undercrossing could be pumped to UICs on Kearney or in the roadway along Greenwood. This option reduces roadway impacts over other pumping options.

4.2.6.2.1 Cost Estimate

Table 25. Greenwood discharge to UICs cost estimate.

-50%	Class V Cost Estimate	+100%
$1,542,500	$3,085,000	$6,170,000

4.2.7 Undercrossing Pumping Option #3 – to the Deschutes River

It has been recognized that any pumping options that discharge to the river (pumping options 2 and 3) will require additional pretreatment beyond standard sediment control. It will require extensive pretreatment water quality facilities to bring discharged waters to contaminant and sediment levels as required by the DEQ. This would also significantly increase the City's regulatory obligations under their MS4 permit. The cost estimates do not include any required pretreatment that these options would require.

4.2.7.1 Franklin Avenue and Greenwood Undercrossings Combined

A combined system that pumps stormwater from both undercrossings to a combined system that outfalls to the Deschutes River. This option will require ±5,200 feet of piping. See Figure 26.The gravity section of this concept is optional and shown for reference.

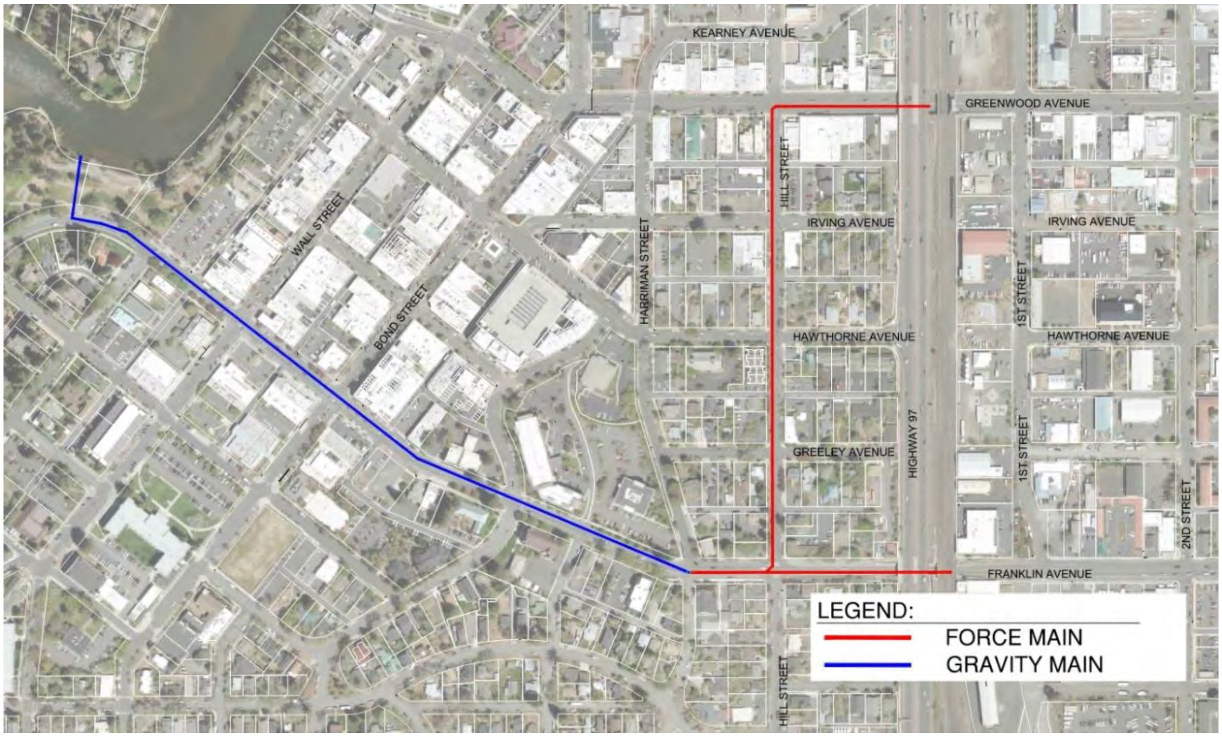


Figure 26. Combined system outfall to Deschutes River.

4.2.7.1.1 Cost Estimate

Table 26. Combined discharges to Deschutes River cost estimate.

-50%	Class V Cost Estimate	+100%
$2,534,750	$5,069,500	$10,139,000

4.2.7.2 Franklin Avenue Undercrossing

Individual pump systems that send stormwater to separate outfalls at the Deschutes River. One near Drake Park, and the other near the Newport Avenue bridge. This will require ±3260 feet of 12” pipe from Franklin to the river and ±2030 feet of 16” pipe from Greenwood to the river. See Figure 27 below. The cost estimate is presented as the cost to build both options in tandem. Franklin could be transitioned to gravity flow as it reaches the system high point.

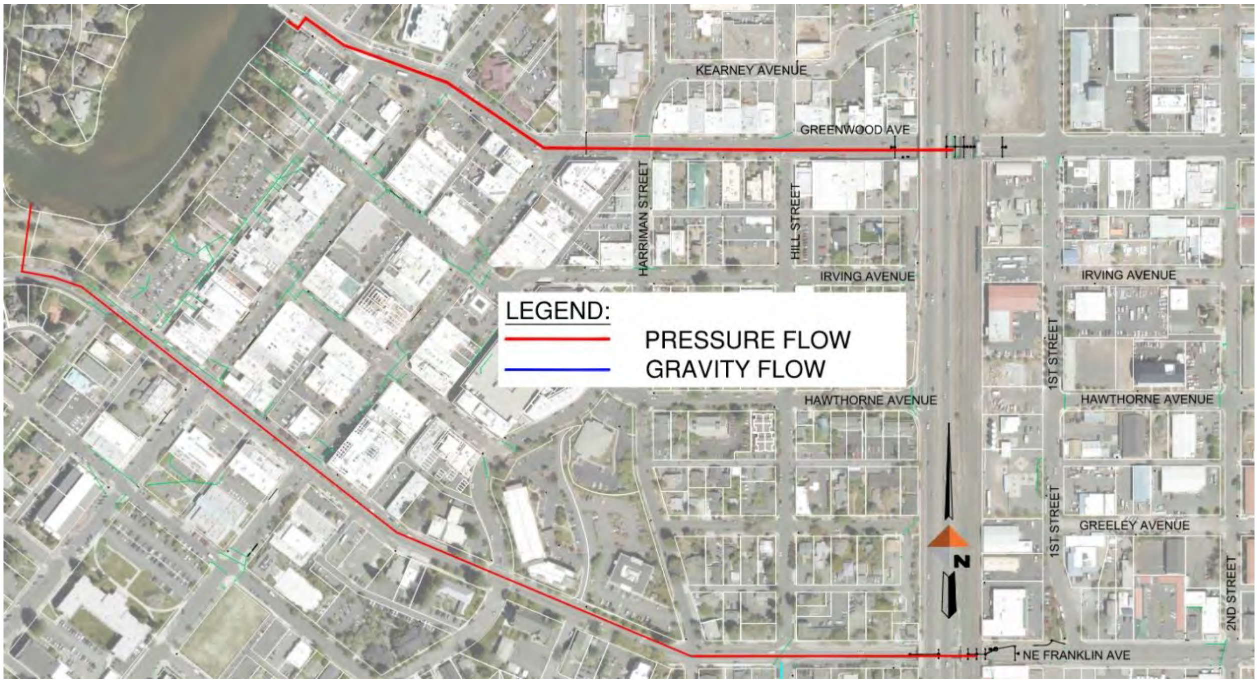


Figure 27. Individual outfalls to the Deschutes River.

4.2.7.2.1 Cost Estimate

Table 27. Separate discharges to Deschutes River cost estimate.

-50%	Class V Cost Estimate	+100%
$2,210,000	$4,420,000	$8,840,000

4.2.7.3 Greenwood Avenue Undercrossing

Individual pump systems that send stormwater to separate outfalls at the Deschutes River. One near Drake Park, and the other near the Newport Avenue bridge. This will require ±3260 feet of 12” pipe from Franklin to the river and ±2030 feet of 16” pipe from Greenwood to the river. See Figure 28. The cost estimate is presented as the cost to build both options in tandem. Greenwood could be transitioned to gravity flows as it reaches the system high point.

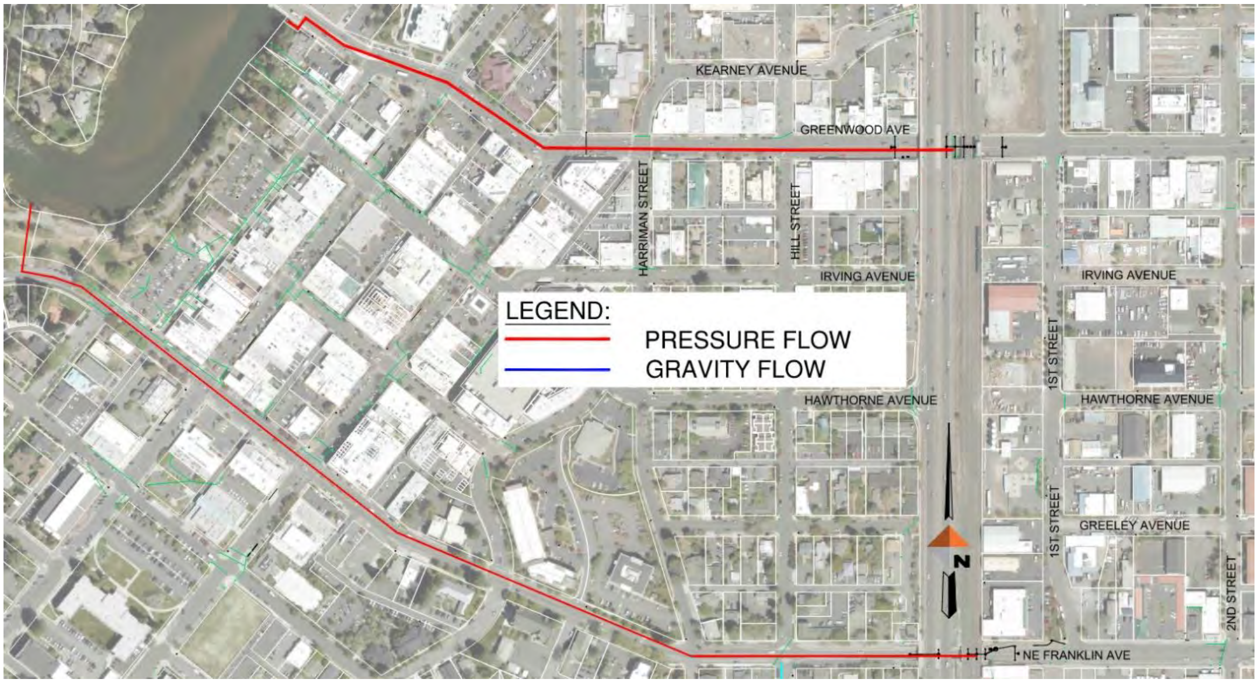


Figure 28. Individual outfalls to the Deschutes River.

4.2.7.3.1 Cost Estimate

Table 28. Separate discharges to Deschutes River cost estimate.

-50%	Class V Cost Estimate	+100%
$2,210,000	$4,420,000	$8,840,000

5.0 REPORT CONCLUSIONS

Through several meetings with City staff including the Stormwater Utility group, City Utilities, and Engineering, an option utilizing standard City catch basins, sedimentation manholes, and UICs (drywells) has been identified as the preferred alternative. Deep drywells may still be required on the western side of Franklin as space is extremely limited. Cost, operations and maintenance, permitting, and support from existing City standards also played a major role in the alternative selection. Overall, an alternative selecting standard stormwater UICs is supported by their operational efficiency, ease of permitting, and alignment with current standards making them a reliable choice for managing stormwater at these two critical undercrossings.

A storm water program to perform maintenance on existing storm infrastructure in the study area basins could be implemented by the City. This program may possibly perform routine maintenance like jetting and vactoring catch basins, pipes, drillholes, sedimentation manholes, and drywells, or it may go as far as to construct upstream improvements in the upper reaches of the basins. This would be followed by performance testing and detailed record taking of test results to further identify problem areas and facilities that may need updates, further rehabilitation, or replacement.

The pros and cons of each of the identified options has been summarized in Table 29 below.

Table 29. Summary of each option's pros and cons.

Storm Water BMP	Pro	Con
Deep Drywells	• Space efficiency. • Contained treatment system.	• Soil and drainage conditions difficult to determine. • High installation cost. • Lack of storage volume. • Dependency on extremely high exfiltration rates. • No opportunity for pre-construction testing. • Movement of pollutants deep underground. • No backup system. • Few implementations in City. • Not recommended for high traffic volume locations (ADT >1000)
Pump Station	• May handle a wide range of rainfall depths. • Future resilience in system. • May use pre-existing pond. • Eliminate need for large deep excavations.	• Not preferred by City staff. • Cost. • Regulatory permitting. • Overall footprint of installation. • Increased system complexity. • Complex. • Costly maintenance. • Difficult connection to existing pond.
Standard Drywell	• Familiar to City Utility staff. • Ease of maintenance. • Established City standards. • Cost. • Provide storage. • Footprint (post-construction). • Ground water recharge. • Highly versatile in many locations.	• Soil conditions impact suitability. • Maintenance requirements. • Groundwater contamination risk. • Capacity limitations. • Footprint (during construction). • Finite lifecycle unless properly maintained and constructed. • Due to space constraints may require design exception to place in roadway.

Table 30. "Red, yellow, green" table of criteria for each option.

	Criteria								
BMP	**Permitting/ Regulatory**	**Cost**	**Space Efficiency**	**Reliability**	**Versatility**	**Future Resilience**	**Environmental Impact**	**Operations & Maintenance**	**Complexity**
Standard UICs	🟩	🟩	🟨	🟩	🟨	🟨	🟨	🟩	🟩
Deep Drywells	🟥	🟥	🟩	🟥	🟨	🟨	🟥	🟨	🟥
Pump Stations - Pond	🟨	🟥	🟨	🟩	🟩	🟩	🟩	🟥	🟥
Pump Stations - UICs	🟨	🟥	🟨	🟩	🟨	🟨	🟩	🟥	🟥
Pump Station - River	🟥	🟥	🟨	🟩	🟩	🟨	🟥	🟥	🟥

APPENDIX 1: COST ESTIMATES

Greenwood Contribution Basin Cost Estimate

Item No.	Description	Section	Unit	Unit Price	QTY	Total	Notes
1	Mobilization	00210	LS	$ 186,300.00	1	$ 186,300.00	
2	Temporary Work Zone Traffic Control, Complete	00221	LS	$ 93,150.00	1	$ 93,150.00	
3	Erosion Control	00280	LS	$ 11,550.60	1	$ 11,550.60	
4	Concrete Washout Facility	00280	EA	$ 951.73	1	$ 951.73	
5	Inlet Protection	00280	EA	$ 41.00	38	$ 1,558.00	
6	Pollution Control Plan	00290	LS	$ 1,000.00	1	$ 1,000.00	
7	Removal of Curbs	00310	FT	$ 6.96	340	$ 2,366.40	
8	Removal of Walks and Driveways	00310	SY	$ 60.53	190	$ 11,500.70	
9	Asphalt and Concrete Saw Cutting	00310	FT	$ 2.88	2040	$ 5,875.20	
10	8 Inch C900 PVC Storm Sewer Pipe	00445	FT	$ 285.21	1700	$ 484,857.00	
11	Catch Basin, Combination Catch Basin Inlet	00470	EA	$ 3,357.67	38	$ 127,591.46	
12	Concrete Manholes, Sedimentation Manhole	00470	EA	$ 10,500.00	19	$ 199,500.00	
13	Drywell Facility	00470	EA	$ 31,685.11	17	$ 538,646.87	
14	Field Explorations	00498	LS	$ 13,570.81	1	$ 13,570.81	
15	Aggregate Base	00641	TON	$ 45.00	250	$ 11,250.00	
16	Level 3, 1/2 Inch ACP with PG 64-28 Asphalt	00744	TON	$ 150.00	463	$ 69,450.00	
17	Concrete Walks	00759	SF	$ 12.39	2040	$ 25,275.60	
18	Concrete Curbs, 16 Inch Standard Curb	00759	FT	$ 23.00	340	$ 7,820.00	
19	Landscaping	01040	SY	$ 35.00	2040	$ 71,400.00	
Greenwood Contribution Base Bid Subtotal						**$ 1,863,614.37**	

Allowance & Contingency

Item No.	Description	Section	Unit	Unit Price	QTY	Total
	Engineering Design Services		%	10%	$ 1,863,614.37	$ 186,361.44
						$ -
Total						$ 1,863,614.37
Gwood Storm Contribution Class 5 Estimate Range					**-50%**	**$ (931,807.19)**
					100%	**$ 1,863,614.37**
				$ 931,807	**to**	**$ 3,727,229**

Greenwood Upper Basins Cost Estimate

Item No.	Description	Section	Unit	Unit Price	QTY	Total	Notes
1	Mobilization	00210	LS	$ 383,000.00	1	$ 383,000.00	
2	Temporary Work Zone Traffic Control, Complete	00221	LS	$ 191,500.00	1	$ 191,500.00	
3	Erosion Control	00280	LS	$ 23,746.00	1	$ 23,746.00	
4	Concrete Washout Facility	00280	EA	$ 951.73	1	$ 951.73	
5	Inlet Protection	00280	EA	$ 41.00	92	$ 3,772.00	
6	Pollution Control Plan	00290	LS	$ 1,000.00	1	$ 1,000.00	
7	Removal of Curbs	00310	FT	$ 6.96	920	$ 6,403.20	
8	Removal of Walks and Driveways	00310	SY	$ 60.53	204	$ 12,348.12	
9	Asphalt and Concrete Saw Cutting	00310	FT	$ 2.88	3680	$ 10,598.40	
10	8 Inch C900 PVC Storm Sewer Pipe	00445	FT	$ 285.21	2760	$ 787,179.60	
11	Catch Basin, Combination Catch Basin Inlet	00470	EA	$ 3,357.67	90	$ 302,190.30	
12	Concrete Manholes, Sedimentation Manhole	00470	EA	$ 10,500.00	46	$ 483,000.00	
13	Drywell Facility	00470	EA	$ 31,685.11	46	$ 1,457,515.06	
14	Field Explorations	00498	LS	$ 13,570.81	1	$ 13,570.81	
15	Aggregate Base	00641	TON	$ 45.00	403	$ 18,135.00	
16	Level 3, 1/2 Inch ACP with PG 64-28 Asphalt	00744	TON	$ 150.00	205	$ 30,750.00	
17	Concrete Walks	00759	SF	$ 12.39	5520	$ 68,392.80	
18	Concrete Curbs, 16 Inch Standard Curb	00759	FT	$ 23.00	920	$ 21,160.00	
19	Landscaping	01040	SY	$ 35.00	370	$ 12,950.00	
Greenwood Upper Base Bid Subtotal						**$ 3,828,163.02**	

Allowance & Contingency

Item No.	Description	Section	Unit	Unit Price	QTY	Total
	Engineering Design Services		%	10%	$ 3,828,163.02	$ 382,816.30
						$ -
Total					$	3,828,163.02
Greenwood Storm Upper Class 5 Estimate Range					**-50%**	**$ (1,914,081.51)**
					100%	**$ 3,828,163.02**
				$ 1,914,082	**to**	**$ 7,656,326**

Franklin Contribution Basin Cost Estimate

Item No.	Description	Section	Unit	Unit Price	QTY	Total	Notes
1	Mobilization	00210	LS	$ 50,900.00	1	$ 50,900.00	
2	Erosion Control	00280	LS	$ 3,155.80	1	$ 3,155.80	
3	Inlet Protection	00280	EA	$ 41.00	16	$ 656.00	
4	8 Inch C900 PVC Storm Sewer Pipe	00445	FT	$ 285.21	460	$ 131,196.60	
5	Catch Basin, Combination Catch Basin Inlet	00470	EA	$ 3,357.67	16	$ 53,722.72	
6	Concrete Manholes, Sedimentation Manhole	00470	EA	$ 10,500.00	6	$ 63,000.00	
7	Drywell Facility	00470	EA	$ 31,685.11	6	$ 190,110.66	
8	Field Explorations	00498	LS	$ 13,570.81	1	$ 13,570.81	
9	8 Inch Gate Valve	01150	EA	$ 2,579.27	1	$ 2,579.27	
Franklin Contribution Base Bid Subtotal						**$ 508,891.86**	

Allowance & Contingency

Item No.	Description	Section	Unit	Unit Price	QTY	Total
	Engineering Design Services		%	10%	$ 508,891.86	$ 50,889.19
Total						$ 508,891.86
Franklin Contribution Storm Upper Class 5 Estimate Range					**-50%**	**$ (254,445.93)**
					100%	**$ 508,891.86**
				$ 254,446	**to**	**$ 1,017,784**

Franklin Upper Basin Cost Estimate

Item No.	Description	Section	Unit	Unit Price	QTY	Total	Notes
1	Mobilization	00210	LS	$ 85,000.00	1	$ 85,000.00	
2	Temporary Work Zone Traffic Control, Complete	00221	LS	$ 42,500.00	1	$ 42,500.00	
3	Erosion Control	00280	LS	$ 5,270.00	1	$ 5,270.00	
4	Concrete Washout Facility	00280	EA	$ 951.73	1	$ 951.73	
5	Inlet Protection	00280	EA	$ 41.00	32	$ 1,312.00	
6	Pollution Control Plan	00290	LS	$ 1,000.00	1	$ 1,000.00	
7	Removal of Curbs	00310	FT	$ 6.96	200	$ 1,392.00	
8	Removal of Walks and Driveways	00310	SY	$ 60.53	111	$ 6,718.83	
9	Asphalt and Concrete Saw Cutting	00310	FT	$ 2.88	800	$ 2,304.00	
10	8 Inch C900 PVC Storm Sewer Pipe	00445	FT	$ 285.21	600	$ 171,126.00	
11	Catch Basin, Combination Catch Basin Inlet	00470	EA	$ 3,357.67	20	$ 67,153.40	
12	Concrete Manholes, Sedimentation Manhole	00470	EA	$ 10,500.00	10	$ 105,000.00	
13	Drywell Facility	00470	EA	$ 31,685.11	10	$ 316,851.10	
14	Field Explorations	00498	LS	$ 13,570.81	1	$ 13,570.81	
15	Aggregate Base	00641	TON	$ 45.00	6	$ 270.00	
16	Level 3, 1/2 Inch ACP with PG 64-28 Asphalt	00744	TON	$ 150.00	45	$ 6,750.00	
17	Concrete Walks	00759	SF	$ 12.39	1200	$ 14,868.00	
18	Concrete Curbs, 16 Inch Standard Curb	00759	FT	$ 23.00	200	$ 4,600.00	
19	Landscaping	01040	SY	$ 35.00	70	$ 2,450.00	
Franklin Upper Base Bid Subtotal						**$ 849,087.87**	

Allowance & Contingency

Item No.	Description	Section	Unit	Unit Price	QTY	Total
	Engineering Design Services		%	10%	$ 849,087.87	$ 84,908.79
Total					$	849,087.87
Franklin Upper Basins Class 5 Estimate Range					**-50%**	**$ (424,543.94)**
					100%	**$ 849,087.87**
				$ 424,544	**to**	**$ 1,698,176**

Midtown Crossing - Storm Report - Cost Estimate
10/18/2024

Undercrossing Option #1 - Pumping to Colorado Interchange

Bid item	Quantity	Unit	Unit Price	Total
Greenwood Duplex pump Station	1	EA	$ 1,400,000.00	$ 1,400,000.00
Franklin Duplex Pump Station	1	EA	$ 850,000.00	$ 850,000.00
12" C900 Pipe	610	LF	$ 200.00	$ 122,000.00
16" C900 Pipe	1820	LF	$ 300.00	$ 546,000.00
24" C900 Pipe	2420	LF	$ 450.00	$ 1,089,000.00
Trench Patch	980	TON	$ 200.00	$ 196,000.00
Traffic Control	1	LS	$ 150,000.00	$ 150,000.00
Mobilization	1	LS	$ 450,000.00	$ 450,000.00
Subtotal				**$ 4,803,000.00**

Undercrossing Option #2 - Pumping to UICs

Bid item	Quantity	Unit	Unit Price	Total
Greenwood Duplex pump Station	1	EA	$ 1,400,000.00	$ 1,400,000.00
Franklin Duplex Pump Station	1	EA	$ 850,000.00	$ 850,000.00
12" C900 Pipe	1350	LF	$ 200.00	$ 270,000.00
16" C900 Pipe	950	LF	$ 300.00	$ 285,000.00
Drywells	29	EA	$ 40,000.00	$ 1,160,000.00
Trench Patch	350	TON	$ 200.00	$ 70,000.00
Traffic Control	1	LS	$ 150,000.00	$ 150,000.00
Mobilization	1	LS	$ 450,000.00	$ 450,000.00
Subtotal				**$ 4,635,000.00**

Undercrossing Option #3 - Pumping to Deschutes Combined

Bid item	Quantity	Unit	Unit Price	Total
Greenwood Duplex pump Station	1	EA	$ 1,400,000.00	$ 1,400,000.00
Franklin Duplex Pump Station	1	EA	$ 850,000.00	$ 850,000.00
12" C900 Pipe	610	LF	$ 200.00	$ 122,000.00
16" C900 Pipe	1820	LF	$ 300.00	$ 546,000.00
24" C900 Pipe	2770	LF	$ 450.00	$ 1,246,500.00
River Outfall	1	EA	$ 50,000.00	$ 50,000.00
Trench Patch	1050	TON	$ 200.00	$ 210,000.00
Traffic Control	1	LS	$ 170,000.00	$ 170,000.00
Mobilization	1	LS	$ 475,000.00	$ 475,000.00
Subtotal				**$ 5,069,500.00**

Undercrossing Option #4 - Pumping to Deschutes Separate Outfalls

Bid item	Quantity	Unit	Unit Price	Total
Greenwood Duplex pump Station	1	EA	$ 1,400,000.00	$ 1,400,000.00
Franklin Duplex Pump Station	1	EA	$ 850,000.00	$ 850,000.00
12" C900 Pipe	3260	LF	$ 200.00	$ 652,000.00
16" C900 Pipe	2030	LF	$ 300.00	$ 609,000.00
River Outfall	2	EA	$ 50,000.00	$ 100,000.00
Trench Patch	1070	TON	$ 200.00	$ 214,000.00
Traffic Control	1	LS	$ 170,000.00	$ 170,000.00
Mobilization	1	LS	$ 425,000.00	$ 425,000.00
Subtotal				**$ 4,420,000.00**

APPENDIX 2: NRCS WEB SOIL SURVEY REPORT

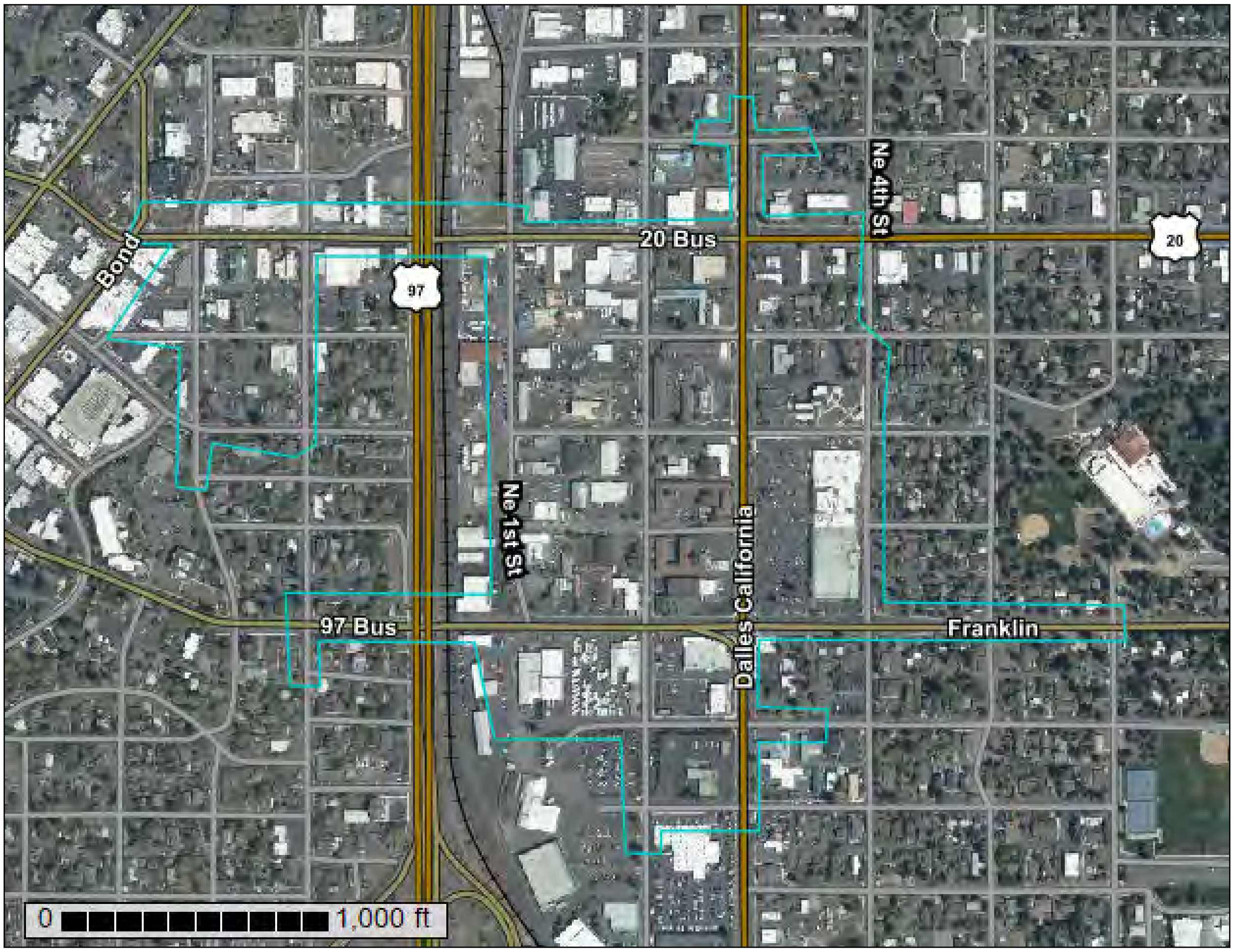
United States
Department of
Agriculture

Natural
Resources
Conservation
Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Upper Deschutes River Area, Oregon, Parts of Deschutes, Jefferson, and Klamath Counties

Midtown Stormwater Report



June 19, 2024

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map

Map Scale: 1:7,330 if printed on A landscape (11" x 8.5") sheet.

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

- □ Area of Interest (AOI)

Soils

- □ Soil Map Unit Polygons
- 〰 Soil Map Unit Lines
- ■ Soil Map Unit Points

Special Point Features

- ◎ Blowout
- ☒ Borrow Pit
- ✱ Clay Spot
- ◇ Closed Depression
- ✕ Gravel Pit
- ∴ Gravelly Spot
- ⊗ Landfill
- Λ Lava Flow
- ψ Marsh or swamp
- ⚒ Mine or Quarry
- ◎ Miscellaneous Water
- ○ Perennial Water
- ∨ Rock Outcrop
- + Saline Spot
- ⁙ Sandy Spot
- ⊖ Severely Eroded Spot
- ◇ Sinkhole
- ≫ Slide or Slip
- ∅ Sodic Spot
- ≡ Spoil Area
- ◆ Stony Spot
- ◆ Very Stony Spot
- ψ Wet Spot
- △ Other
- ▪ Special Line Features

Water Features

- 〰 Streams and Canals

Transportation

- ┼┼┼ Rails
- 〰 Interstate Highways
- 〰 US Routes
- 〰 Major Roads
- 〰 Local Roads

Background

- ▨ Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Upper Deschutes River Area, Oregon, Parts of Deschutes, Jefferson, and Klamath Counties
Survey Area Data: Version 21, Sep 8, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 7, 2020—Jun 2, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

MAP LEGEND	MAP INFORMATION
	imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
155C	Wanoga sandy loam, 0 to 15 percent slopes	69.2	75.1%
157C	Wanoga-Fremkle-Rock outcrop complex, 0 to 15 percent slopes	22.9	24.9%
Totals for Area of Interest		**92.1**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Upper Deschutes River Area, Oregon, Parts of Deschutes, Jefferson, and Klamath Counties

155C—Wanoga sandy loam, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2425
Elevation: 2,800 to 4,000 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 42 to 47 degrees F
Frost-free period: 60 to 90 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Wanoga and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Wanoga

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Volcanic ash over tuff or basalt

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
H1 - 1 to 13 inches: sandy loam
H2 - 13 to 25 inches: sandy loam
H3 - 25 to 35 inches: weathered bedrock
H4 - 35 to 45 inches: unweathered bedrock

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock; 30 to 50 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: F006XY708OR - Frigid Xeric Foothills 12-20 PZ
Hydric soil rating: No

157C—Wanoga-Fremkle-Rock outcrop complex, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 242b
Elevation: 2,800 to 4,000 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 42 to 47 degrees F
Frost-free period: 60 to 90 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Wanoga and similar soils: 35 percent
Fremkle and similar soils: 30 percent
Rock outcrop: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Wanoga

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Nose slope, interfluve, crest
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Volcanic ash over tuff or basalt

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
H1 - 1 to 13 inches: sandy loam
H2 - 13 to 25 inches: sandy loam
H3 - 25 to 35 inches: weathered bedrock
H4 - 35 to 45 inches: unweathered bedrock

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock; 30 to 50 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: F006XY708OR - Frigid Xeric Foothills 12-20 PZ
Hydric soil rating: No

Description of Fremkle

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Nose slope, interfluve, crest
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Volcanic ash over tuff or basalt

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
H1 - 1 to 4 inches: sandy loam
H2 - 4 to 15 inches: sandy loam
H3 - 15 to 25 inches: unweathered bedrock

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.1 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: R006XB002OR - Frigid Xeric Lava Plains 12-16 PZ
Hydric soil rating: No

Description of Rock Outcrop

Typical profile

R - 0 to 60 inches: unweathered bedrock

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: 0 inches to lithic bedrock

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: No

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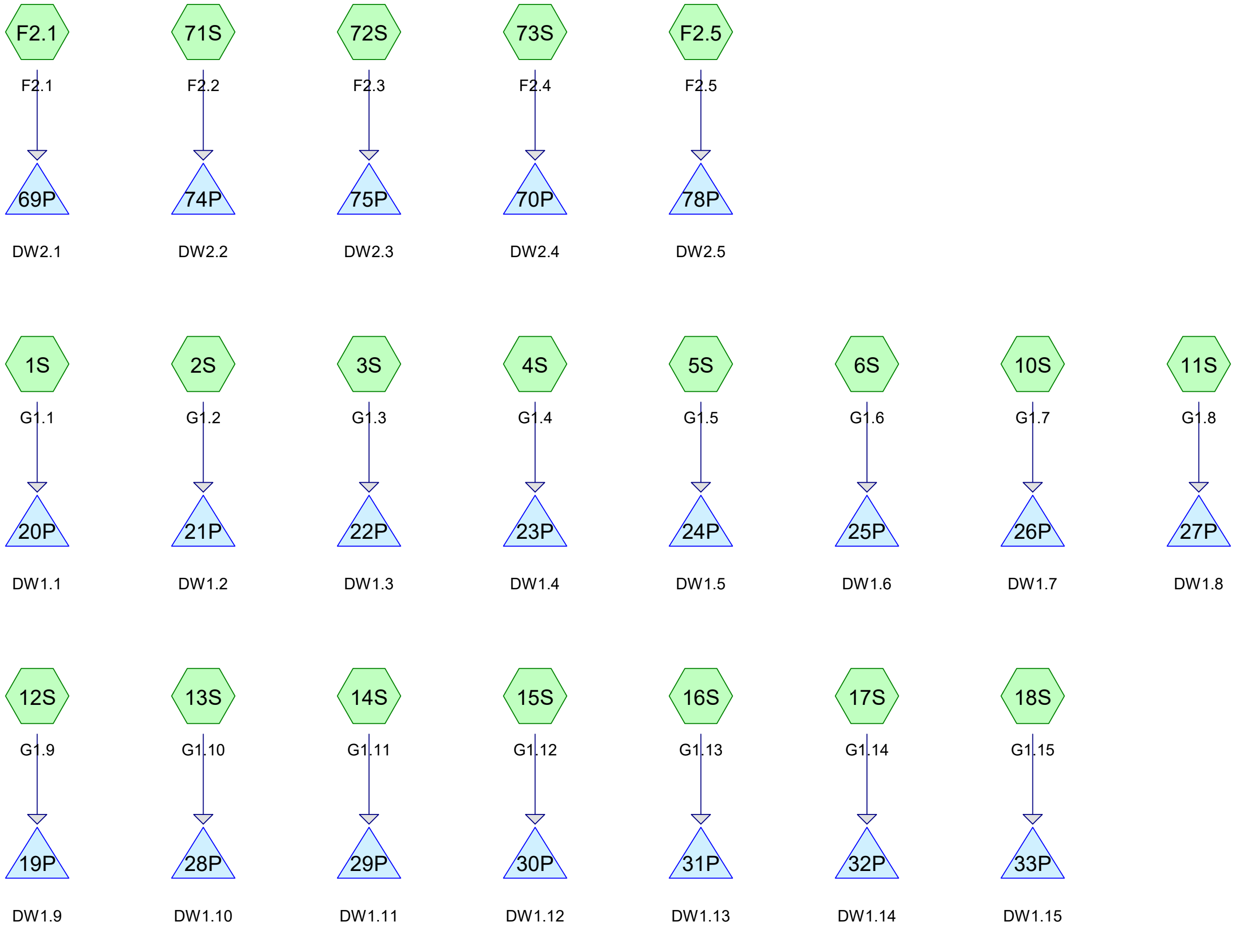
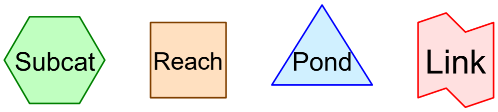
APPENDIX 3: HYDROCAD PLOTS





Routing Diagram for Midtown Crossings_ROW+20
Prepared by DOWL, Printed 10/16/2024
HydroCAD® 10.20-5a s/n 05397 © 2023 HydroCAD Software Solutions LLC

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	6MO-24HOUR	Type I 24-hr		Default	24.00	1	1.00	2
2	25YR-24HOUR	Type I 24-hr		Default	24.00	1	2.50	2
3	100YR-24HOUR	Type I 24-hr		Default	24.00	1	3.00	2

Summary for Subcatchment 1S: G1.1

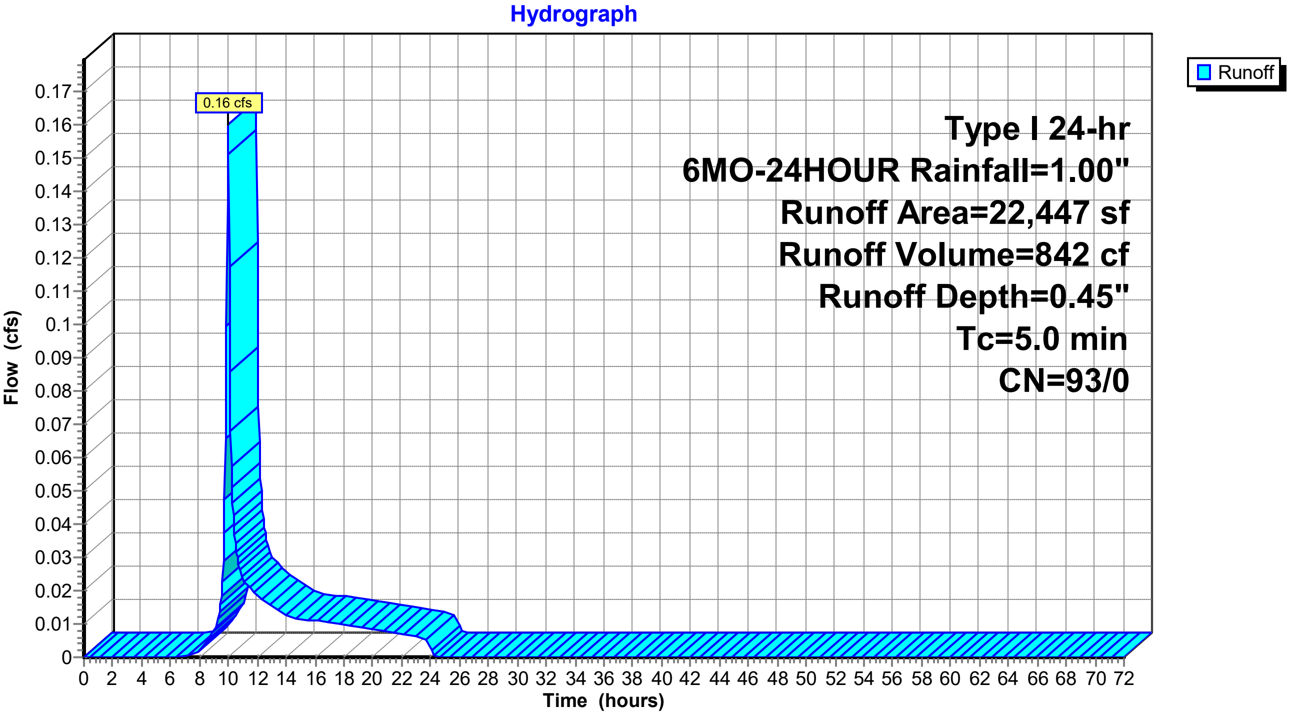
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 842 cf, Depth= 0.45"
Routed to Pond 20P : DW1.1

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,447	93	Paved roads w/curbs & sewers, HSG A
	22,447	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 1S: G1.1



Summary for Subcatchment 2S: G1.2

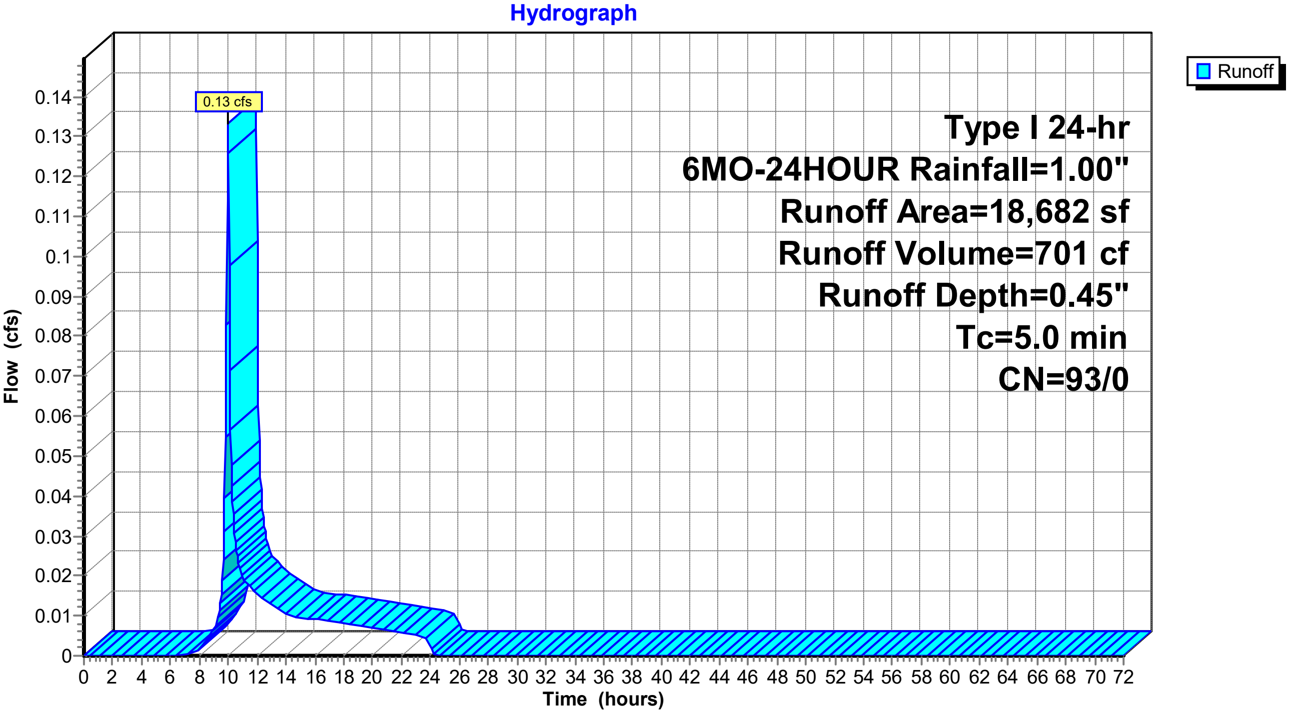
Runoff = 0.13 cfs @ 9.96 hrs, Volume= 701 cf, Depth= 0.45"
Routed to Pond 21P : DW1.2

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	18,682	93	Paved roads w/curbs & sewers, HSG A
	18,682	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 2S: G1.2



Summary for Subcatchment 3S: G1.3

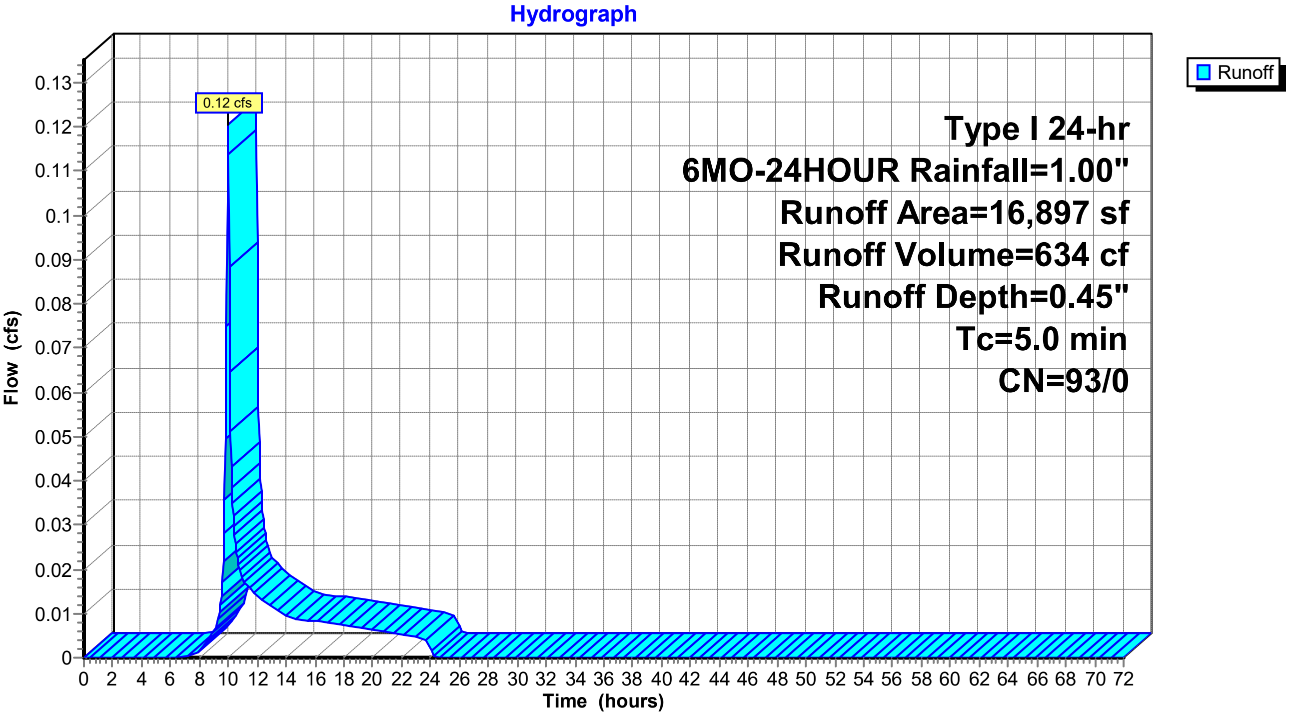
Runoff = 0.12 cfs @ 9.96 hrs, Volume= 634 cf, Depth= 0.45"
Routed to Pond 22P : DW1.3

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	16,897	93	Paved roads w/curbs & sewers, HSG A
	16,897	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 3S: G1.3



Summary for Subcatchment 4S: G1.4

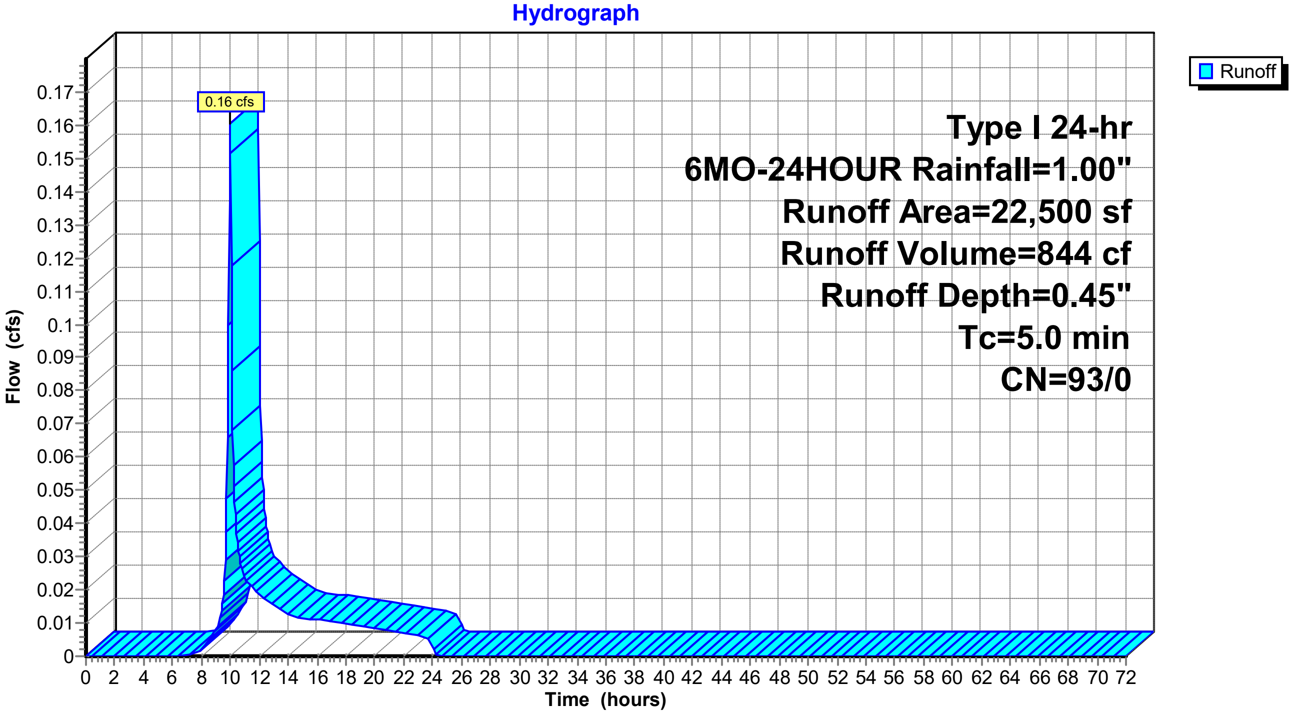
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 844 cf, Depth= 0.45"
Routed to Pond 23P : DW1.4

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 4S: G1.4



Summary for Subcatchment 5S: G1.5

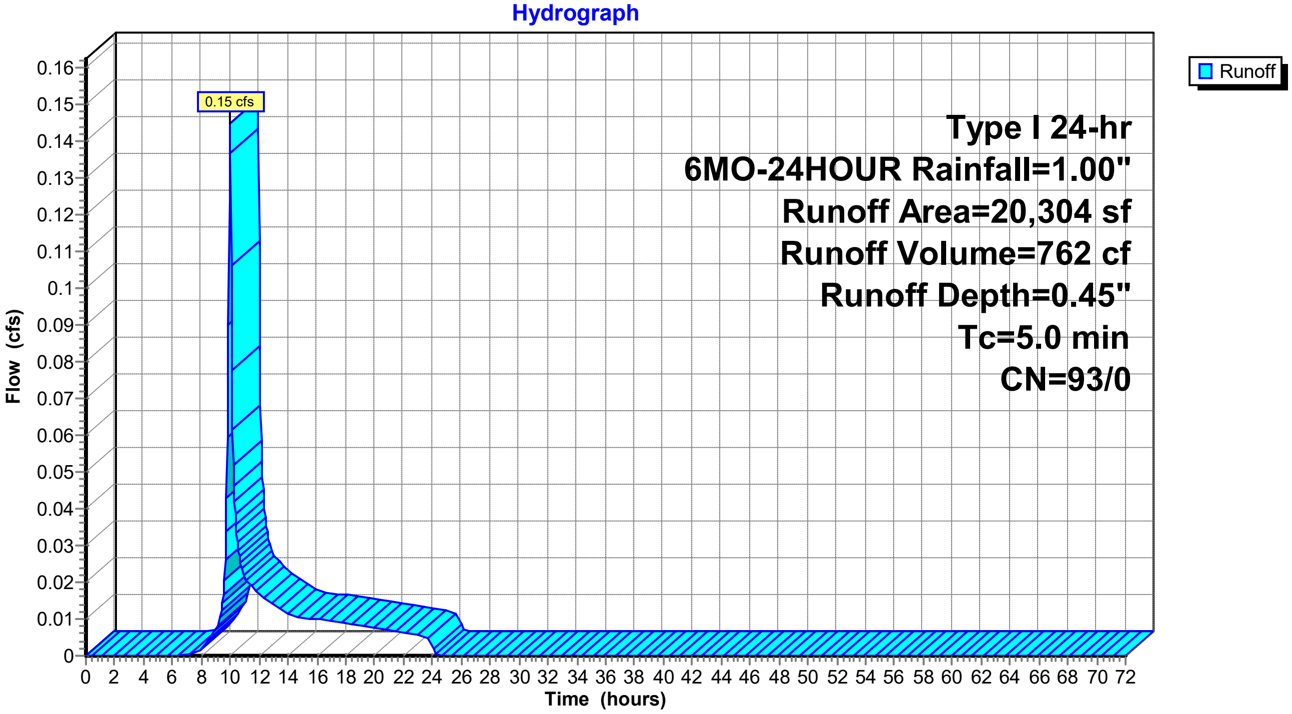
Runoff = 0.15 cfs @ 9.96 hrs, Volume= 762 cf, Depth= 0.45"
Routed to Pond 24P : DW1.5

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	20,304	93	Paved roads w/curbs & sewers, HSG A
	20,304	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 5S: G1.5



Summary for Subcatchment 6S: G1.6

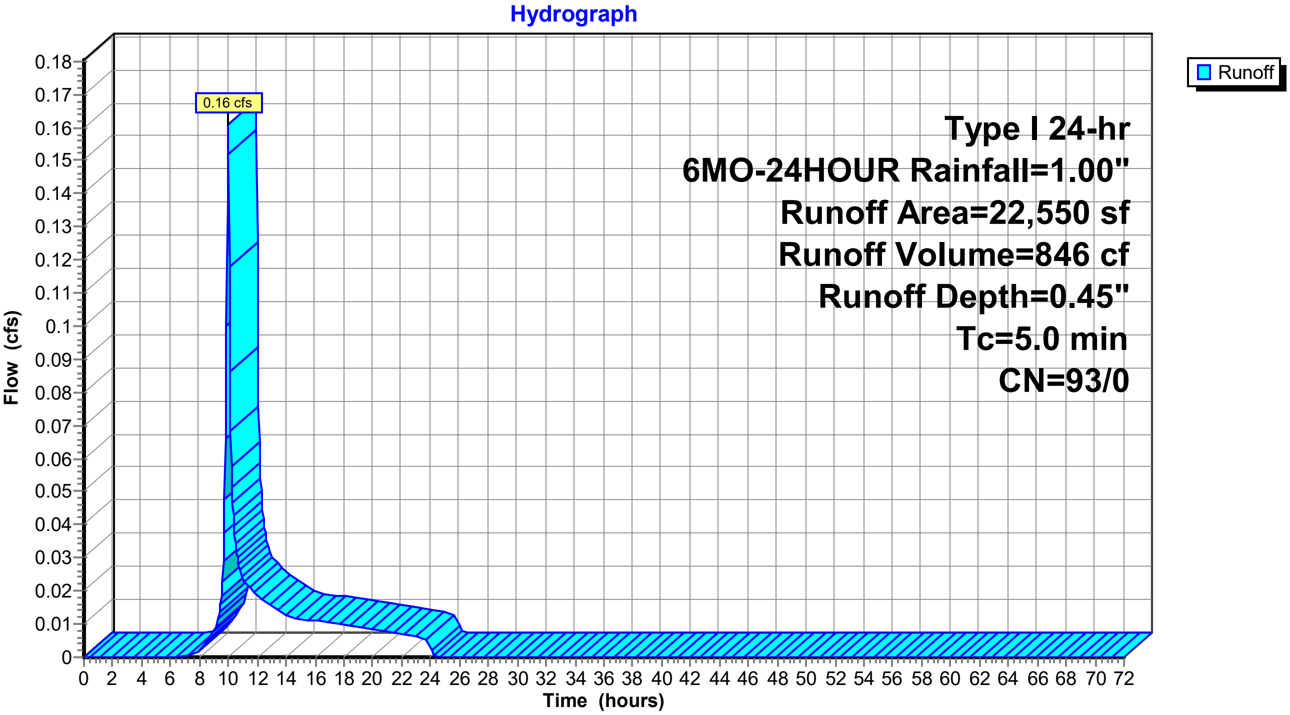
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 846 cf, Depth= 0.45"
Routed to Pond 25P : DW1.6

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,550	93	Paved roads w/curbs & sewers, HSG A
	22,550	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 6S: G1.6



Summary for Subcatchment 10S: G1.7

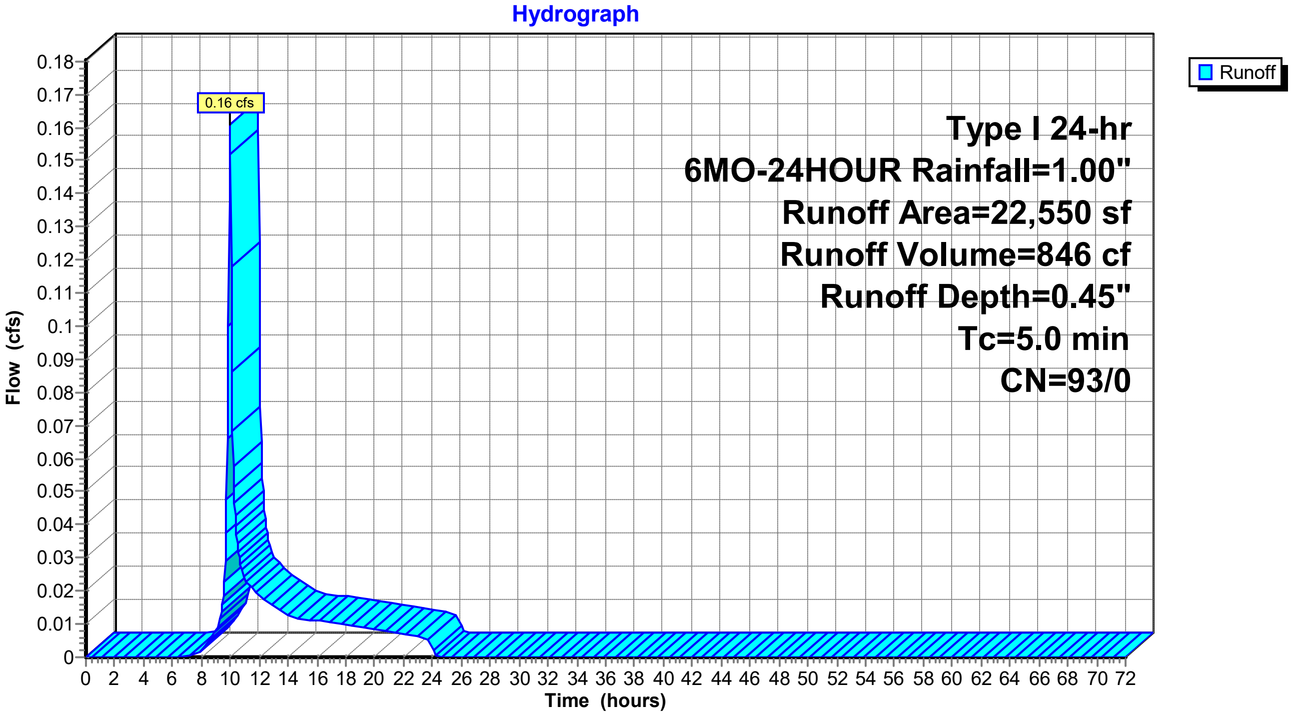
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 846 cf, Depth= 0.45"
Routed to Pond 26P : DW1.7

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,550	93	Paved roads w/curbs & sewers, HSG A
	22,550	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 10S: G1.7



Summary for Subcatchment 11S: G1.8

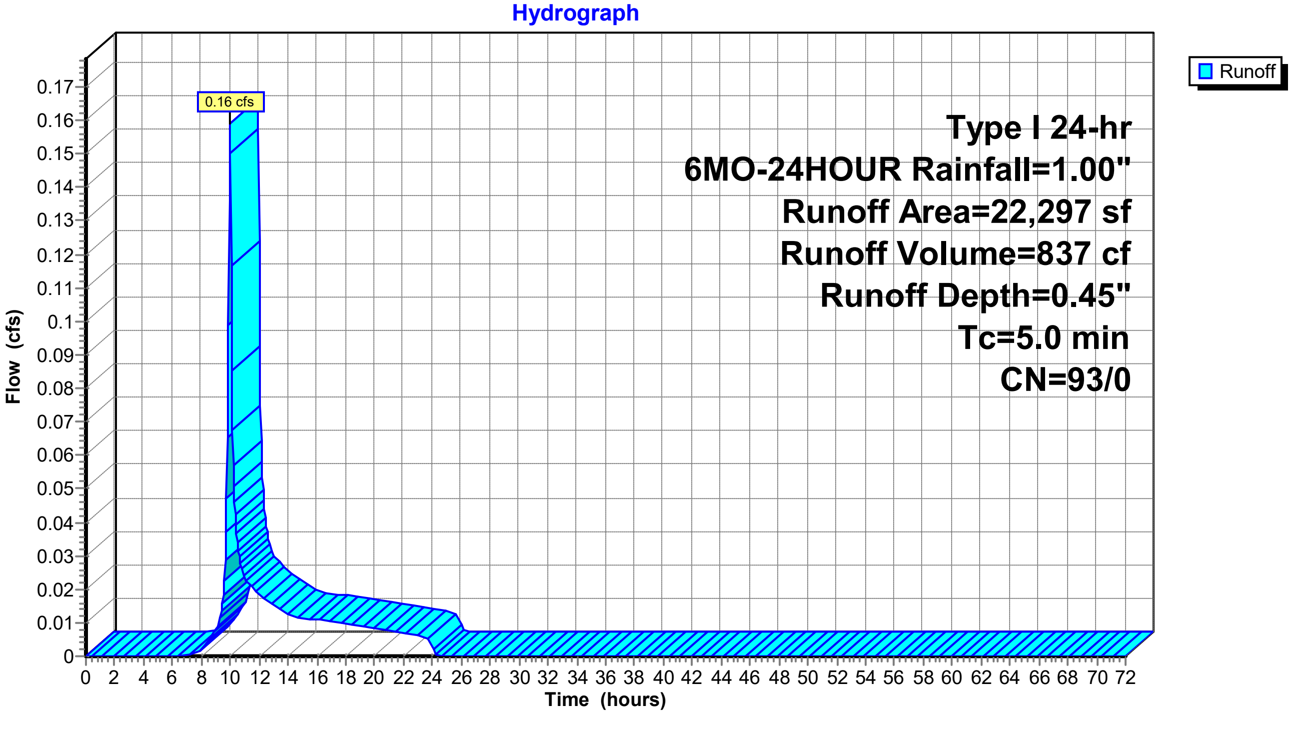
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 837 cf, Depth= 0.45"
Routed to Pond 27P : DW1.8

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,297	93	Paved roads w/curbs & sewers, HSG A
	22,297	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 11S: G1.8



Summary for Subcatchment 12S: G1.9

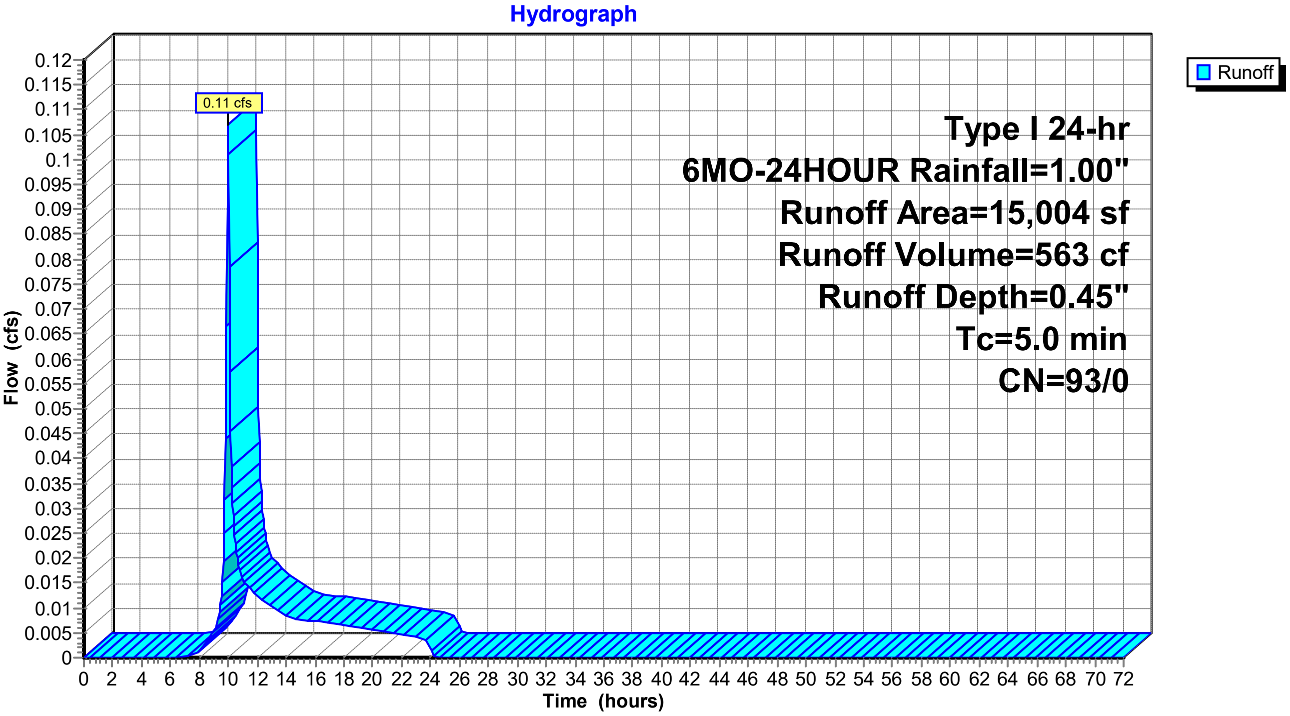
Runoff = 0.11 cfs @ 9.96 hrs, Volume= 563 cf, Depth= 0.45"
Routed to Pond 19P : DW1.9

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	15,004	93	Paved roads w/curbs & sewers, HSG A
	15,004	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 12S: G1.9



Summary for Subcatchment 13S: G1.10

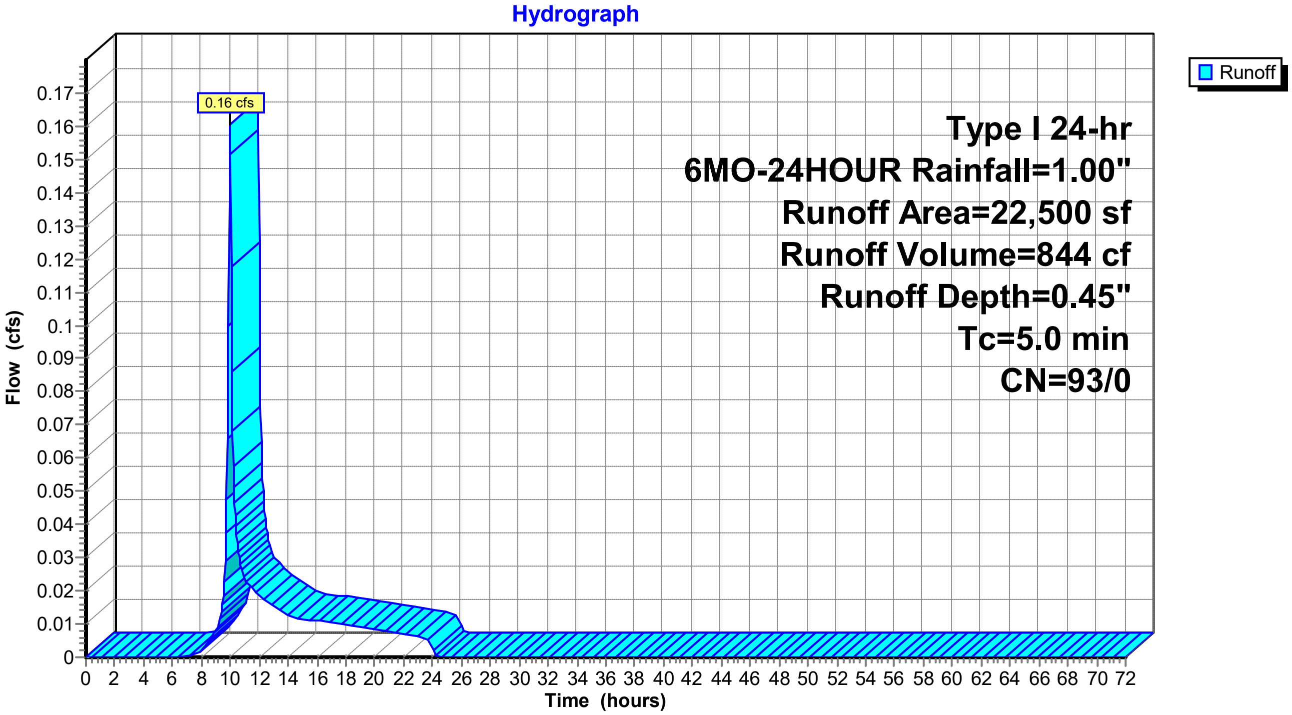
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 844 cf, Depth= 0.45"
Routed to Pond 28P : DW1.10

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 13S: G1.10



Summary for Subcatchment 14S: G1.11

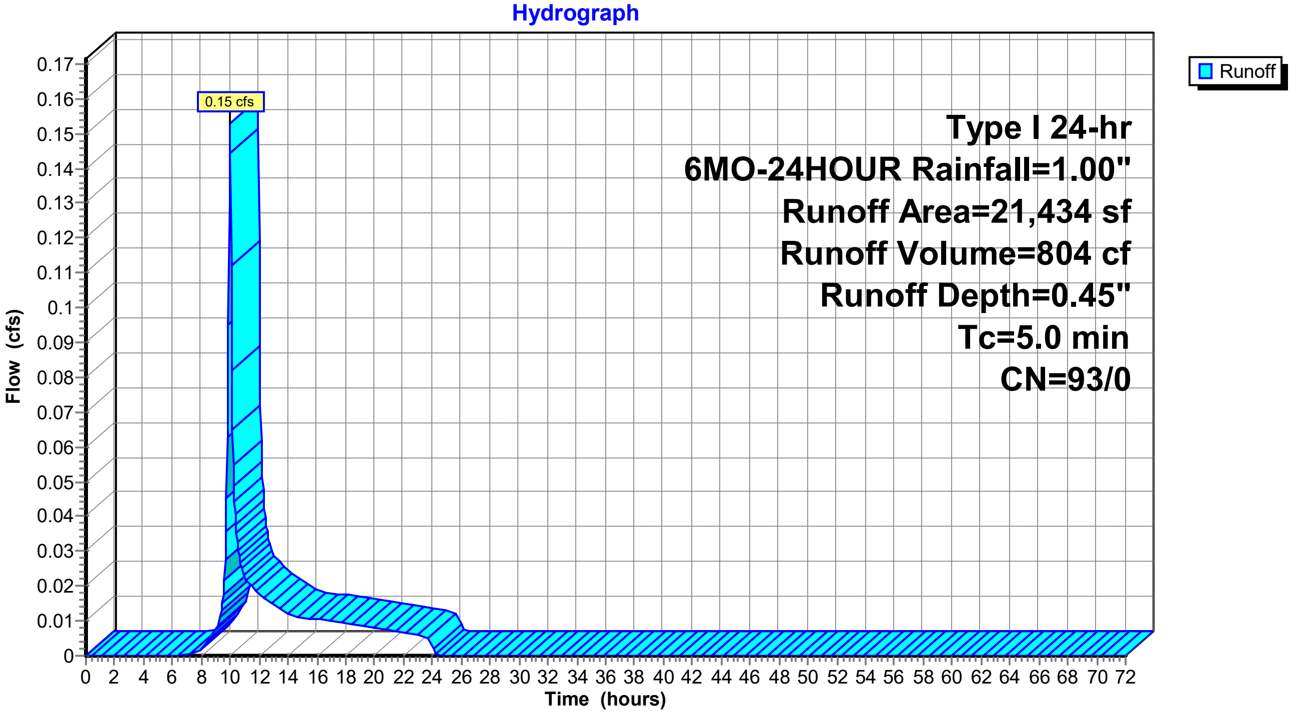
```
Runoff      =      0.15 cfs @    9.96 hrs,  Volume=            804 cf,  Depth=  0.45"
    Routed to Pond 29P : DW1.11
```

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	21,434	93	Paved roads w/curbs & sewers, HSG A
	21,434	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 14S: G1.11



Summary for Subcatchment 15S: G1.12

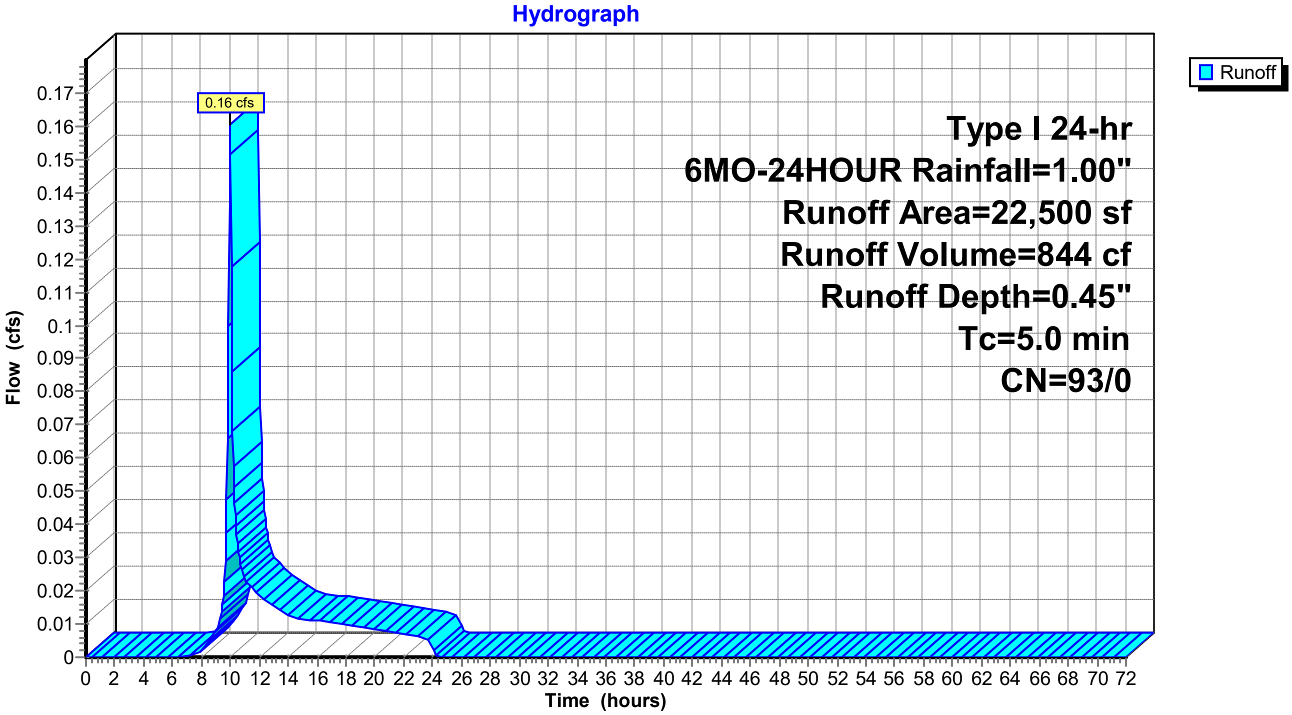
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 844 cf, Depth= 0.45"
Routed to Pond 30P : DW1.12

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 15S: G1.12



Summary for Subcatchment 16S: G1.13

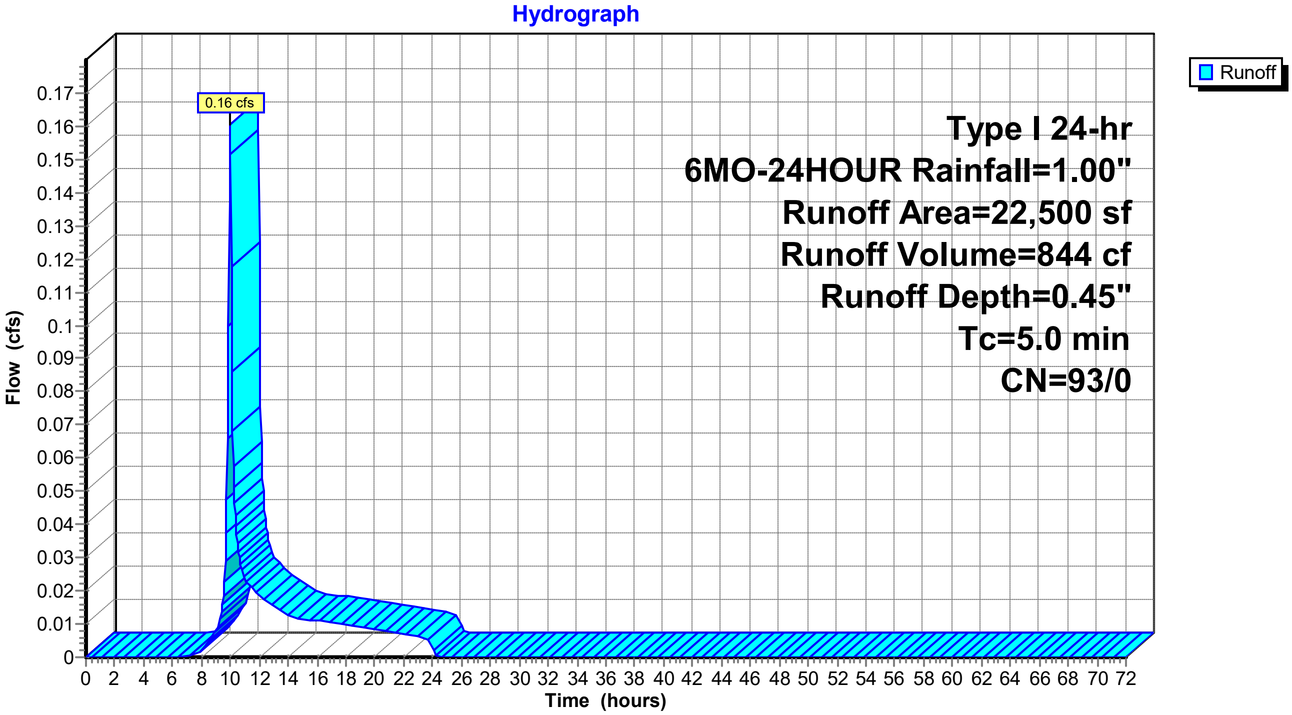
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 844 cf, Depth= 0.45"
Routed to Pond 31P : DW1.13

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 16S: G1.13



Summary for Subcatchment 17S: G1.14

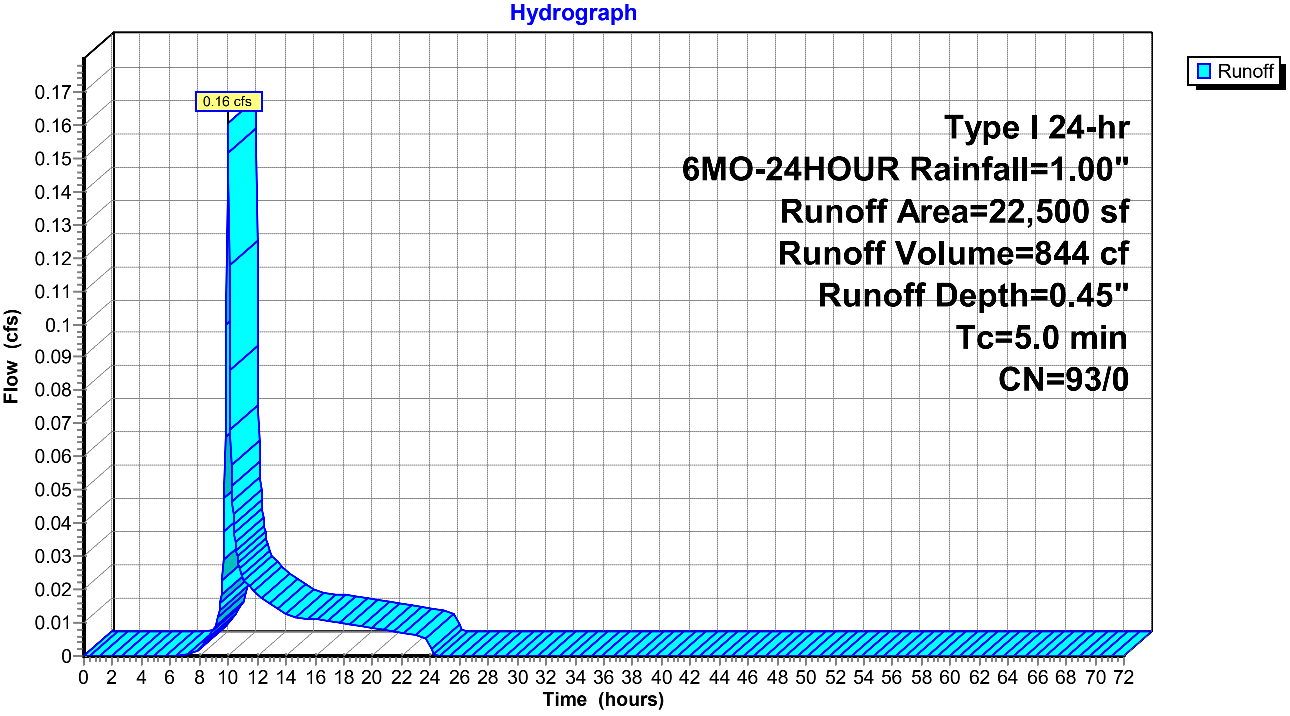
```
Runoff     =      0.16 cfs @   9.96 hrs,  Volume=            844 cf,  Depth=  0.45"
   Routed to Pond 32P : DW1.14
```

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 17S: G1.14



Summary for Subcatchment 18S: G1.15

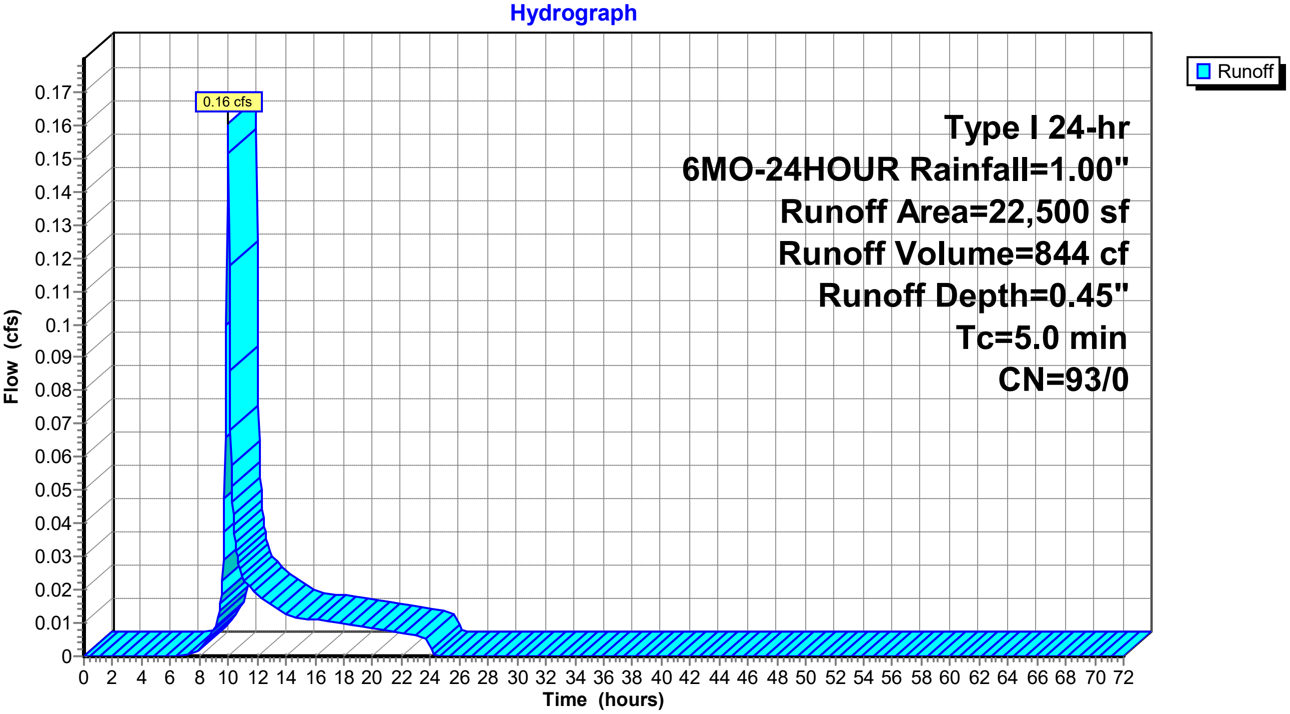
```
Runoff      =      0.16 cfs @   9.96 hrs,  Volume=           844 cf,  Depth=  0.45"
    Routed to Pond 33P : DW1.15
```

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 18S: G1.15



Summary for Pond 19P: DW1.9

Inflow Area = 15,004 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.11 cfs @ 9.96 hrs, Volume= 563 cf
Outflow = 0.08 cfs @ 9.95 hrs, Volume= 563 cf, Atten= 22%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.95 hrs, Volume= 563 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.22' @ 10.04 hrs Surf.Area= 225 sf Storage= 20 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 2.7 min calculated for 563 cf (100% of inflow)
Center-of-Mass det. time= 2.7 min (827.4 - 824.7)

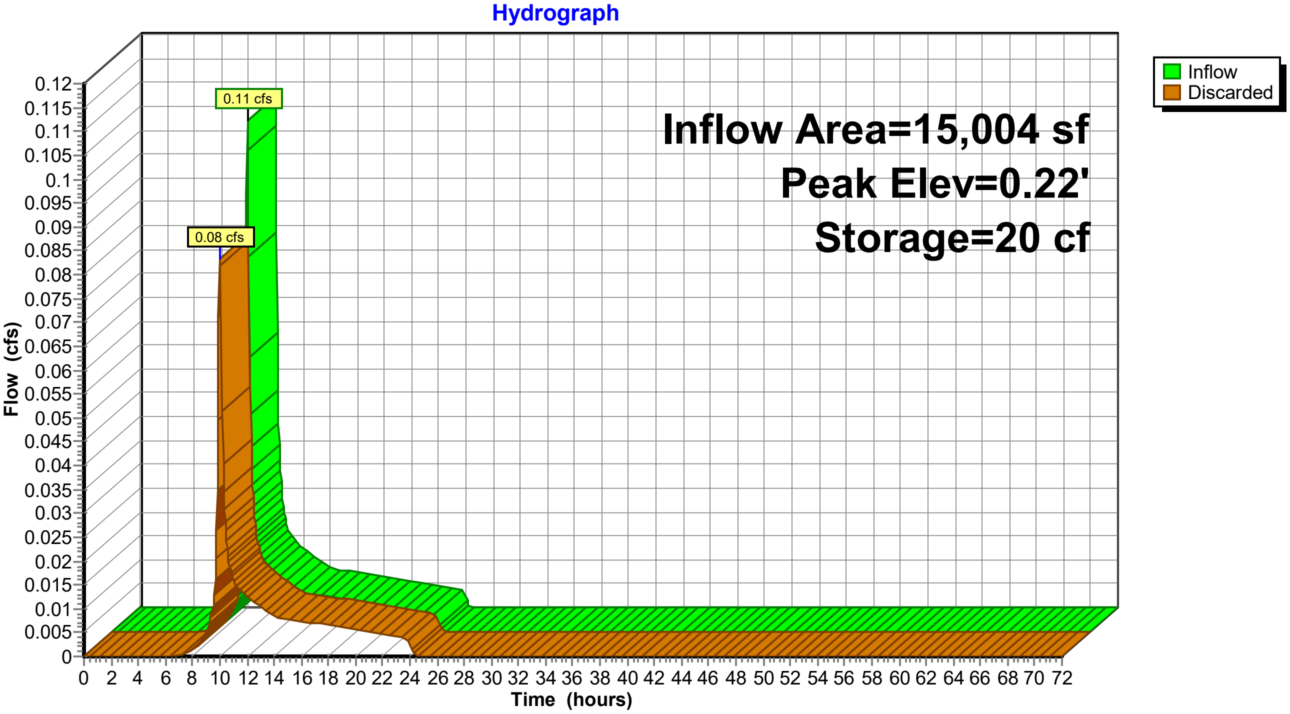
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.95 hrs HW=0.17' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 19P: DW1.9



Summary for Pond 20P: DW1.1

Inflow Area = 22,447 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.16 cfs @ 9.96 hrs, Volume= 842 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 842 cf, Atten= 48%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 842 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.62' @ 10.11 hrs Surf.Area= 225 sf Storage= 56 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 842 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

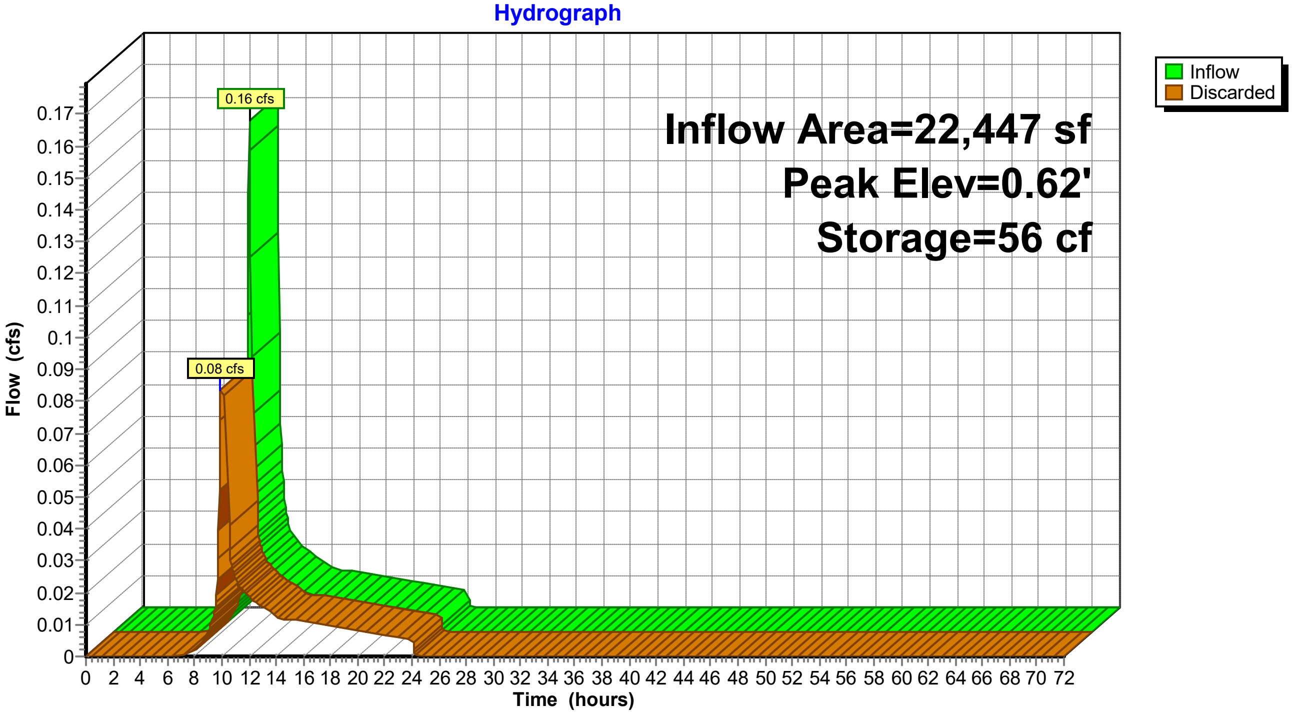
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 20P: DW1.1



Summary for Pond 21P: DW1.2

Inflow Area = 18,682 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.13 cfs @ 9.96 hrs, Volume= 701 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 701 cf, Atten= 38%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 701 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.39' @ 10.08 hrs Surf.Area= 225 sf Storage= 35 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.1 min calculated for 701 cf (100% of inflow)
Center-of-Mass det. time= 3.1 min (827.8 - 824.7)

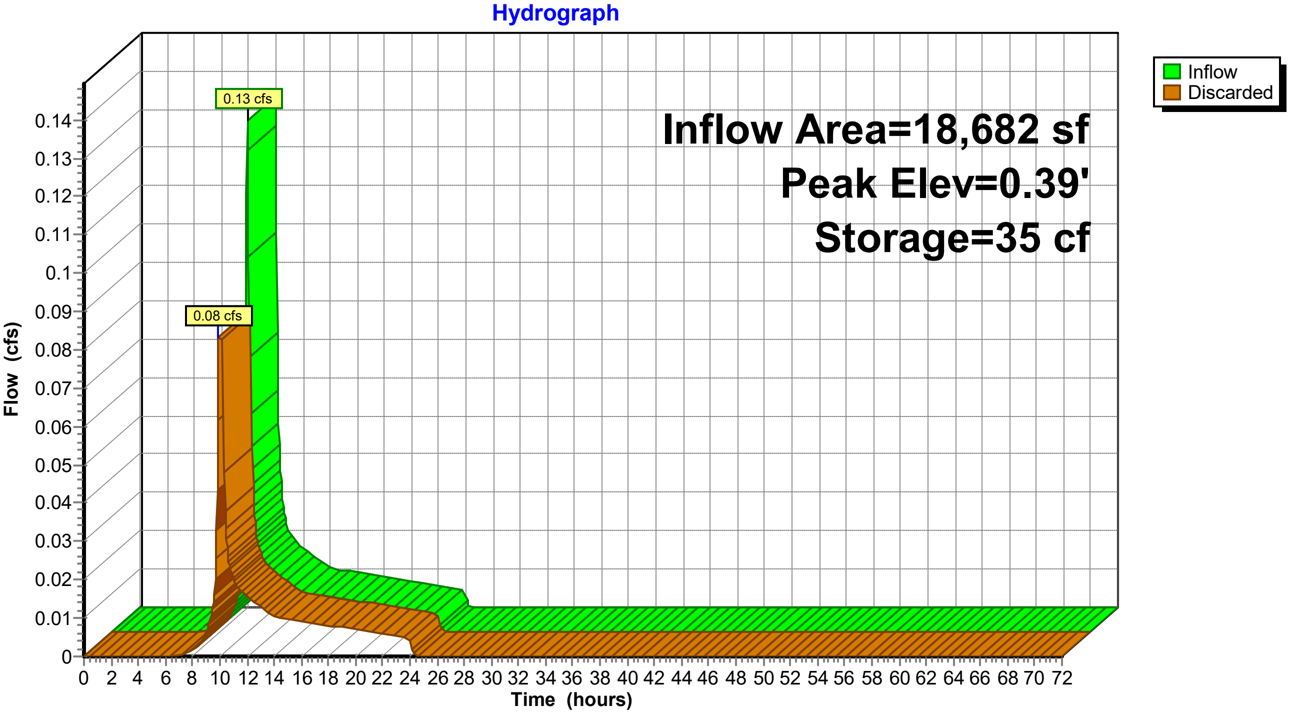
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.16' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 21P: DW1.2



Summary for Pond 22P: DW1.3

Inflow Area = 16,897 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.12 cfs @ 9.96 hrs, Volume= 634 cf
Outflow = 0.08 cfs @ 9.95 hrs, Volume= 634 cf, Atten= 31%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.95 hrs, Volume= 634 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.30' @ 10.06 hrs Surf.Area= 225 sf Storage= 27 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 2.9 min calculated for 634 cf (100% of inflow)
Center-of-Mass det. time= 2.9 min (827.6 - 824.7)

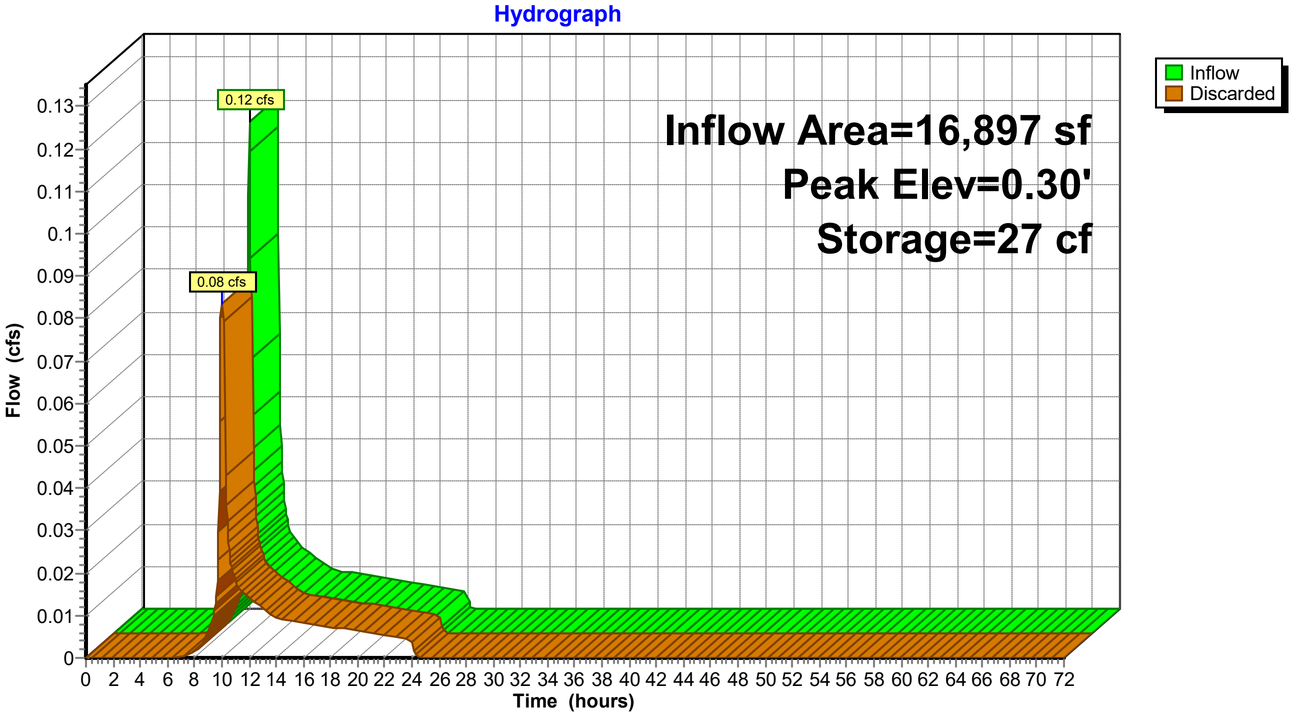
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.95 hrs HW=0.20' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 22P: DW1.3



Summary for Pond 23P: DW1.4

```
Inflow Area =         22,500 sf,   0.00% Impervious,  Inflow Depth =   0.45"    for  6MO-24HOUR event
Inflow       =       0.16 cfs @    9.96 hrs,  Volume=                844 cf
Outflow      =       0.08 cfs @    9.90 hrs,  Volume=                844 cf,  Atten= 48%,  Lag= 0.0 min
Discarded  =         0.08 cfs @    9.90 hrs,  Volume=                844 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs   Surf.Area= 225 sf   Storage= 56 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 844 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

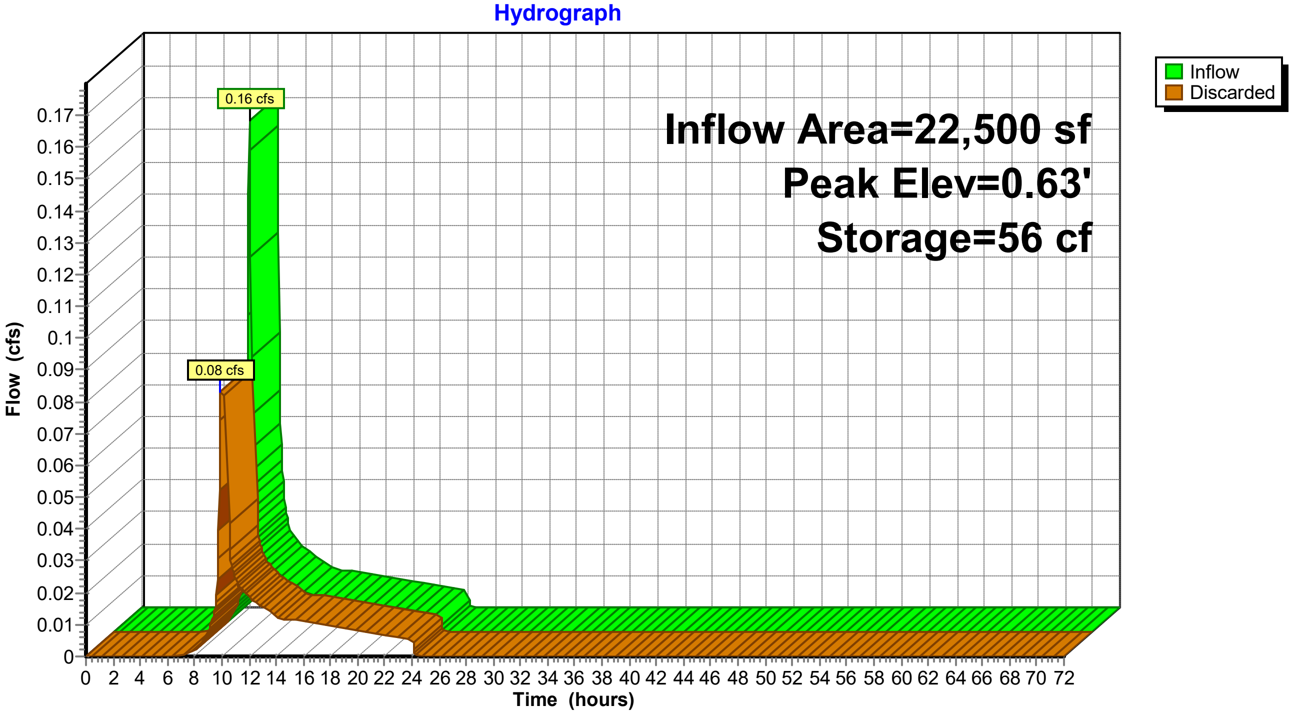
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 23P: DW1.4



Summary for Pond 24P: DW1.5

Inflow Area = 20,304 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.15 cfs @ 9.96 hrs, Volume= 762 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 762 cf, Atten= 43%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 762 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.49' @ 10.09 hrs Surf.Area= 225 sf Storage= 44 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.3 min calculated for 762 cf (100% of inflow)
Center-of-Mass det. time= 3.3 min (828.0 - 824.7)

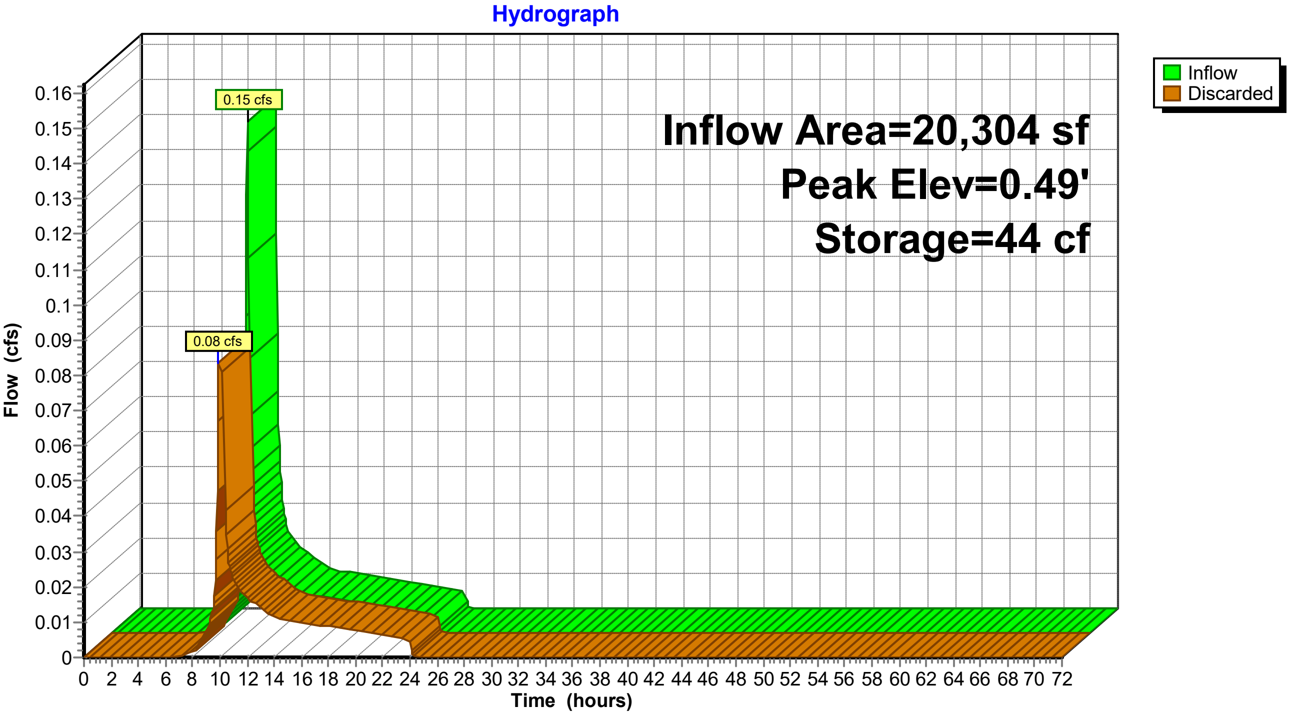
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.18' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 24P: DW1.5



Summary for Pond 25P: DW1.6

```
Inflow Area =          22,550 sf,   0.00% Impervious,  Inflow Depth =   0.45"    for  6MO-24HOUR event
Inflow      =        0.16 cfs @    9.96 hrs,  Volume=              846 cf
Outflow     =        0.08 cfs @    9.90 hrs,  Volume=              846 cf,  Atten= 48%,  Lag= 0.0 min
Discarded  =         0.08 cfs @    9.90 hrs,  Volume=              846 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs   Surf.Area= 225 sf   Storage= 57 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 846 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

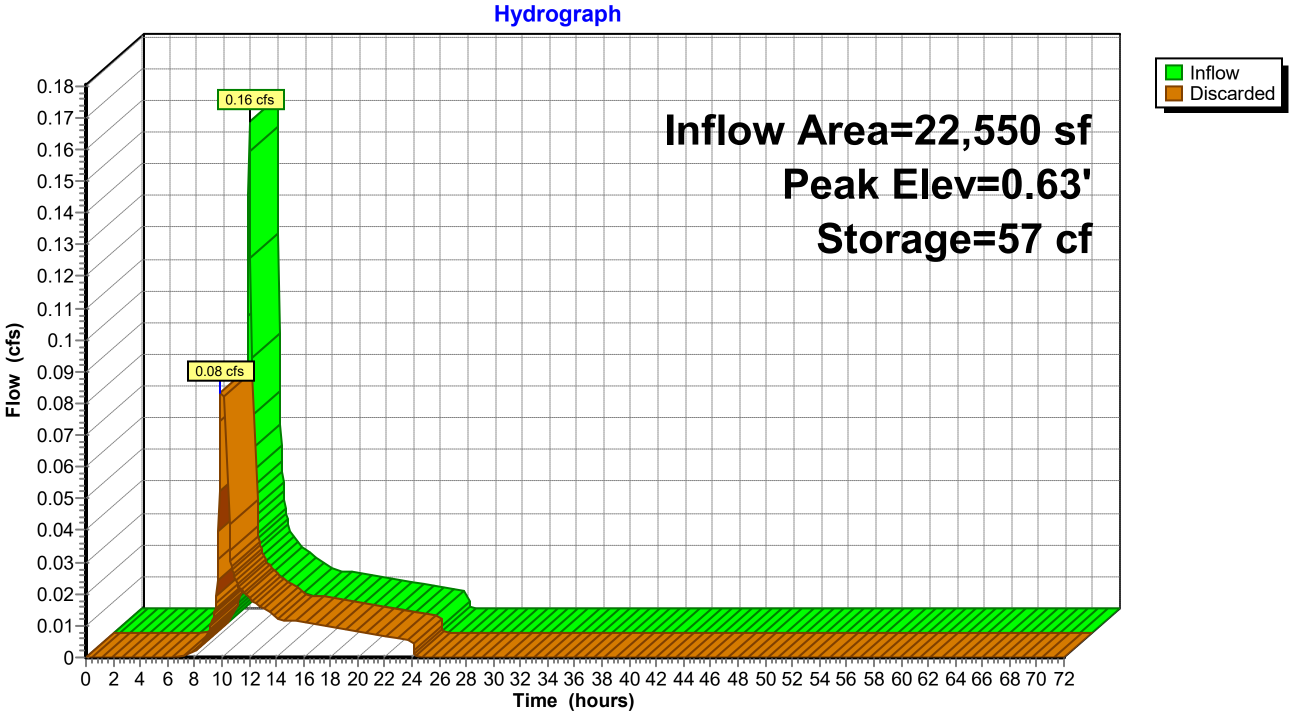
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 25P: DW1.6



Summary for Pond 26P: DW1.7

```
Inflow Area =          22,550 sf,   0.00% Impervious,  Inflow Depth =   0.45"    for  6MO-24HOUR event
Inflow      =       0.16 cfs @    9.96 hrs,  Volume=            846 cf
Outflow     =       0.08 cfs @    9.90 hrs,  Volume=            846 cf,  Atten= 48%,  Lag= 0.0 min
Discarded  =        0.08 cfs @    9.90 hrs,  Volume=            846 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs   Surf.Area= 225 sf   Storage= 57 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 846 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

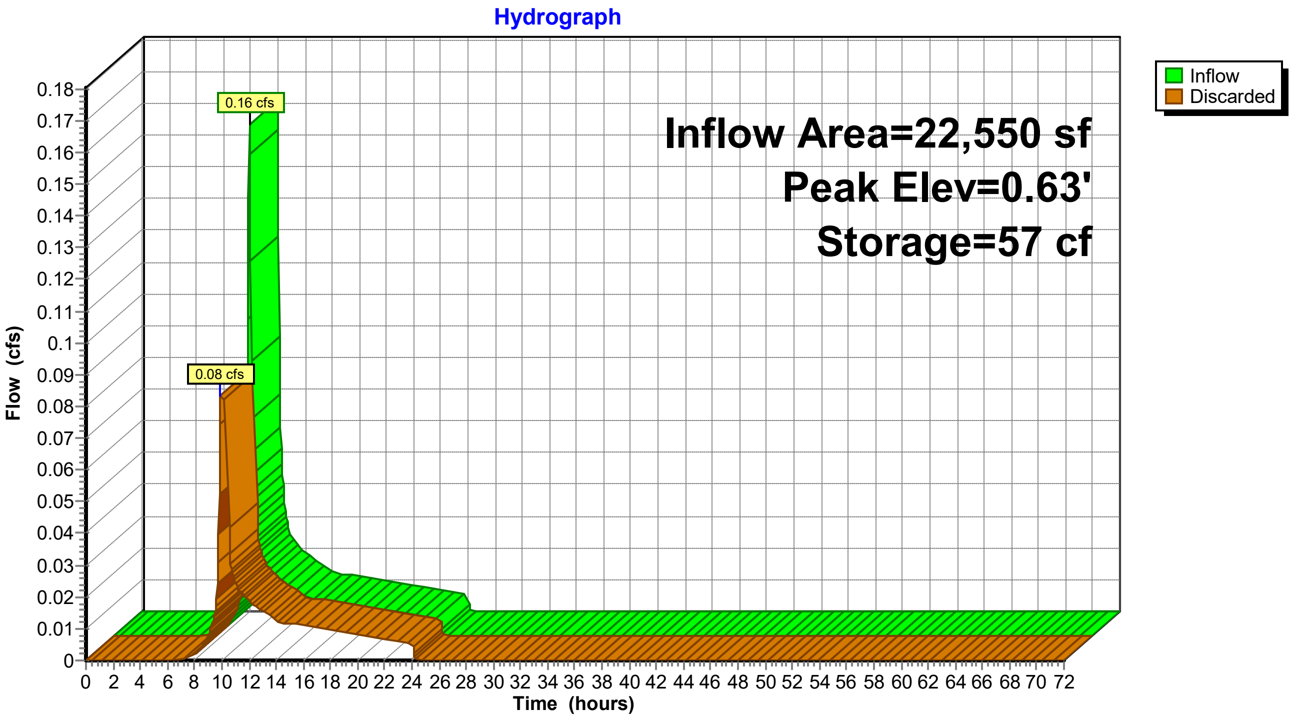
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
└—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

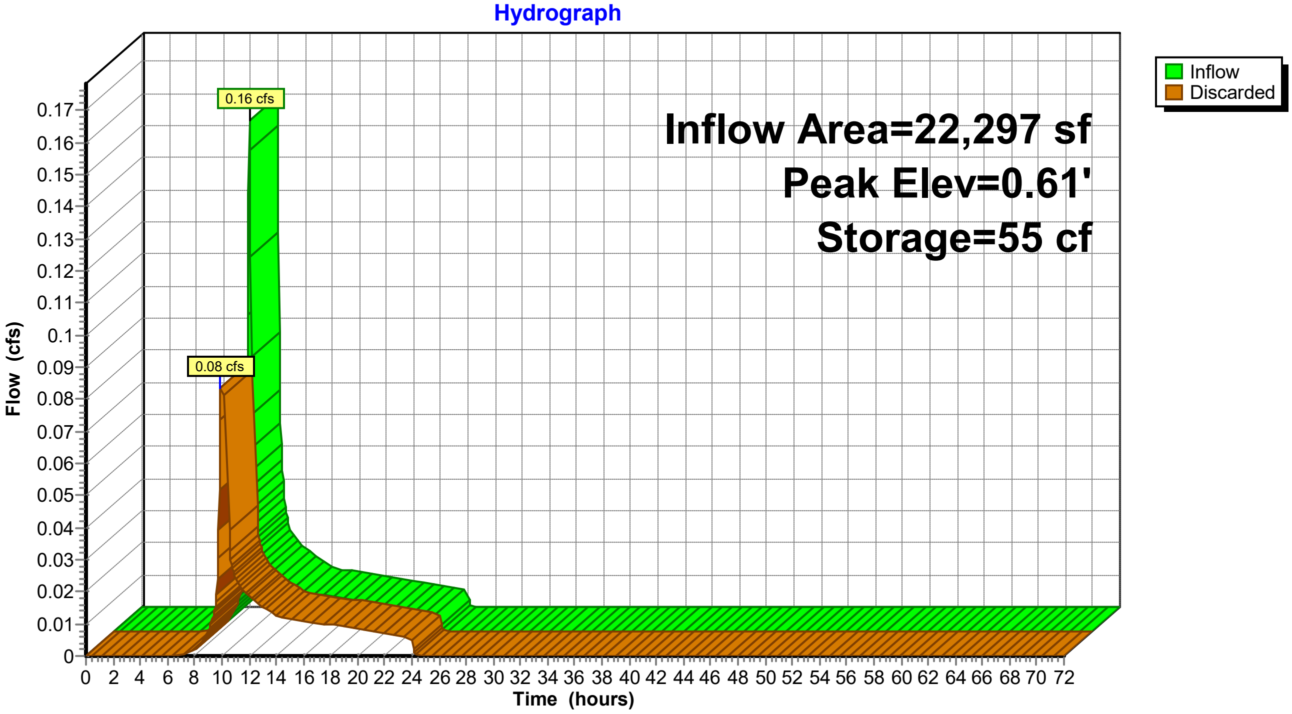
Pond 26P: DW1.7



Summary for Pond 27P: DW1.8

```
Inflow Area =        22,297 sf,   0.00% Impervious,  Inflow Depth =   0.45"    for  6MO-24HOUR event
Inflow      =      0.16 cfs @    9.96 hrs,  Volume=             837 cf
Outflow     =      0.08 cfs @    9.90 hrs,  Volume=             837 cf,  Atten= 48%,  Lag= 0.0 min
Discarded  =       0.08 cfs @    9.90 hrs,  Volume=             837 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.61' @ 10.11 hrs   Surf.Area= 225 sf   Storage= 55 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 836 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min ( 828.4 - 824.7 )

Volume        Invert    Avail.Storage   Storage Description
    #1         0.00'           767 cf   DW (Pyramidal) Listed below
                                        2,166 cf Overall - 248 cf Embedded = 1,918 cf  x 40.0% Voids
    #2         1.00'           170 cf   4.00'D x 13.50'H Vertical Cone/Cylinder  Inside #1
                                        248 cf Overall - 5.0" Wall Thickness = 170 cf
                               937 cf   Total Available Storage

 Elevation        Surf.Area          Inc.Store        Cum.Store          Wet.Area
    (feet)           (sq-ft)      (cubic-feet)     (cubic-feet)           (sq-ft)
      0.00               225                 0                0               225
      9.00               225             2,025            2,025               765
      9.50                18                51            2,076               973
     14.50                18                90            2,166             1,058

Device   Routing            Invert   Outlet Devices
    #1   Discarded           0.00'   16.000 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.08 cfs @ 9.90 hrs  HW=0.21'   (Free Discharge)
 └─1=Exfiltration  (Exfiltration Controls 0.08 cfs)
```

Pond 27P: DW1.8



Summary for Pond 28P: DW1.10

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.16 cfs @ 9.96 hrs, Volume= 844 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 844 cf, Atten= 48%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 844 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs Surf.Area= 225 sf Storage= 56 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 844 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

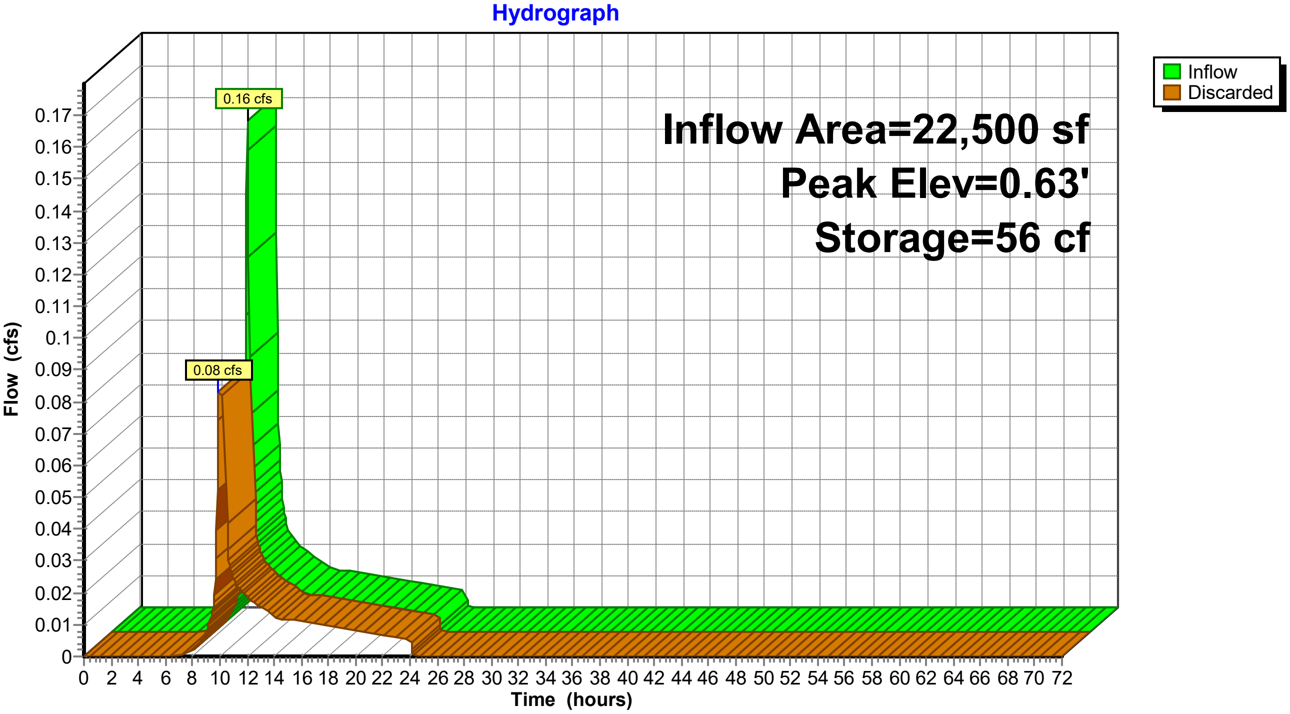
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 28P: DW1.10



Summary for Pond 29P: DW1.11

```
Inflow Area =          21,434 sf,   0.00% Impervious,  Inflow Depth =   0.45"    for  6MO-24HOUR event
Inflow      =        0.15 cfs @    9.96 hrs,  Volume=              804 cf
Outflow     =        0.08 cfs @    9.90 hrs,  Volume=              804 cf,  Atten= 46%,  Lag= 0.0 min
Discarded  =         0.08 cfs @    9.90 hrs,  Volume=              804 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.56' @ 10.10 hrs Surf.Area= 225 sf Storage= 50 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.5 min calculated for 804 cf (100% of inflow)
Center-of-Mass det. time= 3.5 min (828.2 - 824.7)

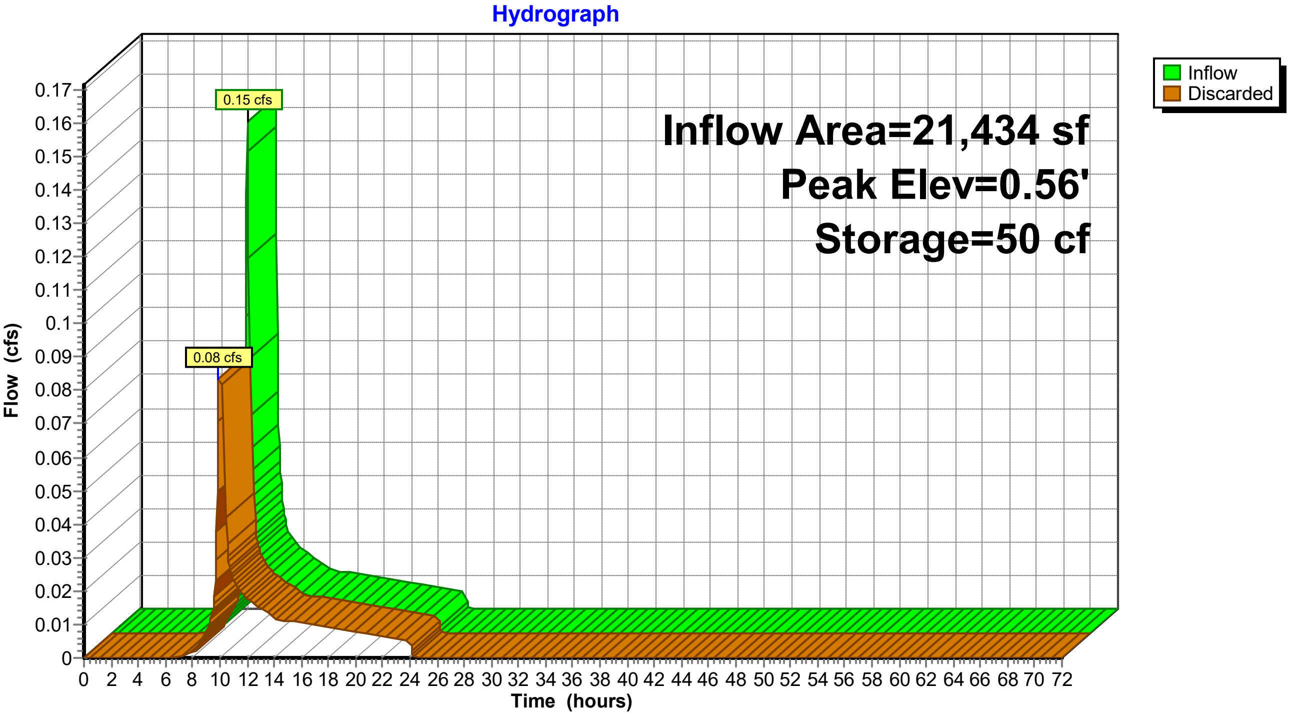
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.20' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 29P: DW1.11



Summary for Pond 30P: DW1.12

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.16 cfs @ 9.96 hrs, Volume= 844 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 844 cf, Atten= 48%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 844 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs Surf.Area= 225 sf Storage= 56 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 844 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

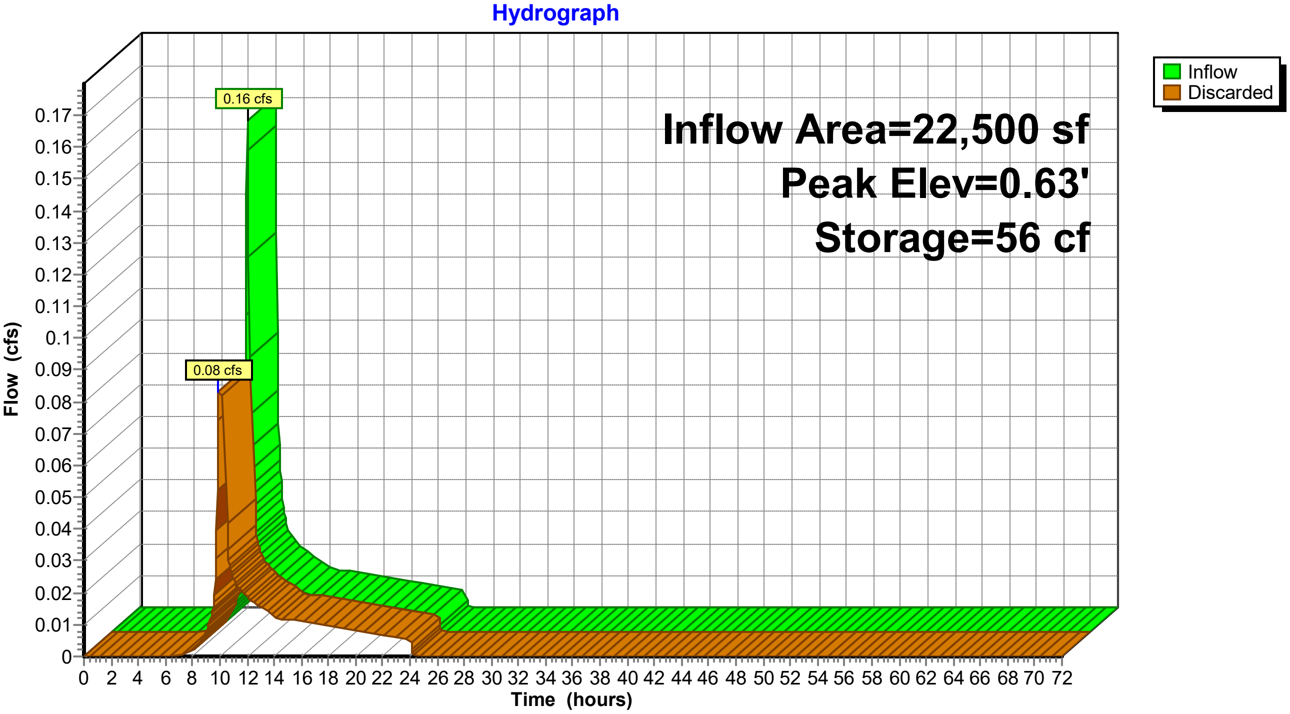
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 30P: DW1.12



Summary for Pond 31P: DW1.13

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.16 cfs @ 9.96 hrs, Volume= 844 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 844 cf, Atten= 48%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 844 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs Surf.Area= 225 sf Storage= 56 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 844 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

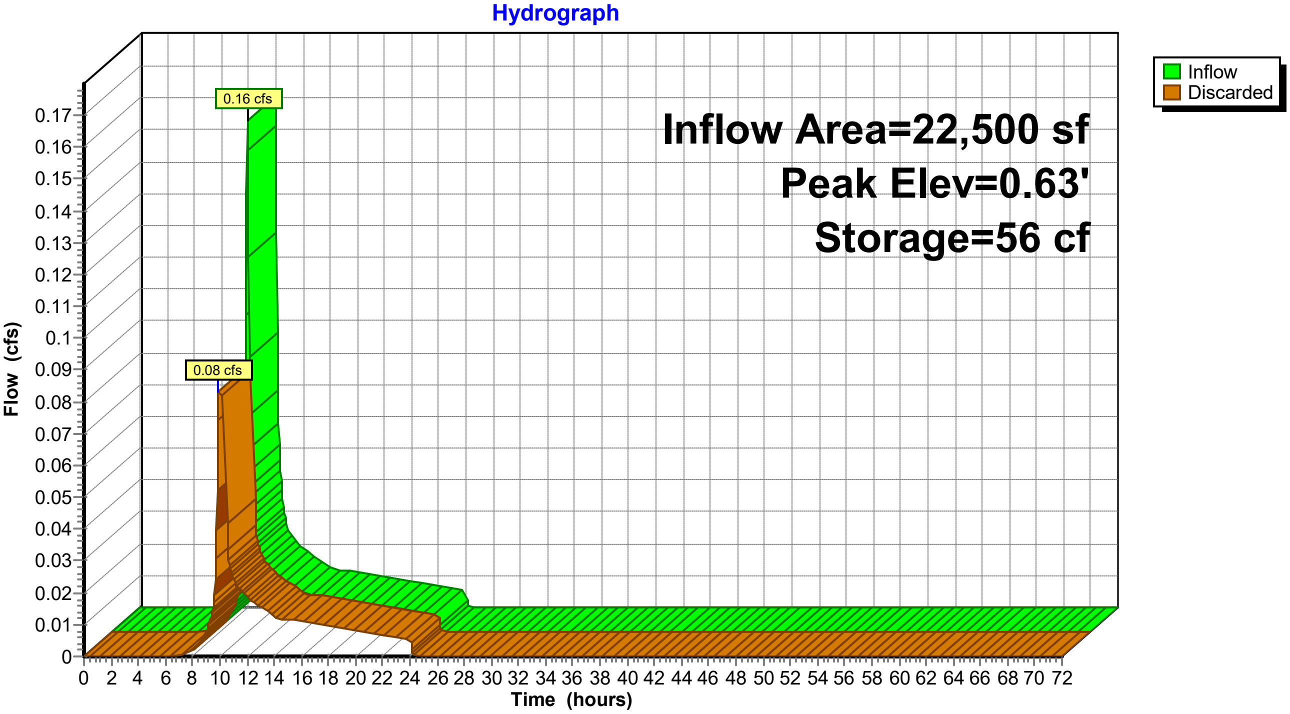
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 31P: DW1.13



Summary for Pond 32P: DW1.14

```
Inflow Area =        22,500 sf,   0.00% Impervious,  Inflow Depth =   0.45"    for  6MO-24HOUR event
Inflow      =      0.16 cfs @    9.96 hrs,  Volume=            844 cf
Outflow     =      0.08 cfs @    9.90 hrs,  Volume=            844 cf,  Atten= 48%,  Lag= 0.0 min
Discarded  =       0.08 cfs @    9.90 hrs,  Volume=            844 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs   Surf.Area= 225 sf   Storage= 56 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 844 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

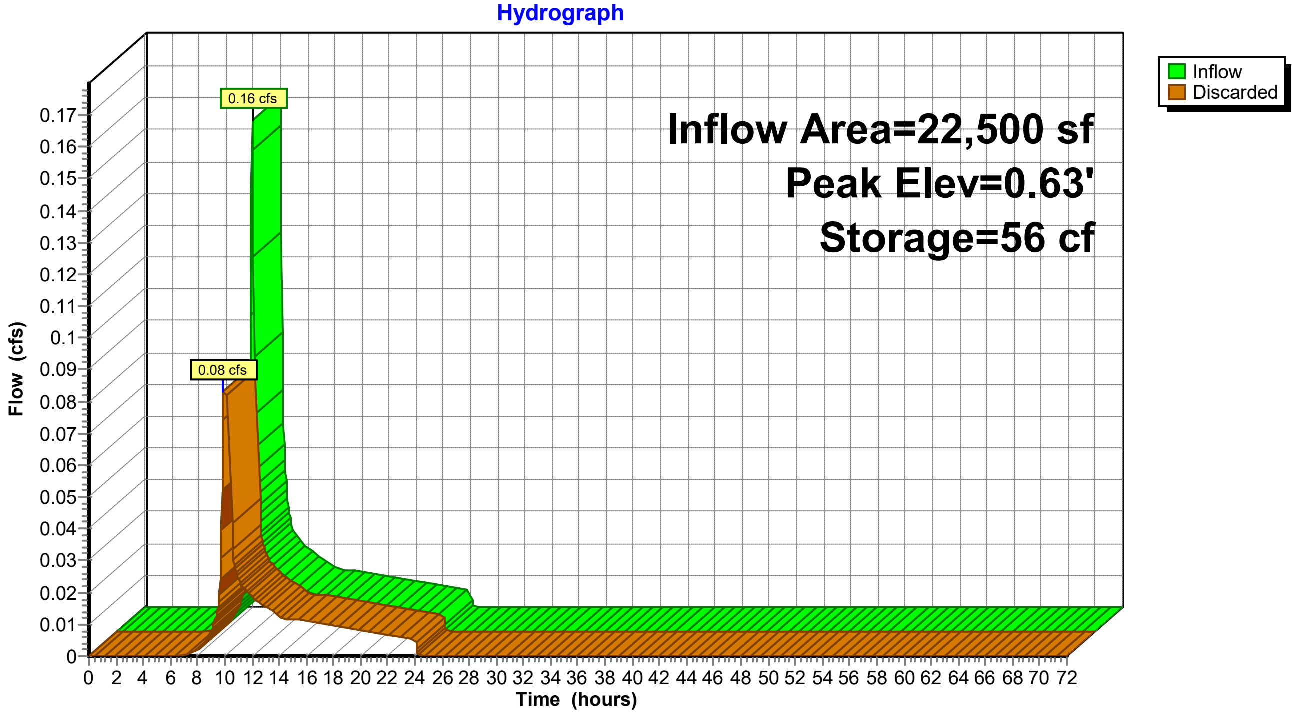
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 32P: DW1.14



Summary for Pond 33P: DW1.15

```
Inflow Area =          22,500 sf,   0.00% Impervious,  Inflow Depth =   0.45"    for  6MO-24HOUR event
Inflow      =       0.16 cfs @    9.96 hrs,  Volume=             844 cf
Outflow     =       0.08 cfs @    9.90 hrs,  Volume=             844 cf,  Atten= 48%,  Lag= 0.0 min
Discarded  =        0.08 cfs @    9.90 hrs,  Volume=             844 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs   Surf.Area= 225 sf   Storage= 56 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 844 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

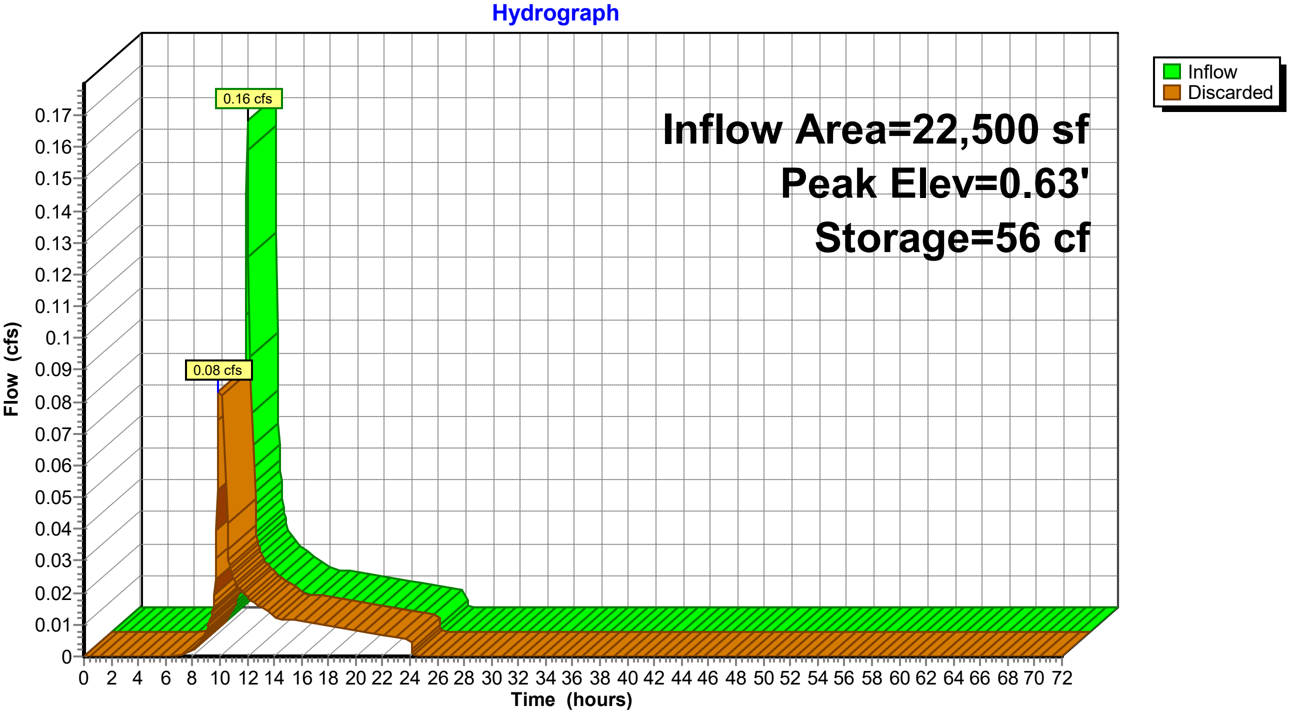
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21'   (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 33P: DW1.15



Summary for Pond 69P: DW2.1

Inflow Area = 7,700 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.05 cfs @ 9.96 hrs, Volume= 289 cf
Outflow = 0.05 cfs @ 10.00 hrs, Volume= 289 cf, Atten= 6%, Lag= 2.4 min
Discarded = 0.05 cfs @ 10.00 hrs, Volume= 289 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.09' @ 10.00 hrs Surf.Area= 225 sf Storage= 8 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 2.6 min calculated for 289 cf (100% of inflow)
Center-of-Mass det. time= 2.6 min (827.3 - 824.7)

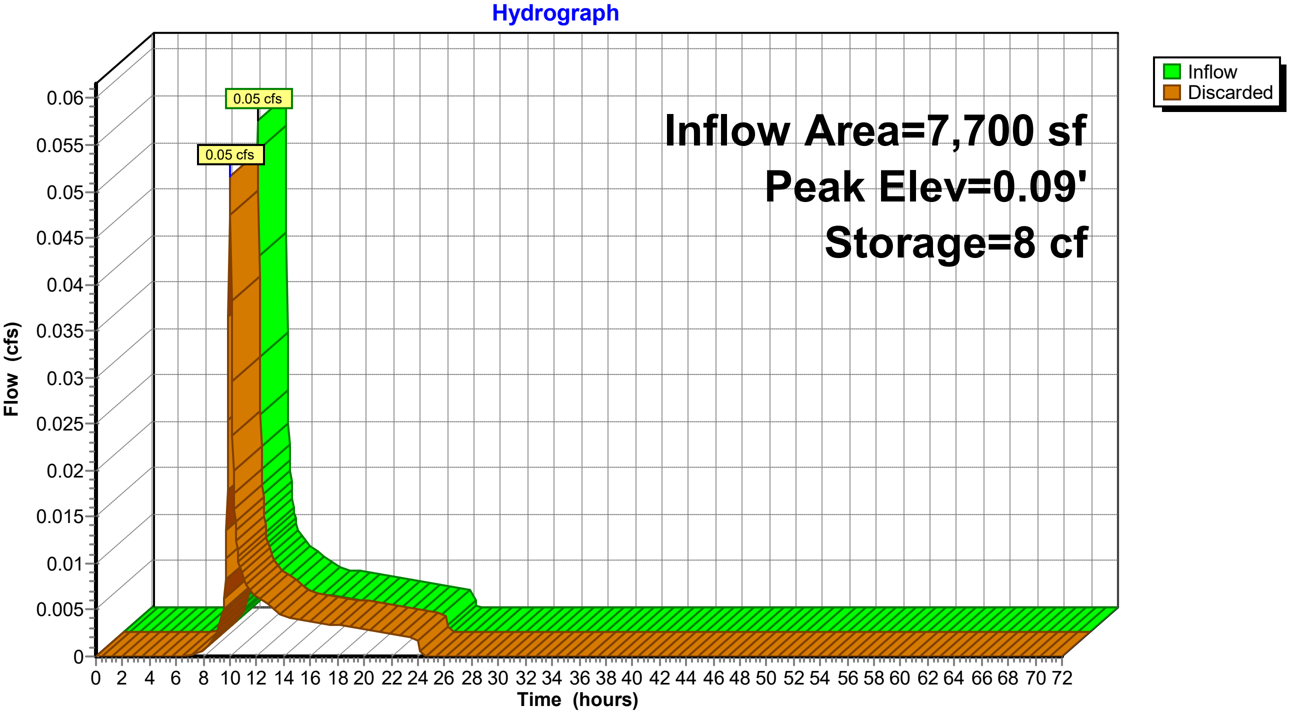
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 10.00 hrs HW=0.09' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 69P: DW2.1



Summary for Pond 70P: DW2.4

```
Inflow Area =        17,300 sf,   0.00% Impervious,  Inflow Depth =   0.45"    for  6MO-24HOUR event
Inflow      =      0.12 cfs @    9.96 hrs,  Volume=           649 cf
Outflow     =      0.08 cfs @    9.95 hrs,  Volume=           649 cf,  Atten= 33%,  Lag= 0.0 min
Discarded  =      0.08 cfs @    9.95 hrs,  Volume=           649 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.32' @ 10.07 hrs   Surf.Area= 225 sf   Storage= 29 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 2.9 min calculated for 649 cf (100% of inflow)
Center-of-Mass det. time= 2.9 min (827.6 - 824.7)

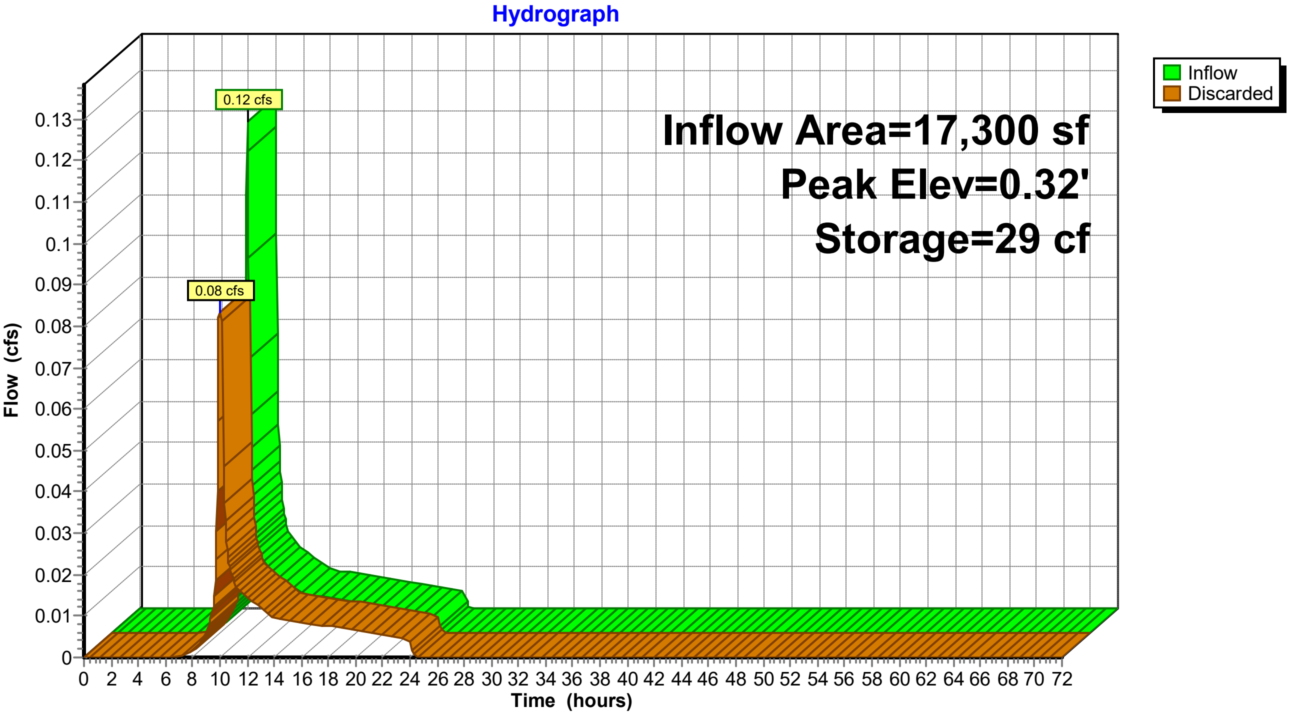
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.95 hrs HW=0.21' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 70P: DW2.4



Summary for Subcatchment 71S: F2.2

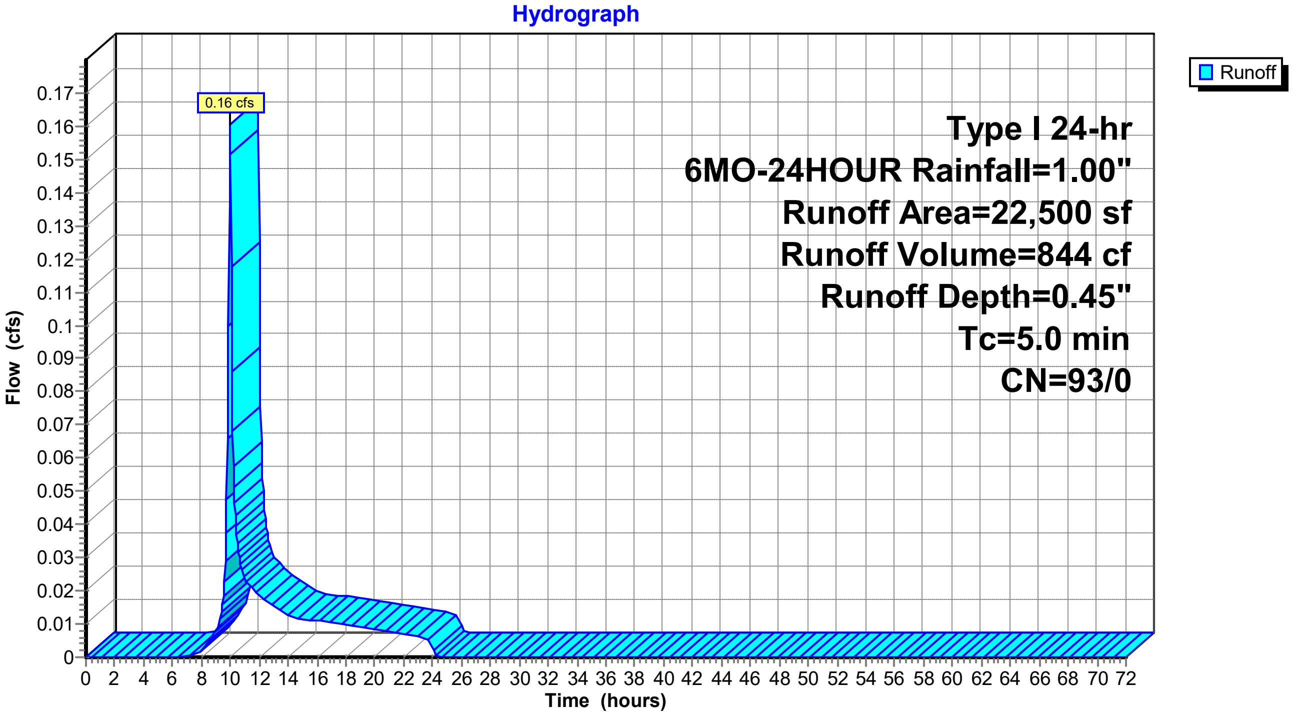
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 844 cf, Depth= 0.45"
Routed to Pond 74P : DW2.2

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 71S: F2.2



Summary for Subcatchment 72S: F2.3

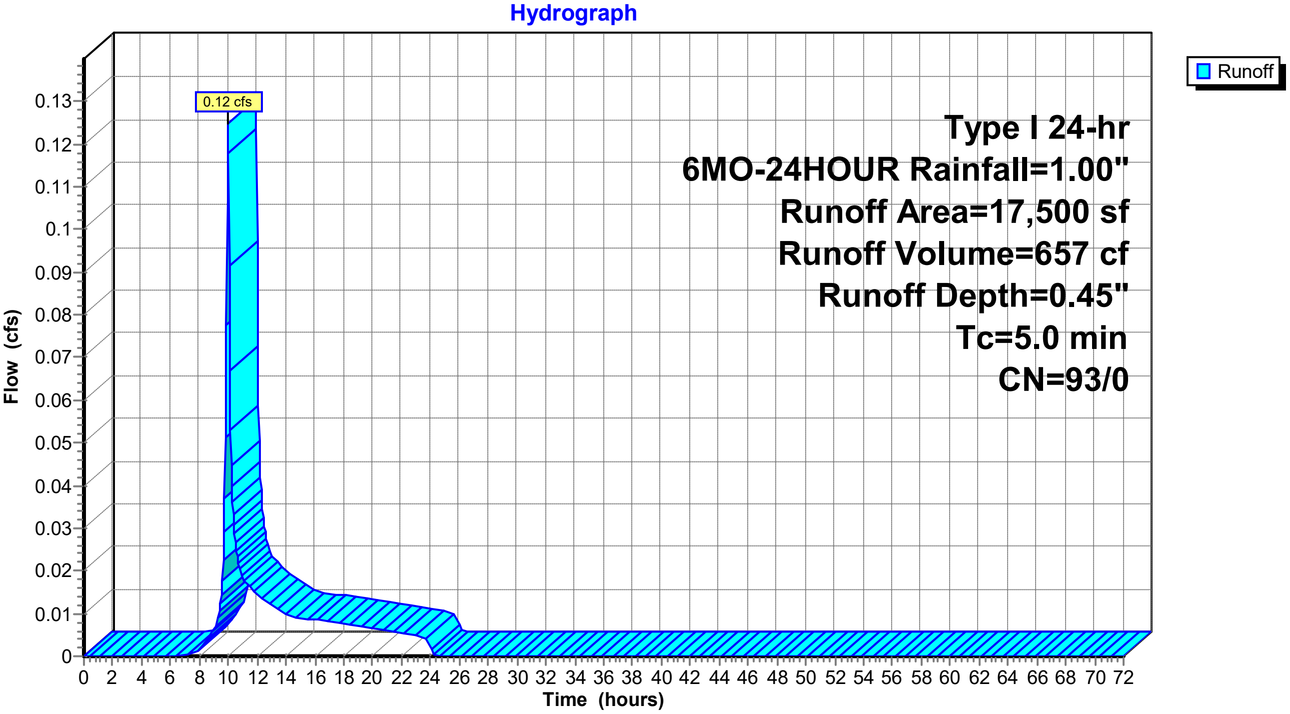
Runoff = 0.12 cfs @ 9.96 hrs, Volume= 657 cf, Depth= 0.45"
Routed to Pond 75P : DW2.3

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	17,500	93	Paved roads w/curbs & sewers, HSG A
	17,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 72S: F2.3



Summary for Subcatchment 73S: F2.4

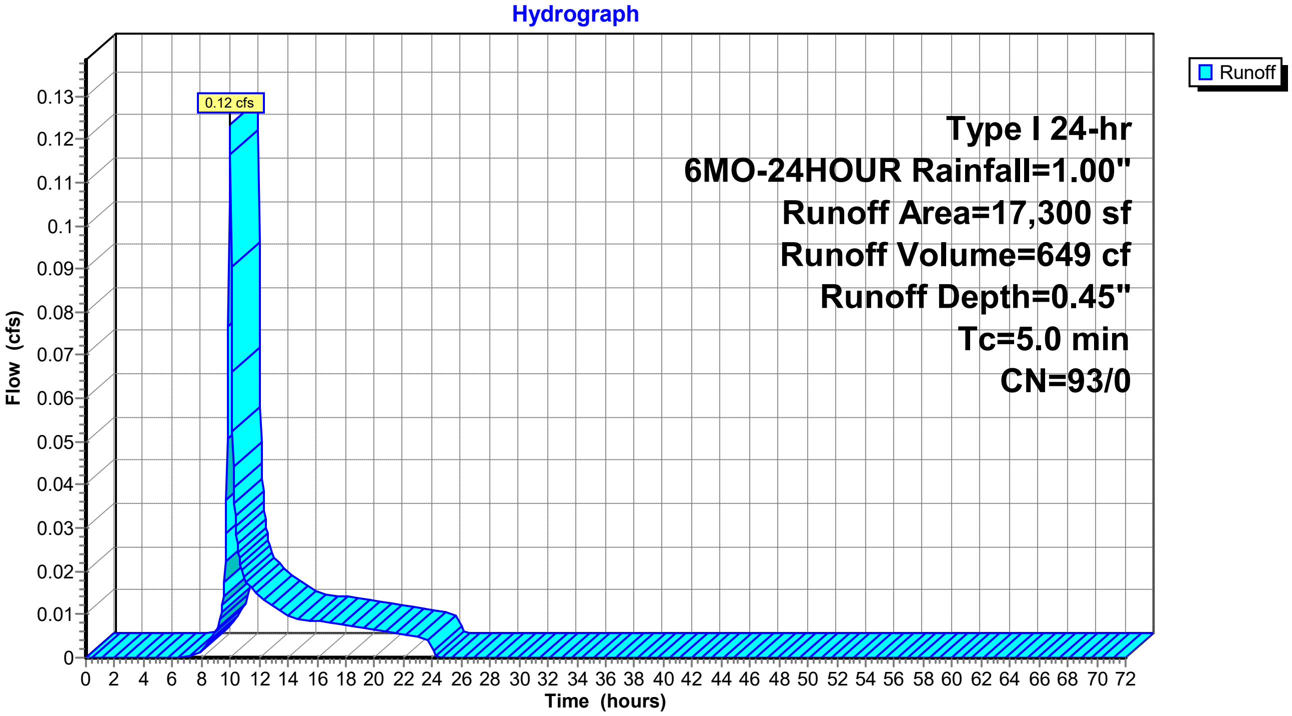
Runoff = 0.12 cfs @ 9.96 hrs, Volume= 649 cf, Depth= 0.45"
Routed to Pond 70P : DW2.4

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	17,300	93	Paved roads w/curbs & sewers, HSG A
	17,300	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

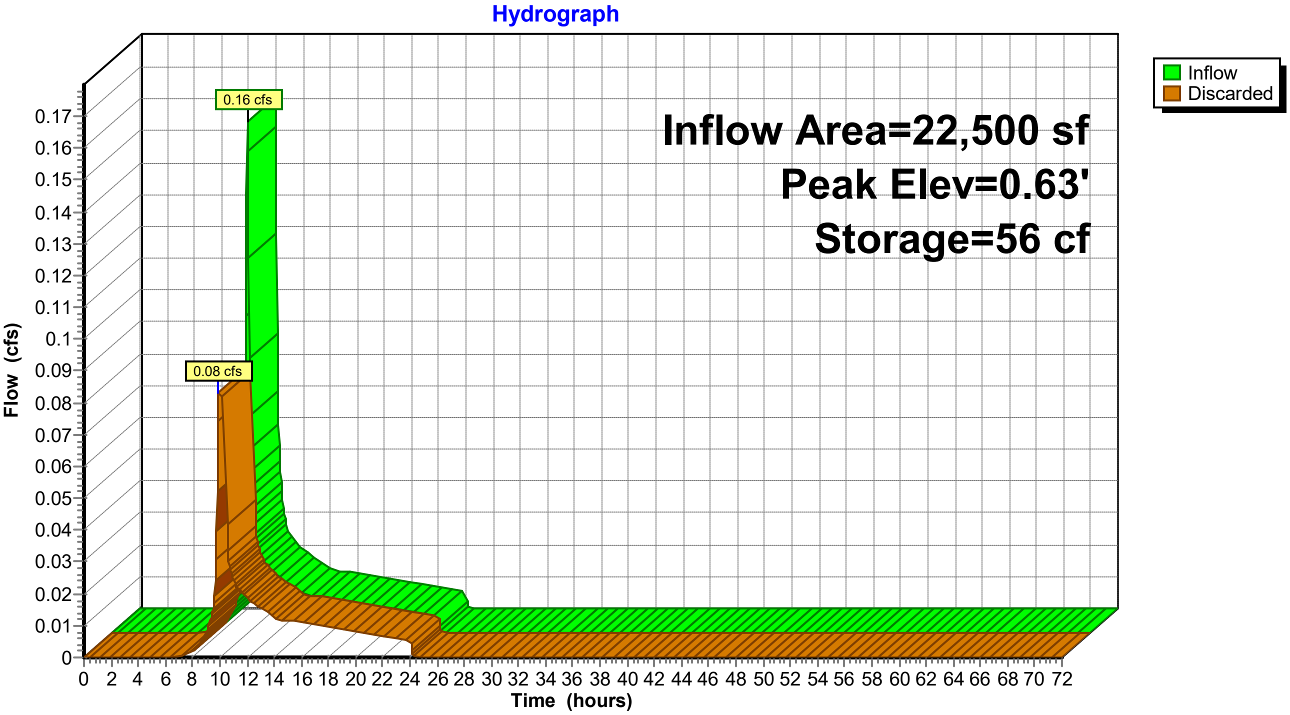
Subcatchment 73S: F2.4



Summary for Pond 74P: DW2.2

```
Inflow Area =          22,500 sf,   0.00% Impervious,  Inflow Depth =   0.45"    for  6MO-24HOUR event
Inflow       =        0.16 cfs @    9.96 hrs,  Volume=              844 cf
Outflow      =        0.08 cfs @    9.90 hrs,  Volume=              844 cf,  Atten= 48%,  Lag= 0.0 min
Discarded  =          0.08 cfs @    9.90 hrs,  Volume=              844 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs   Surf.Area= 225 sf   Storage= 56 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 844 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min ( 828.4 - 824.7 )

Volume        Invert    Avail.Storage   Storage Description
   #1          0.00'          767 cf    DW (Pyramidal) Listed below
                                        2,166 cf Overall - 248 cf Embedded = 1,918 cf  x 40.0% Voids
   #2          1.00'          170 cf    4.00'D x 13.50'H Vertical Cone/Cylinder  Inside #1
                                        248 cf Overall - 5.0" Wall Thickness = 170 cf
                              937 cf    Total Available Storage

 Elevation          Surf.Area          Inc.Store         Cum.Store          Wet.Area
    (feet)             (sq-ft)       (cubic-feet)      (cubic-feet)            (sq-ft)
      0.00                225                  0                 0               225
      9.00                225              2,025             2,025               765
      9.50                 18                 51             2,076               973
     14.50                 18                 90             2,166             1,058

Device   Routing           Invert   Outlet Devices
    #1   Discarded          0.00'   16.000 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.08 cfs @ 9.90 hrs  HW=0.21'   (Free Discharge)
└─1=Exfiltration  (Exfiltration Controls 0.08 cfs)
```

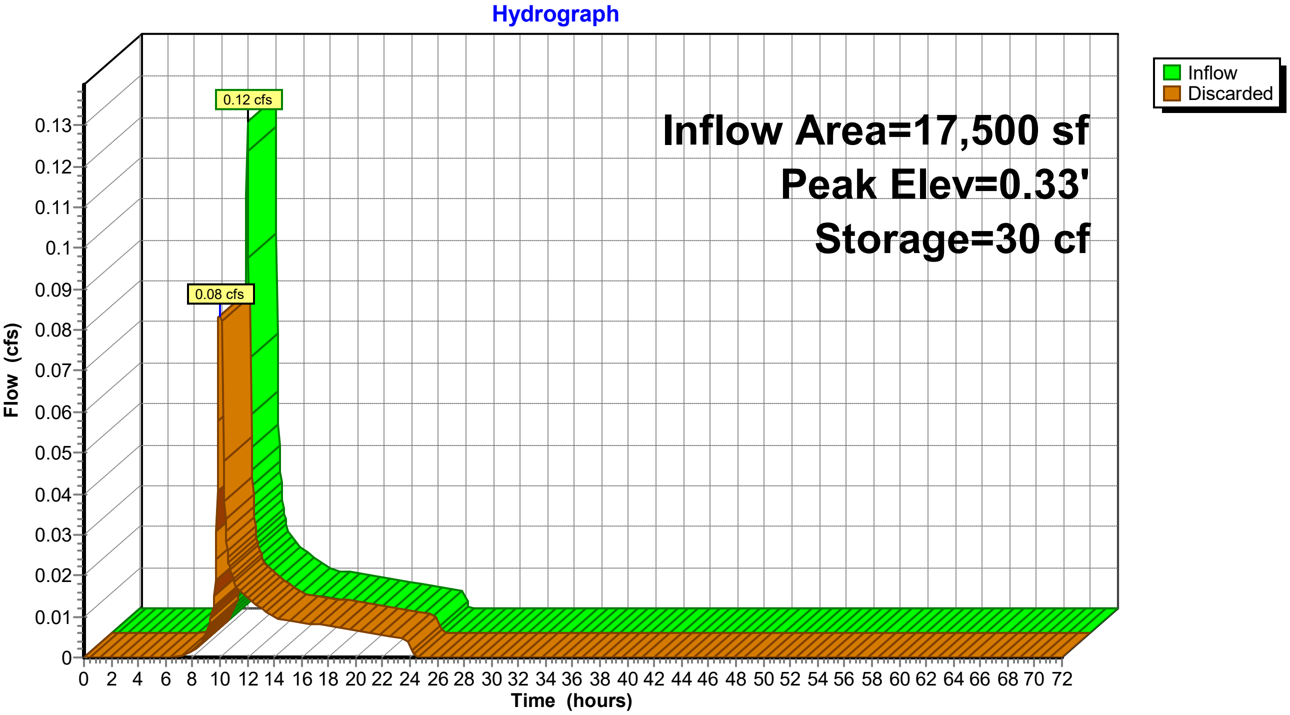
Pond 74P: DW2.2



Summary for Pond 75P: DW2.3

```
Inflow Area =        17,500 sf,   0.00% Impervious,  Inflow Depth =   0.45"    for  6MO-24HOUR event
Inflow      =      0.12 cfs @    9.96 hrs,  Volume=            657 cf
Outflow     =      0.08 cfs @    9.95 hrs,  Volume=            657 cf,  Atten= 33%,  Lag= 0.0 min
Discarded  =       0.08 cfs @    9.95 hrs,  Volume=            657 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.33' @ 10.07 hrs   Surf.Area= 225 sf   Storage= 30 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 2.9 min calculated for 656 cf (100% of inflow)
Center-of-Mass det. time= 2.9 min ( 827.6 - 824.7 )

Volume       Invert    Avail.Storage   Storage Description
   #1          0.00'          767 cf   DW (Pyramidal) Listed below
                                       2,166 cf Overall - 248 cf Embedded = 1,918 cf  x 40.0% Voids
   #2          1.00'          170 cf   4.00'D x 13.50'H Vertical Cone/Cylinder  Inside #1
                                       248 cf Overall - 5.0" Wall Thickness = 170 cf
                              937 cf   Total Available Storage

 Elevation       Surf.Area        Inc.Store        Cum.Store         Wet.Area
    (feet)          (sq-ft)     (cubic-feet)     (cubic-feet)           (sq-ft)
      0.00              225                0                0               225
      9.00              225            2,025            2,025               765
      9.50               18               51            2,076               973
     14.50               18               90            2,166             1,058

Device  Routing            Invert   Outlet Devices
   #1   Discarded           0.00'   16.000 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.08 cfs @ 9.95 hrs  HW=0.21'   (Free Discharge)
↑—1=Exfiltration  (Exfiltration Controls 0.08 cfs)
```

Pond 75P: DW2.3



Summary for Pond 78P: DW2.5

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.16 cfs @ 9.96 hrs, Volume= 844 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 844 cf, Atten= 48%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 844 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs Surf.Area= 225 sf Storage= 56 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 844 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

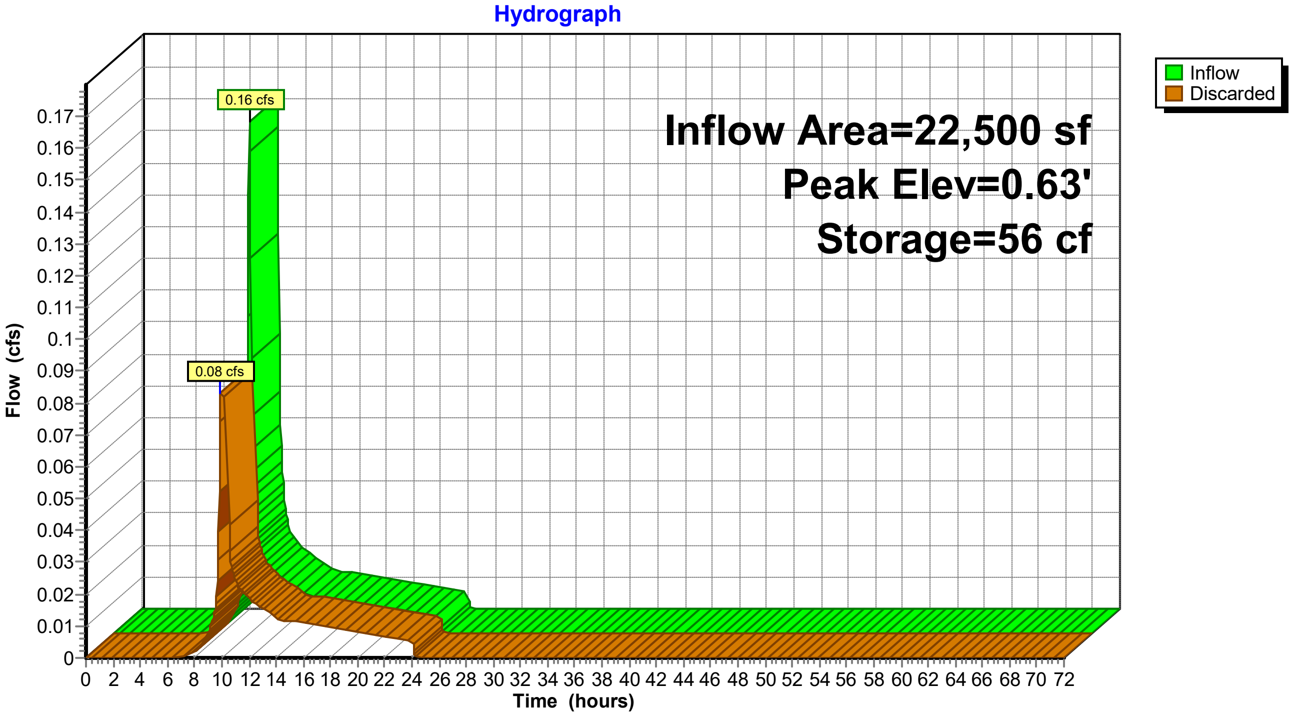
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 78P: DW2.5



Summary for Subcatchment F2.1: F2.1

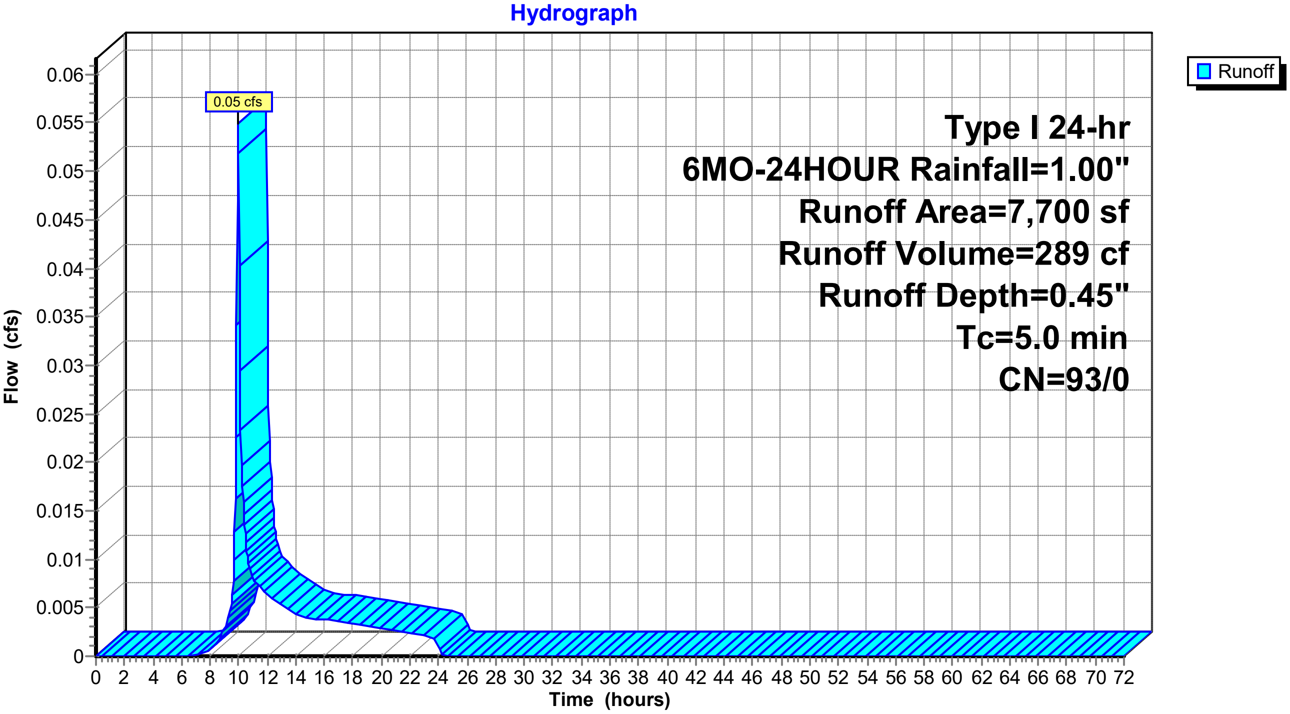
Runoff = 0.05 cfs @ 9.96 hrs, Volume= 289 cf, Depth= 0.45"
Routed to Pond 69P : DW2.1

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	7,700	93	Paved roads w/curbs & sewers, HSG A
	7,700	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment F2.1: F2.1



Summary for Subcatchment F2.5: F2.5

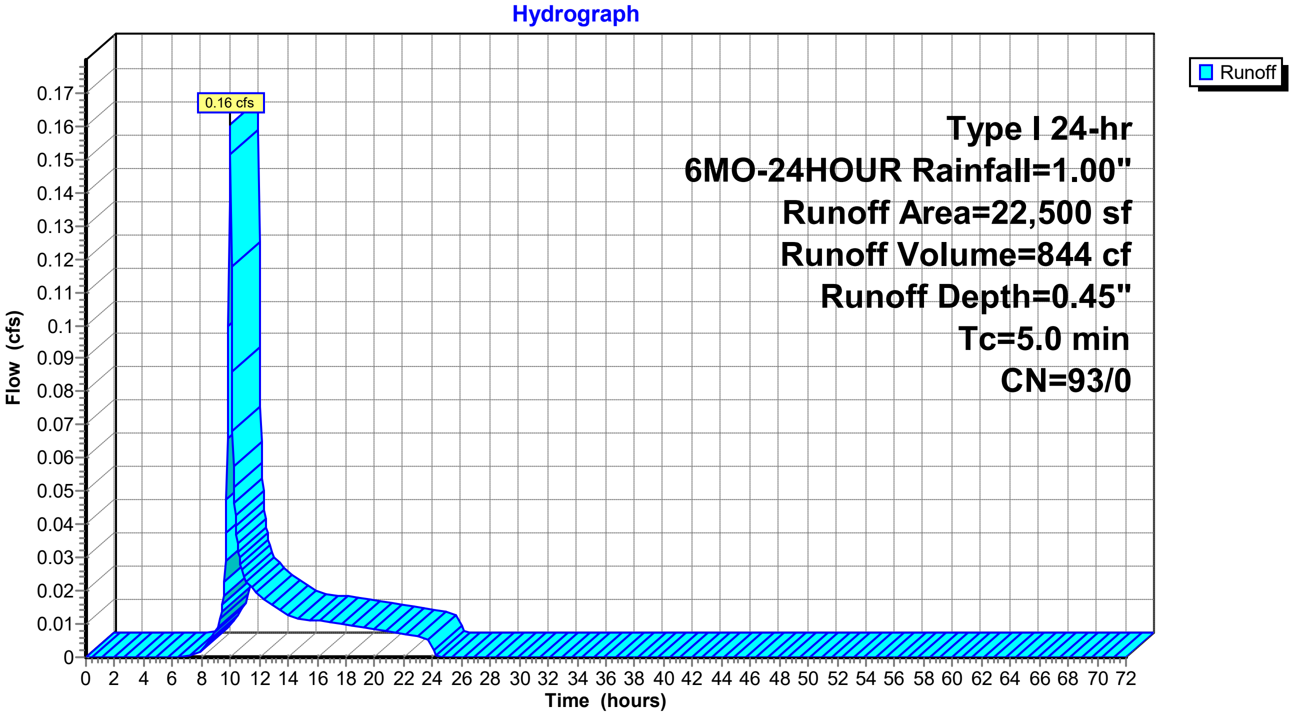
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 844 cf, Depth= 0.45"
Routed to Pond 78P : DW2.5

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment F2.5: F2.5



Summary for Subcatchment 1S: G1.1

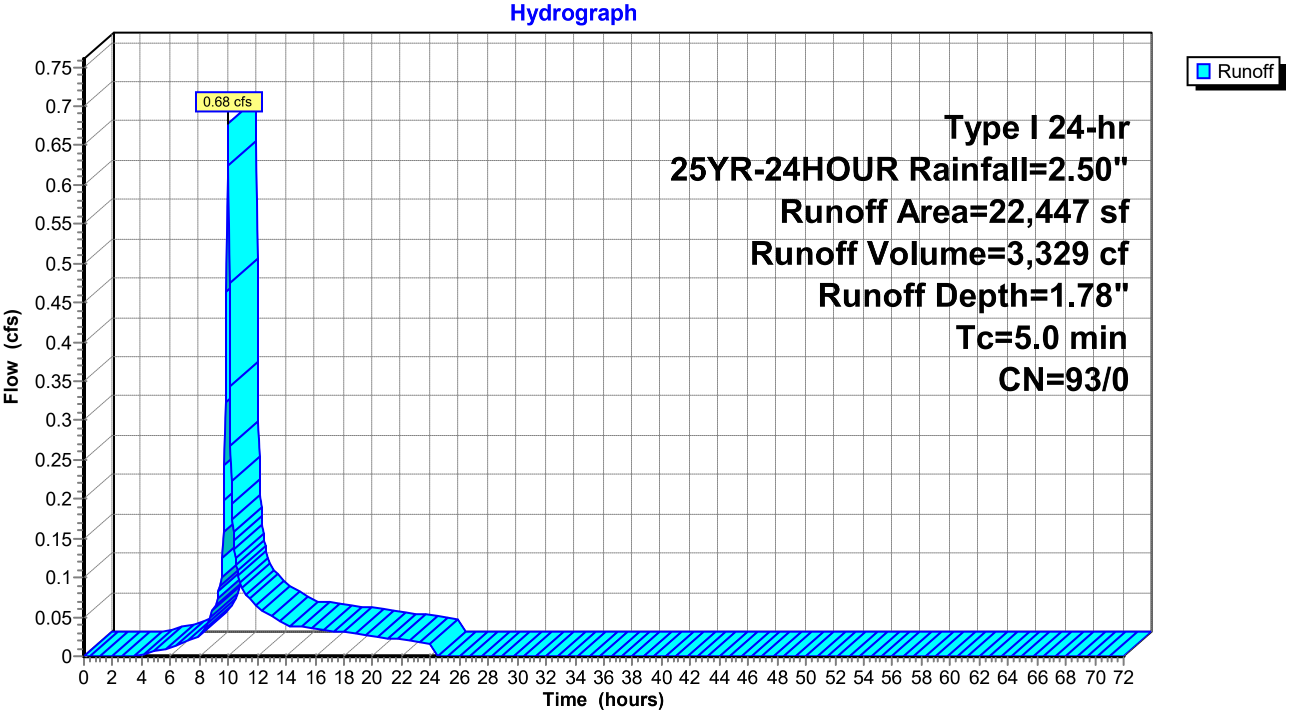
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,329 cf, Depth= 1.78"
Routed to Pond 20P : DW1.1

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,447	93	Paved roads w/curbs & sewers, HSG A
	22,447	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 1S: G1.1



Summary for Subcatchment 2S: G1.2

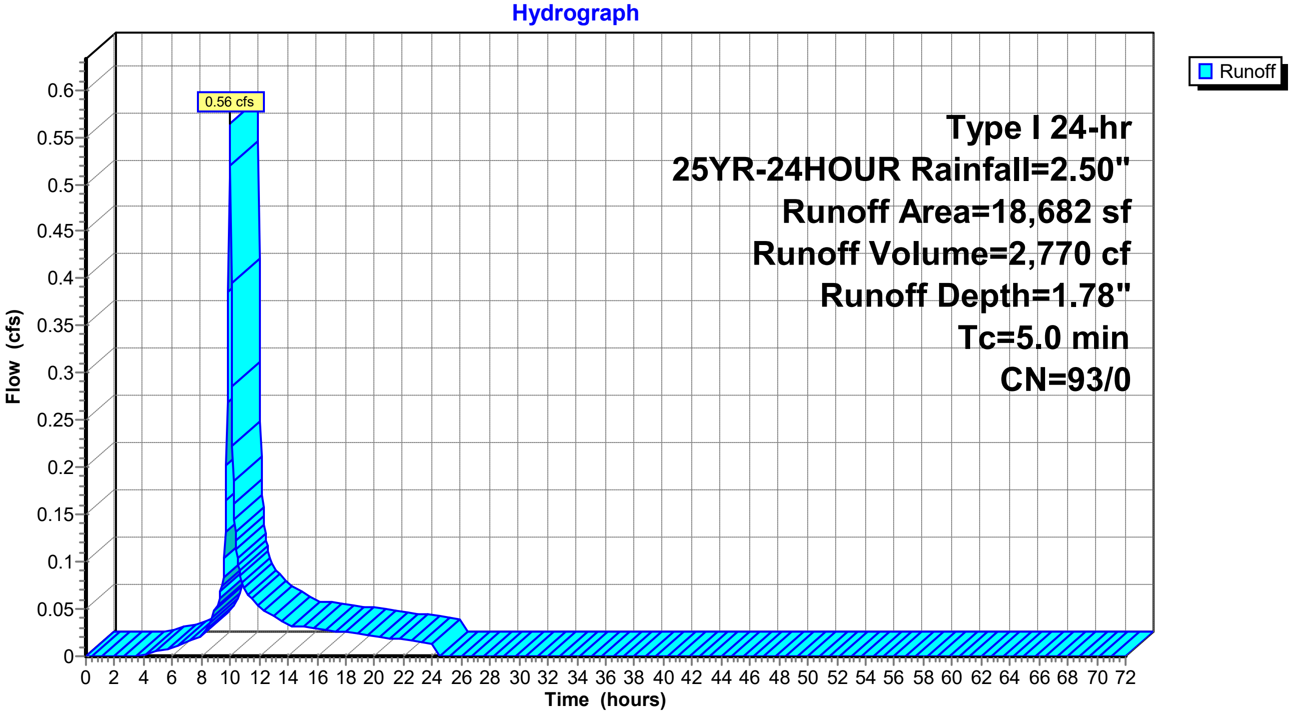
Runoff = 0.56 cfs @ 9.95 hrs, Volume= 2,770 cf, Depth= 1.78"
Routed to Pond 21P : DW1.2

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	18,682	93	Paved roads w/curbs & sewers, HSG A
	18,682	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 2S: G1.2



Summary for Subcatchment 3S: G1.3

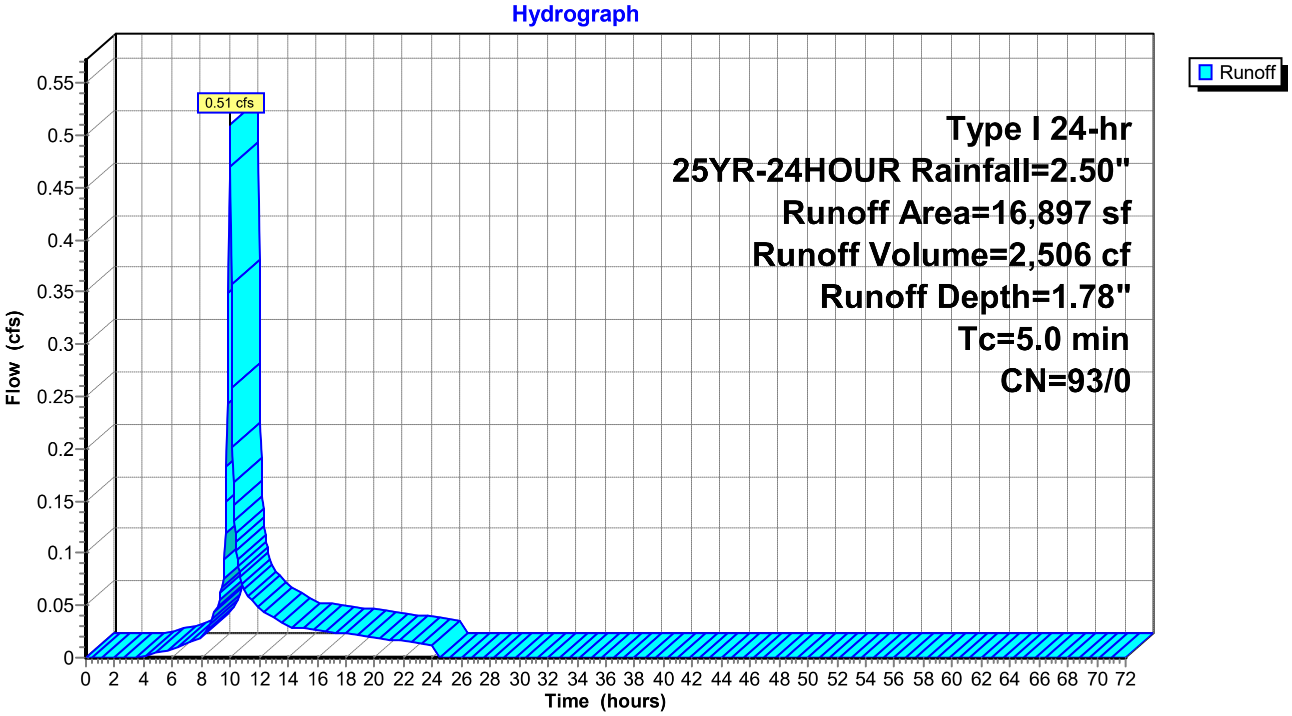
Runoff = 0.51 cfs @ 9.95 hrs, Volume= 2,506 cf, Depth= 1.78"
Routed to Pond 22P : DW1.3

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	16,897	93	Paved roads w/curbs & sewers, HSG A
	16,897	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 3S: G1.3



Summary for Subcatchment 4S: G1.4

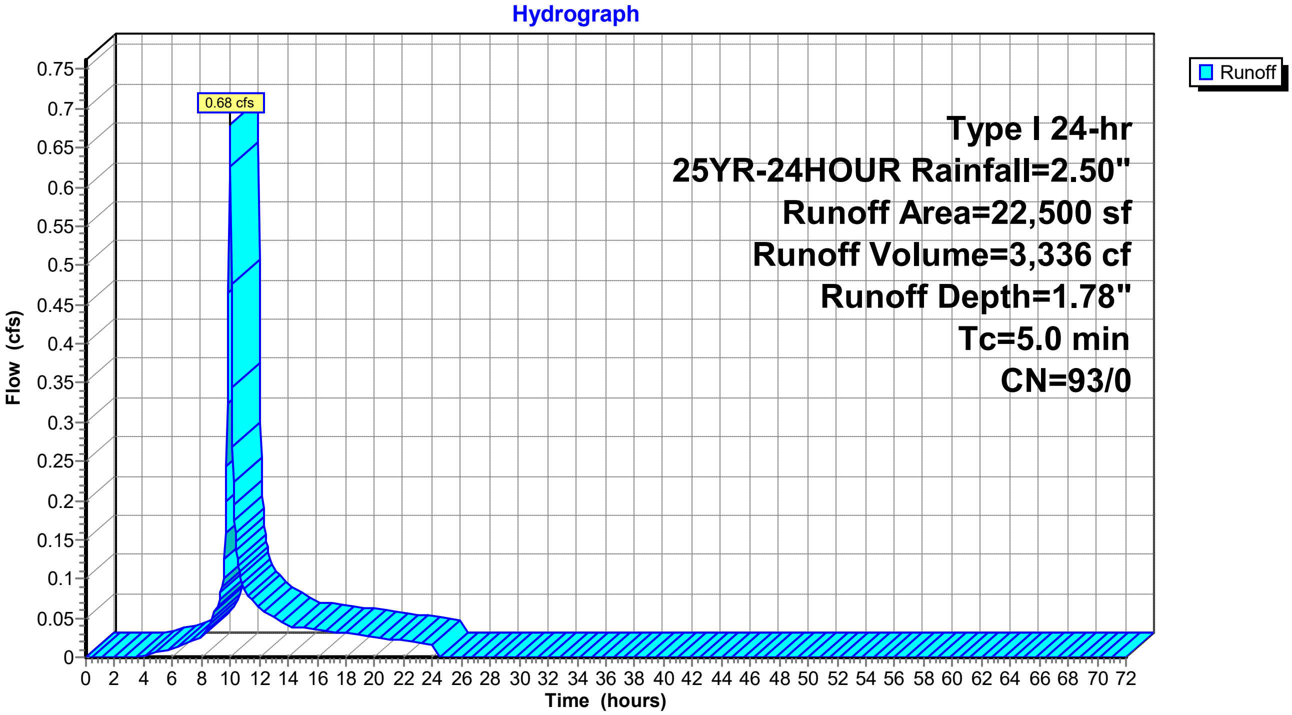
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf, Depth= 1.78"
Routed to Pond 23P : DW1.4

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 4S: G1.4



Summary for Subcatchment 5S: G1.5

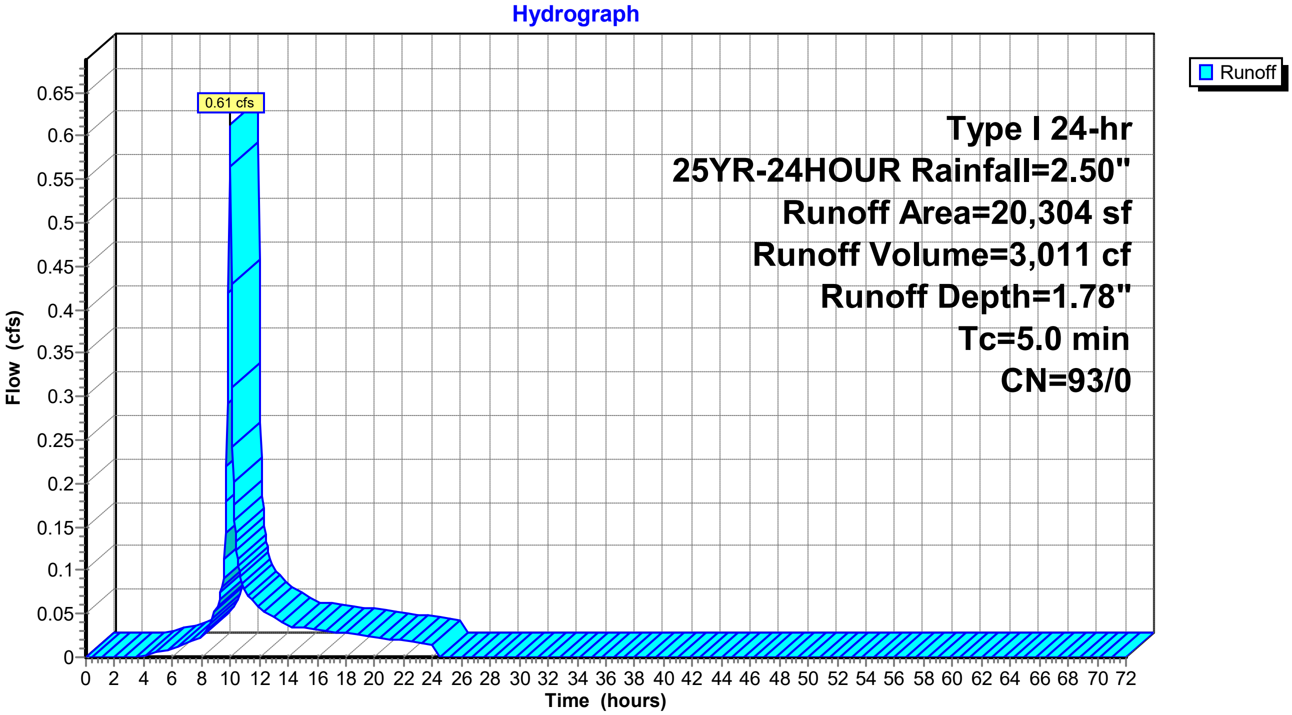
Runoff = 0.61 cfs @ 9.95 hrs, Volume= 3,011 cf, Depth= 1.78"
Routed to Pond 24P : DW1.5

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	20,304	93	Paved roads w/curbs & sewers, HSG A
	20,304	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 5S: G1.5



Summary for Subcatchment 6S: G1.6

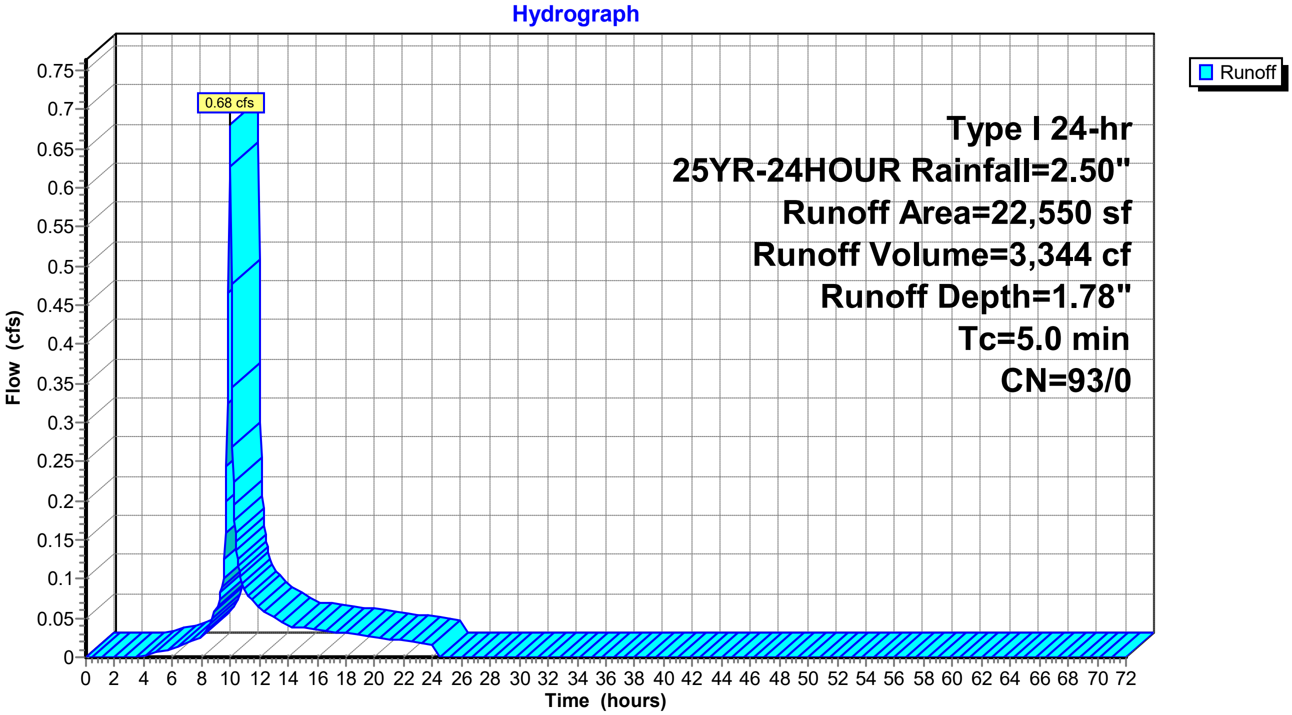
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,344 cf, Depth= 1.78"
Routed to Pond 25P : DW1.6

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,550	93	Paved roads w/curbs & sewers, HSG A
	22,550	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 6S: G1.6



Summary for Subcatchment 10S: G1.7

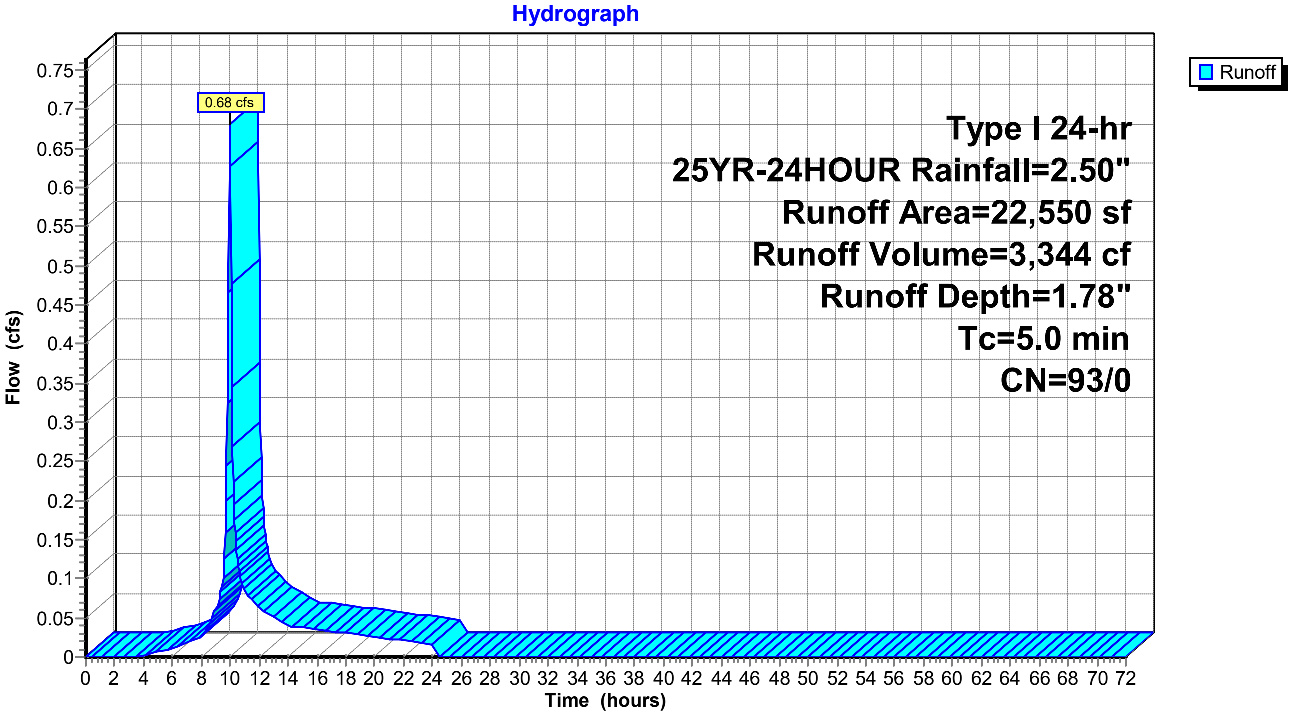
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,344 cf, Depth= 1.78"
Routed to Pond 26P : DW1.7

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,550	93	Paved roads w/curbs & sewers, HSG A
	22,550	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 10S: G1.7



Summary for Subcatchment 11S: G1.8

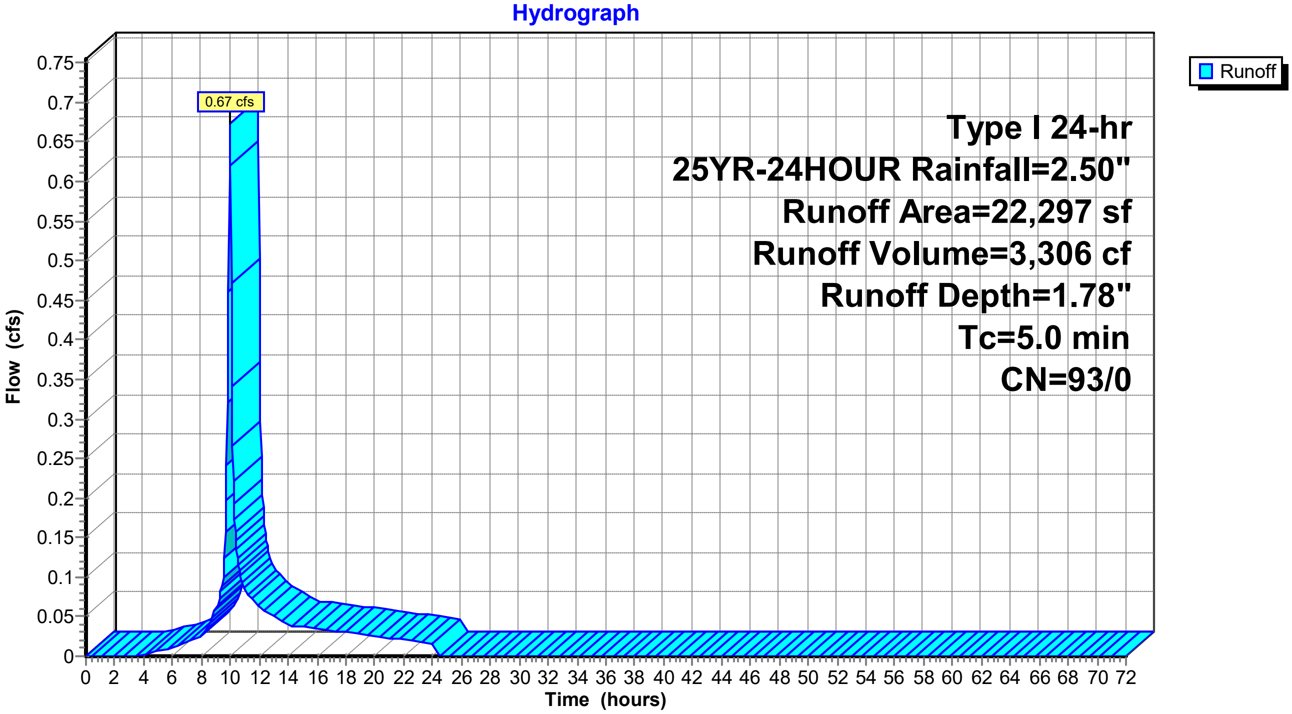
Runoff = 0.67 cfs @ 9.95 hrs, Volume= 3,306 cf, Depth= 1.78"
Routed to Pond 27P : DW1.8

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,297	93	Paved roads w/curbs & sewers, HSG A
	22,297	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 11S: G1.8



Summary for Subcatchment 12S: G1.9

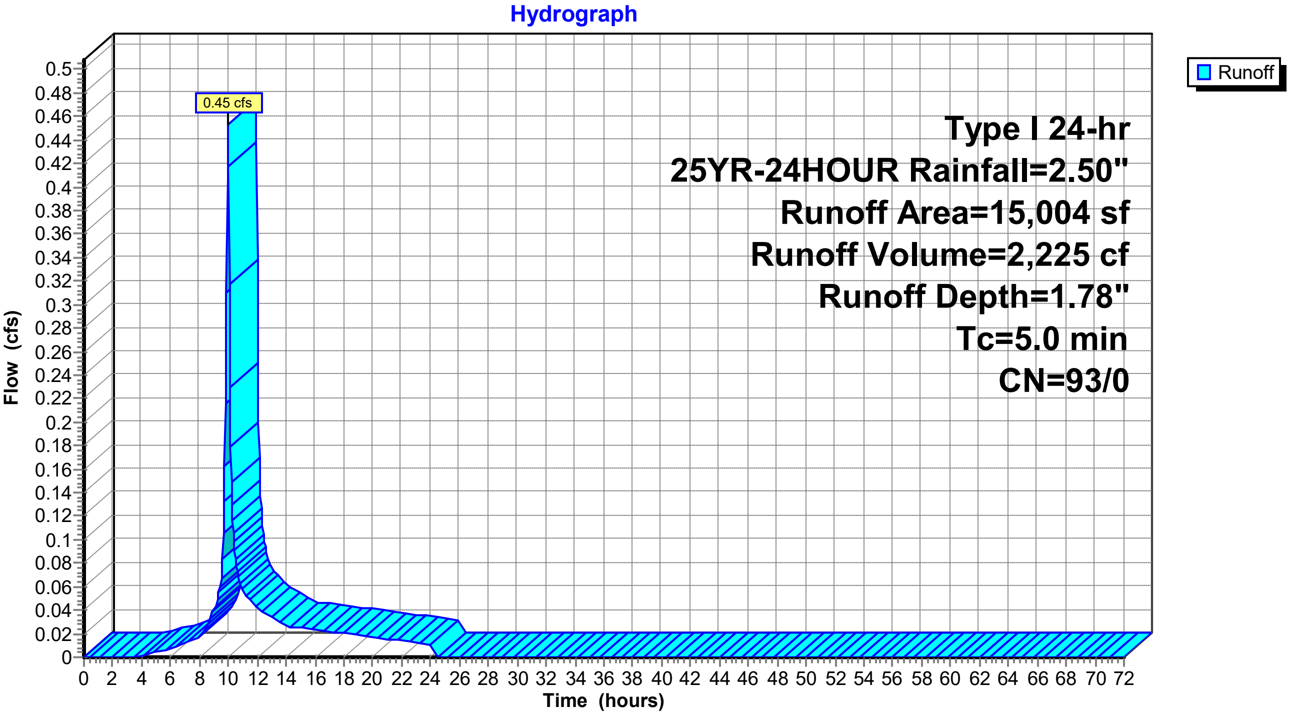
Runoff = 0.45 cfs @ 9.95 hrs, Volume= 2,225 cf, Depth= 1.78"
Routed to Pond 19P : DW1.9

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	15,004	93	Paved roads w/curbs & sewers, HSG A
	15,004	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 12S: G1.9



Summary for Subcatchment 13S: G1.10

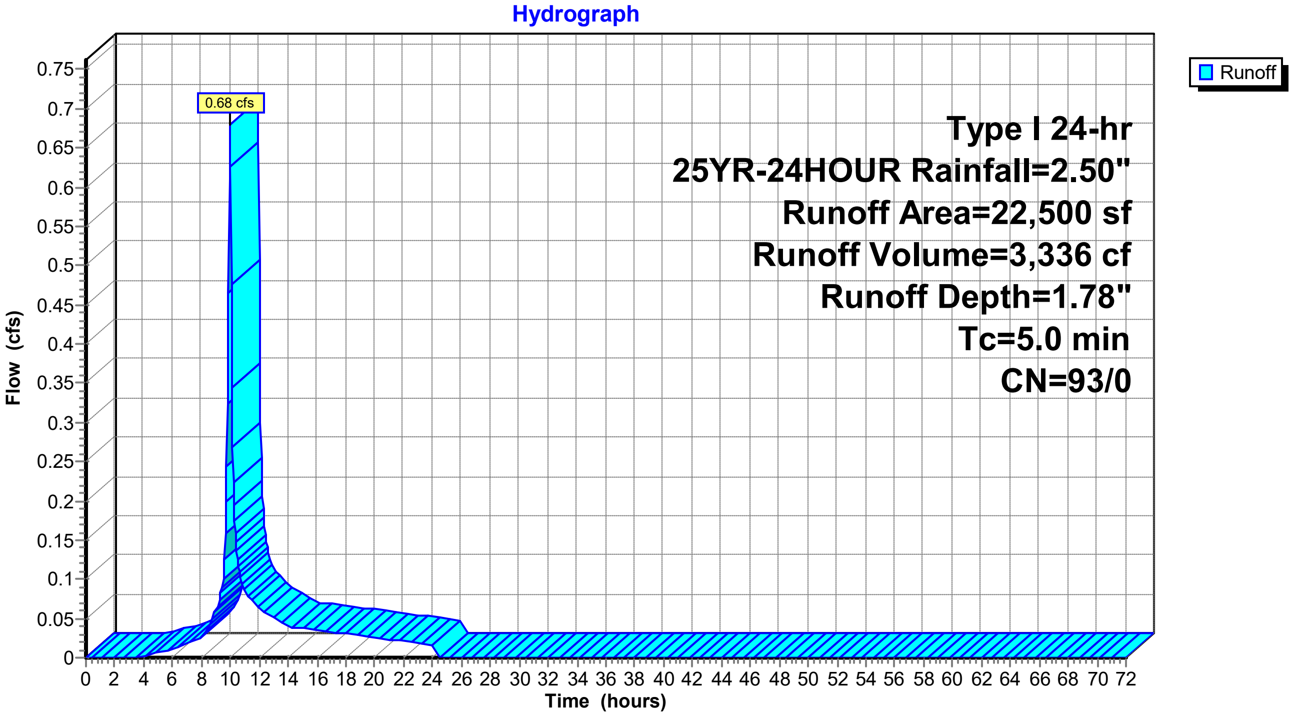
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf, Depth= 1.78"
Routed to Pond 28P : DW1.10

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 13S: G1.10



Summary for Subcatchment 14S: G1.11

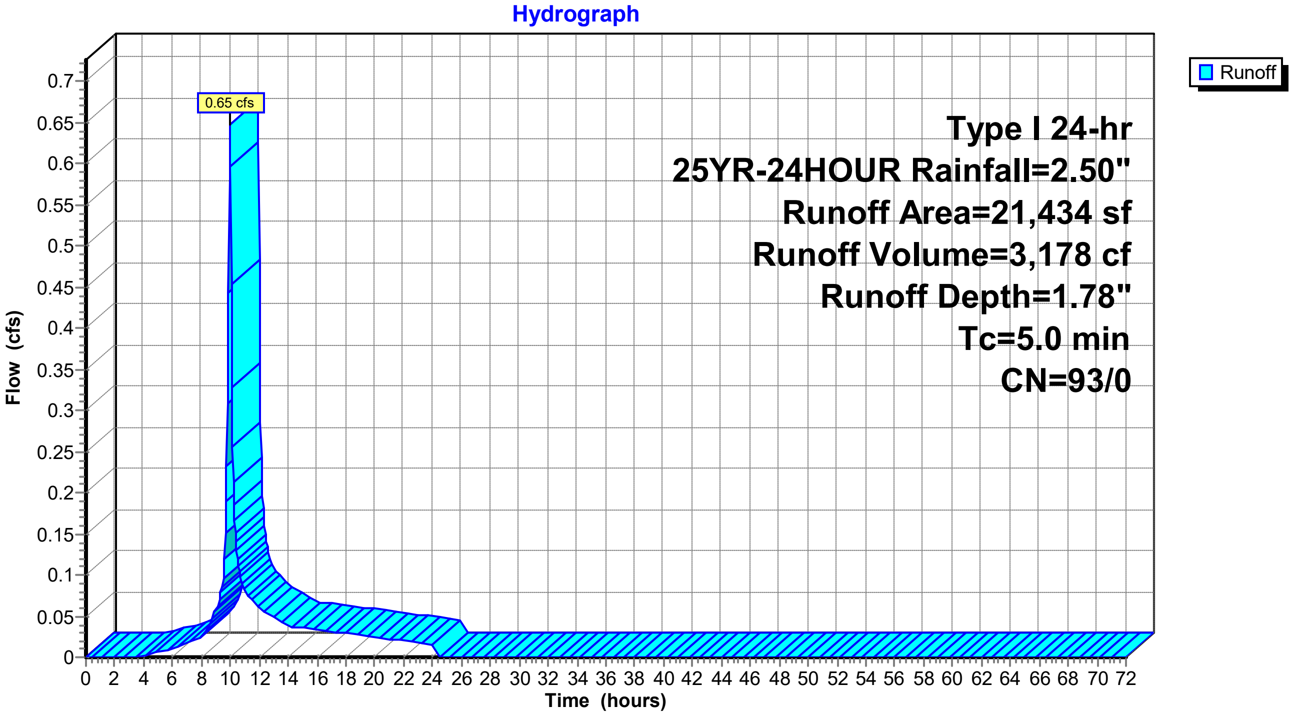
Runoff = 0.65 cfs @ 9.95 hrs, Volume= 3,178 cf, Depth= 1.78"
Routed to Pond 29P : DW1.11

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	21,434	93	Paved roads w/curbs & sewers, HSG A
	21,434	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 14S: G1.11



Summary for Subcatchment 15S: G1.12

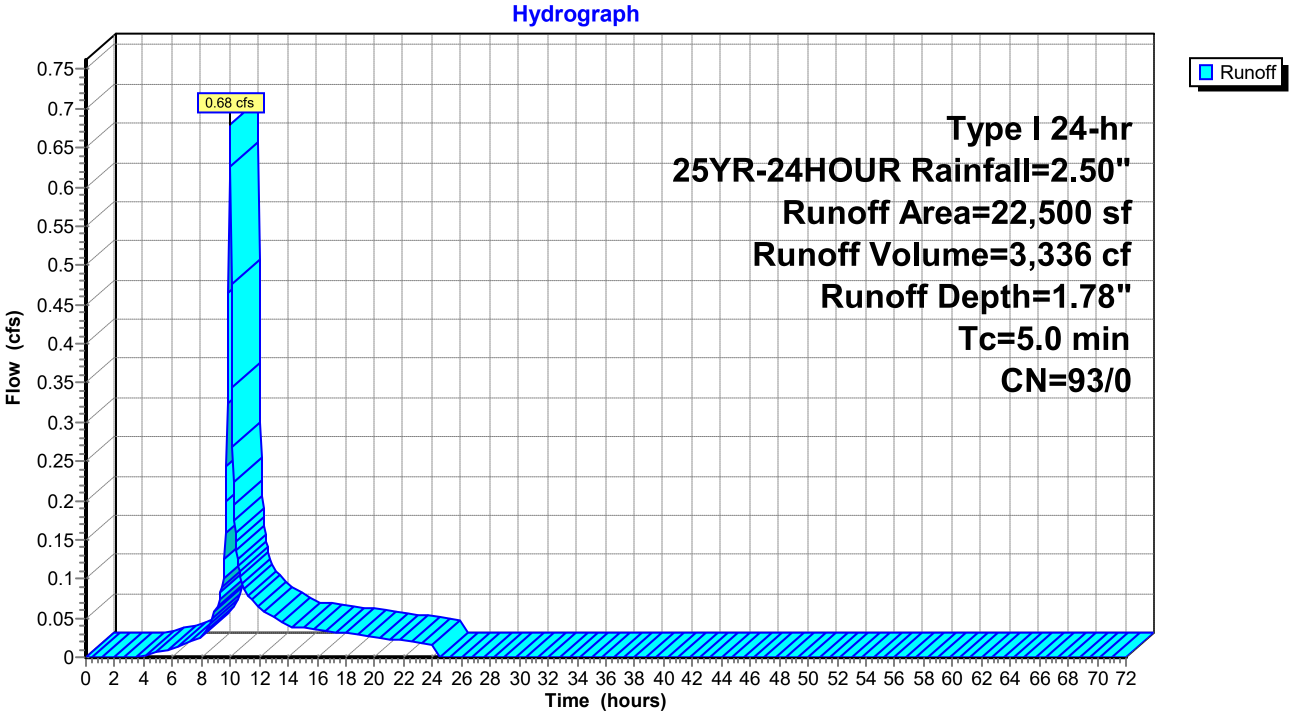
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf, Depth= 1.78"
Routed to Pond 30P : DW1.12

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 15S: G1.12



Summary for Subcatchment 16S: G1.13

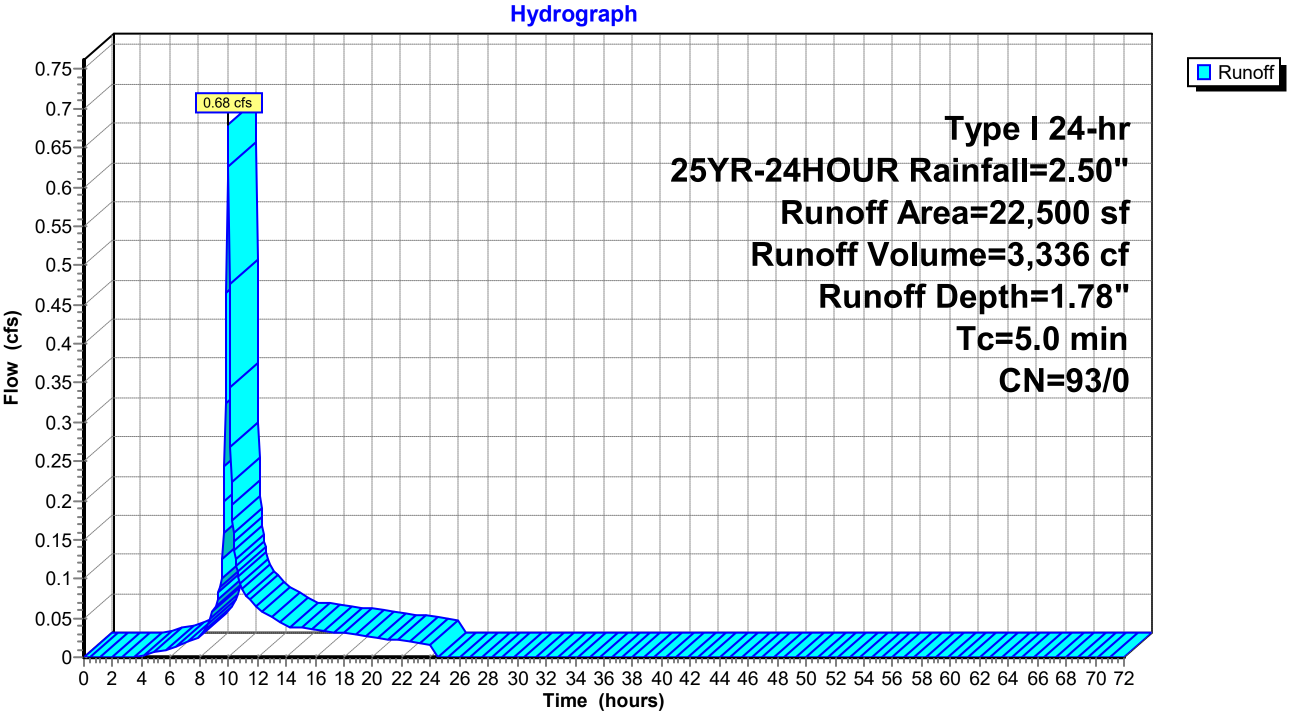
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf, Depth= 1.78"
Routed to Pond 31P : DW1.13

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 16S: G1.13



Summary for Subcatchment 17S: G1.14

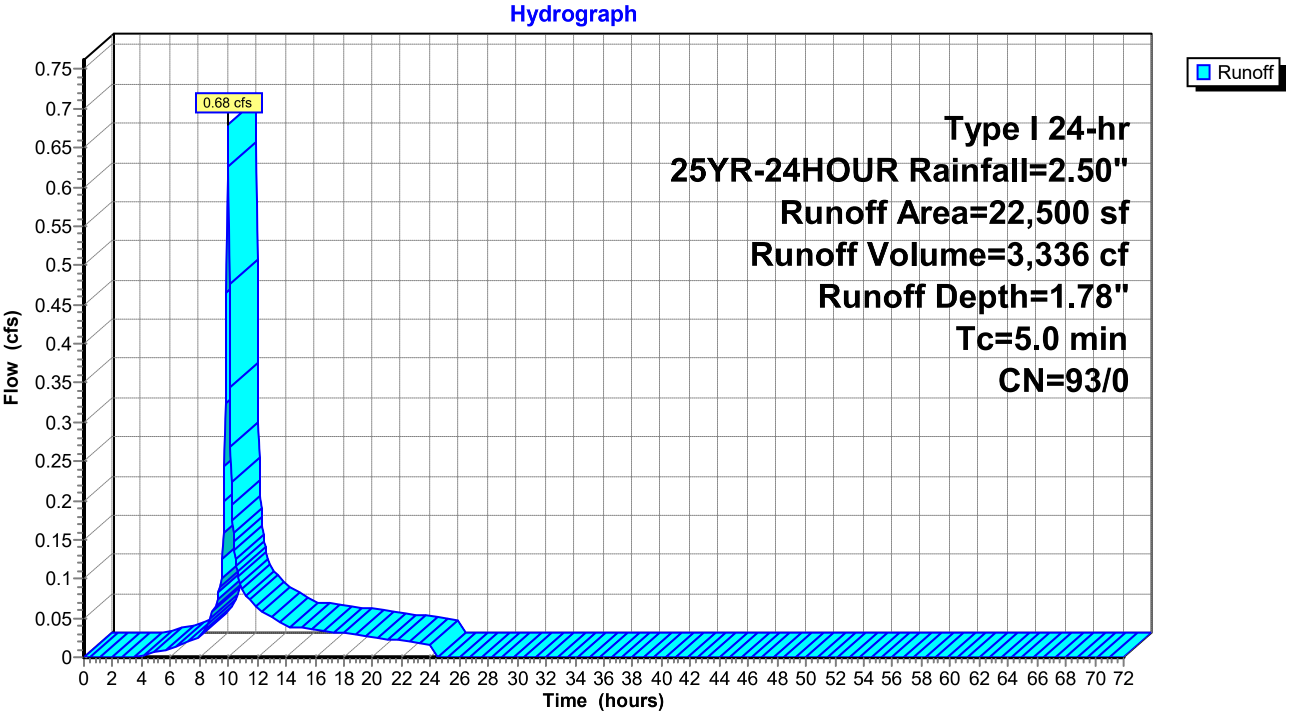
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf, Depth= 1.78"
Routed to Pond 32P : DW1.14

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 17S: G1.14



Summary for Subcatchment 18S: G1.15

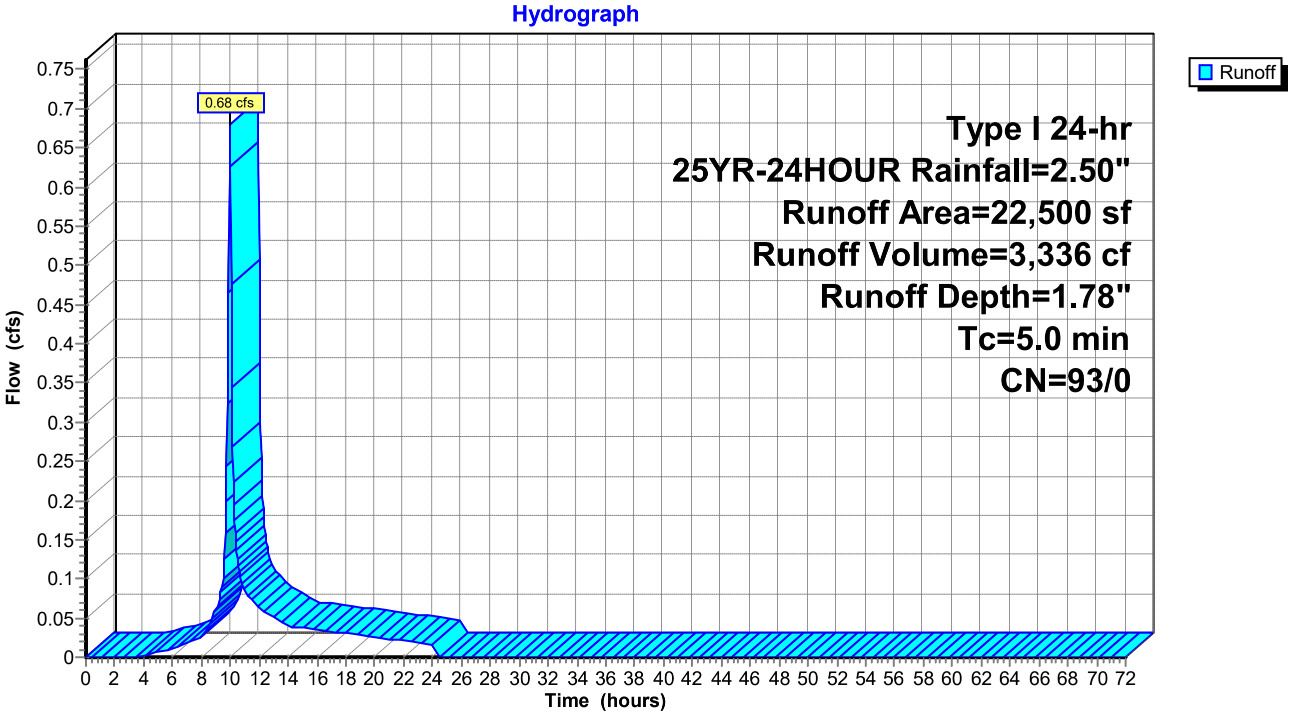
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf, Depth= 1.78"
Routed to Pond 33P : DW1.15

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 18S: G1.15



Summary for Pond 19P: DW1.9

Inflow Area = 15,004 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.45 cfs @ 9.95 hrs, Volume= 2,225 cf
Outflow = 0.08 cfs @ 9.65 hrs, Volume= 2,225 cf, Atten= 82%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.65 hrs, Volume= 2,225 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 4.35' @ 10.50 hrs Surf.Area= 225 sf Storage= 409 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 26.4 min calculated for 2,223 cf (100% of inflow)
Center-of-Mass det. time= 26.4 min (790.7 - 764.3)

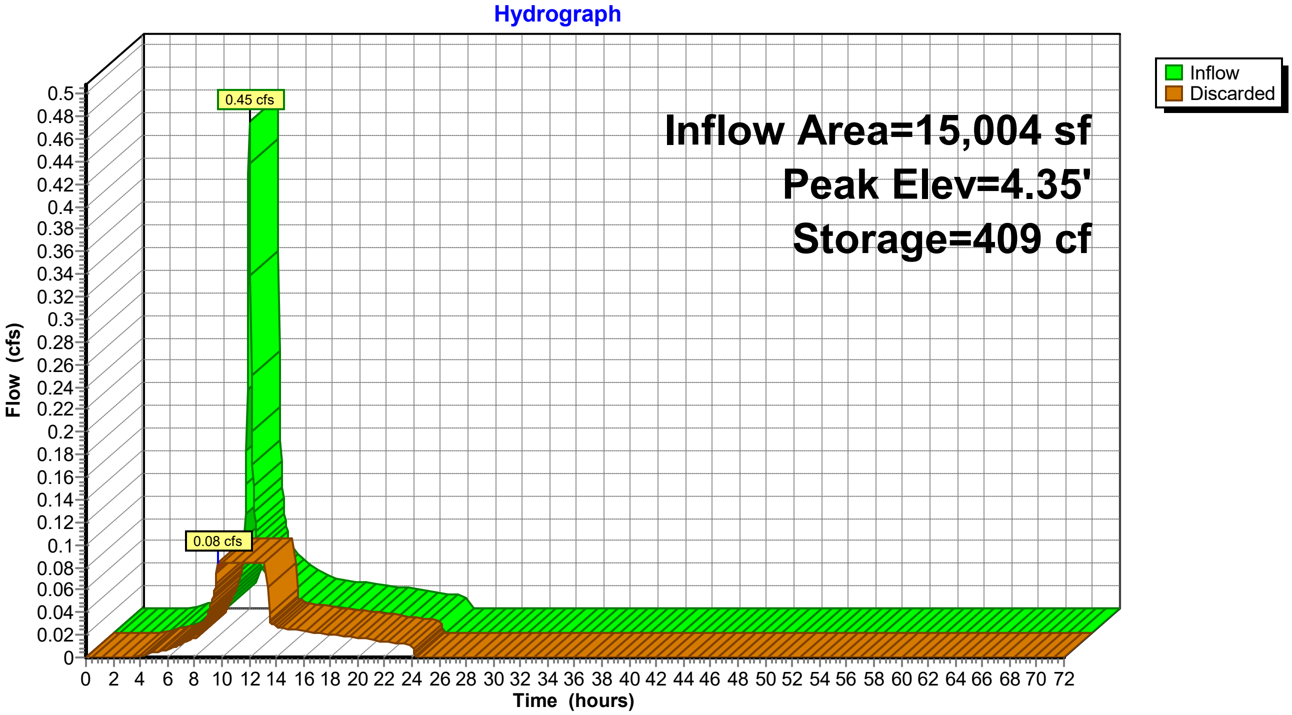
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.65 hrs HW=0.16' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 19P: DW1.9



Summary for Pond 20P: DW1.1

Inflow Area = 22,447 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.68 cfs @ 9.95 hrs, Volume= 3,329 cf
Outflow = 0.08 cfs @ 9.40 hrs, Volume= 3,329 cf, Atten= 88%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.40 hrs, Volume= 3,329 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.24' @ 11.02 hrs Surf.Area= 225 sf Storage= 780 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 66.1 min calculated for 3,326 cf (100% of inflow)
Center-of-Mass det. time= 66.1 min (830.4 - 764.3)

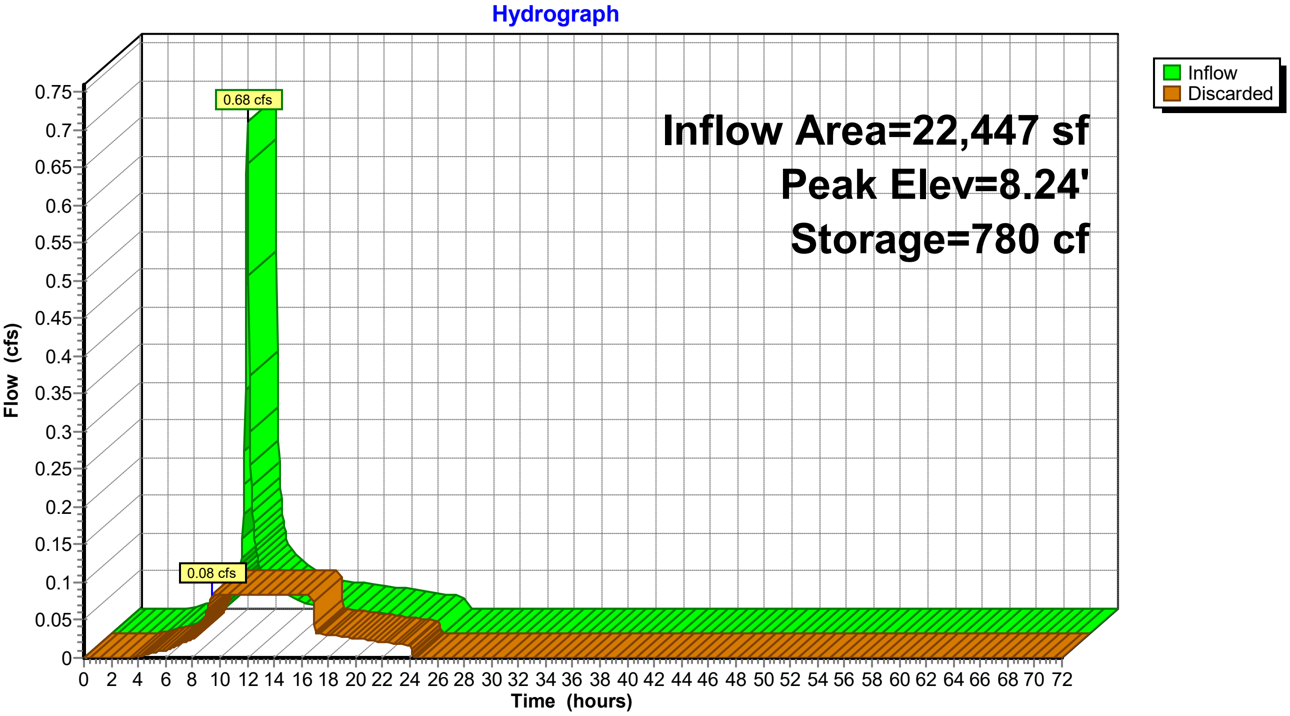
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 20P: DW1.1



Summary for Pond 21P: DW1.2

Inflow Area = 18,682 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.56 cfs @ 9.95 hrs, Volume= 2,770 cf
Outflow = 0.08 cfs @ 9.60 hrs, Volume= 2,770 cf, Atten= 85%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.60 hrs, Volume= 2,770 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 6.15' @ 10.70 hrs Surf.Area= 225 sf Storage= 580 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 43.3 min calculated for 2,768 cf (100% of inflow)
Center-of-Mass det. time= 43.3 min (807.6 - 764.3)

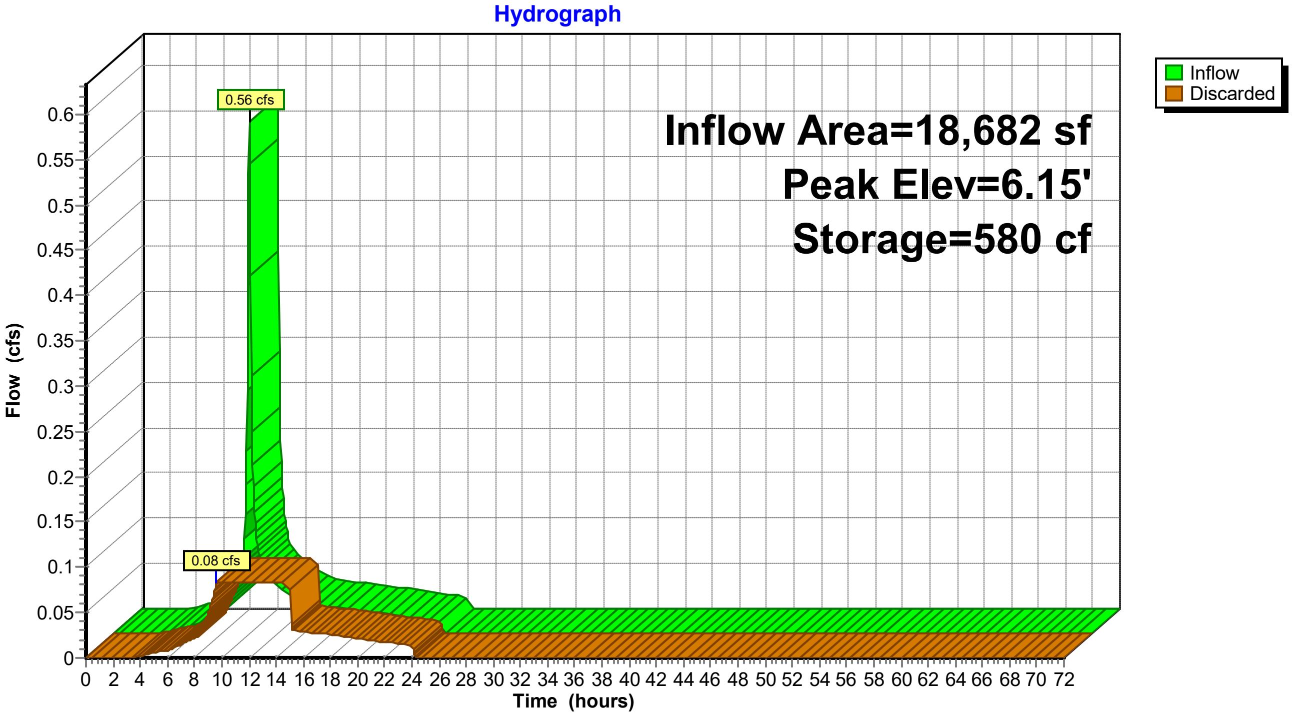
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.60 hrs HW=0.17' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 21P: DW1.2



Summary for Pond 22P: DW1.3

```
Inflow Area =          16,897 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow      =        0.51 cfs @    9.95 hrs,  Volume=              2,506 cf
Outflow     =        0.08 cfs @    9.65 hrs,  Volume=              2,506 cf,  Atten= 84%,  Lag= 0.0 min
Discarded  =         0.08 cfs @    9.65 hrs,  Volume=              2,506 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 5.25' @ 10.58 hrs   Surf.Area= 225 sf   Storage= 495 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 34.5 min calculated for 2,504 cf (100% of inflow)
Center-of-Mass det. time= 34.5 min (798.8 - 764.3)

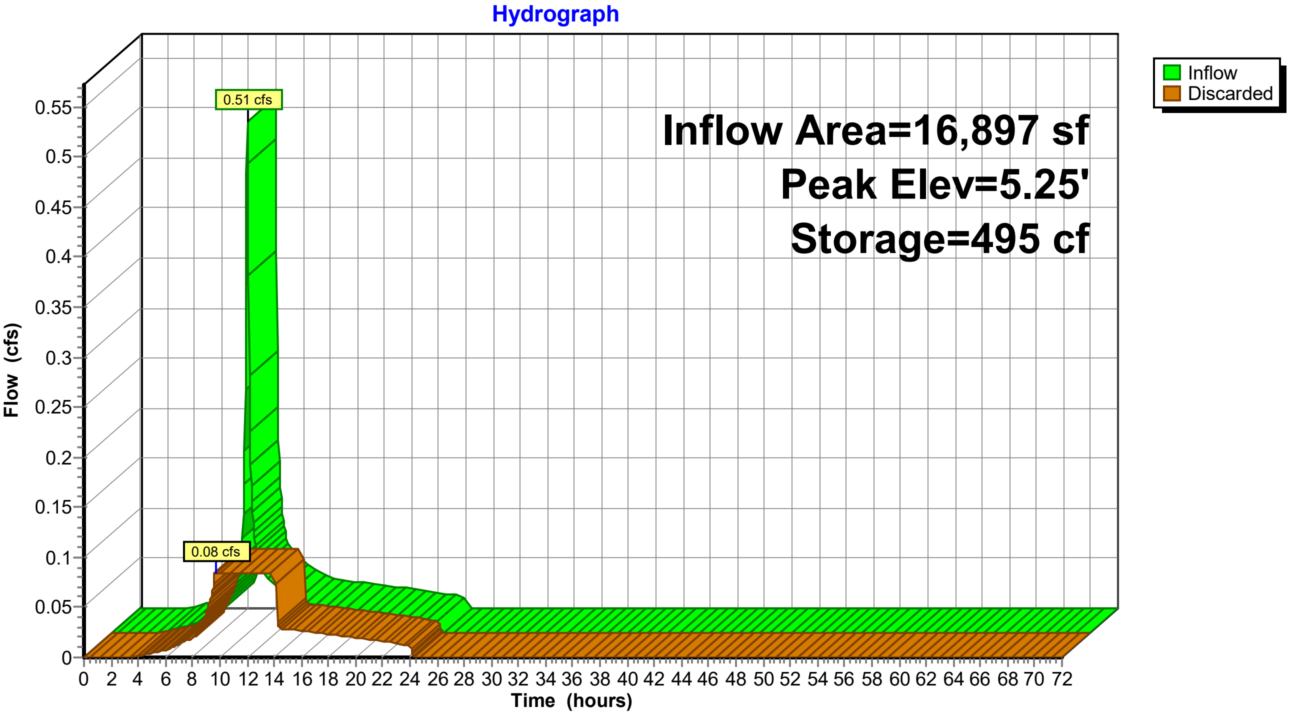
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.65 hrs HW=0.19' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 22P: DW1.3



Summary for Pond 23P: DW1.4

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf
Outflow = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf, Atten= 88%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.27' @ 11.02 hrs Surf.Area= 225 sf Storage= 783 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 66.5 min calculated for 3,334 cf (100% of inflow)
Center-of-Mass det. time= 66.4 min (830.7 - 764.3)

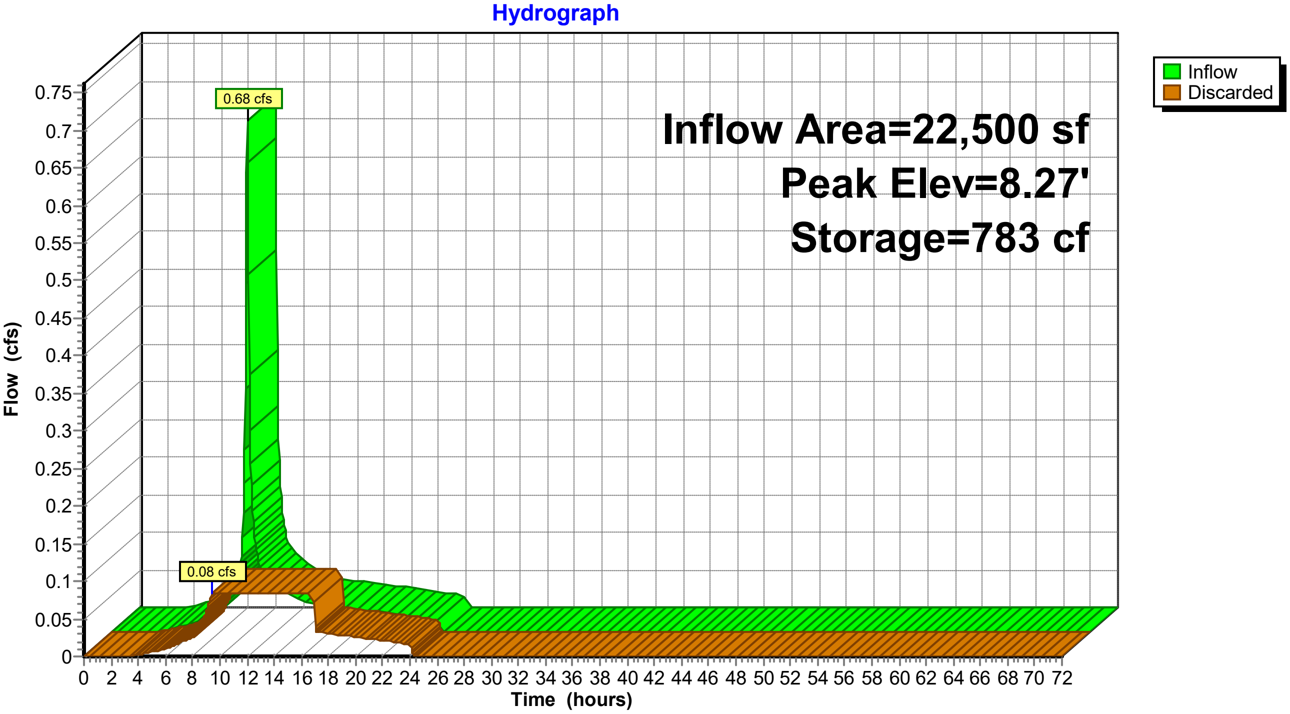
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 23P: DW1.4



Summary for Pond 24P: DW1.5

Inflow Area = 20,304 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.61 cfs @ 9.95 hrs, Volume= 3,011 cf
Outflow = 0.08 cfs @ 9.50 hrs, Volume= 3,011 cf, Atten= 86%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.50 hrs, Volume= 3,011 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 7.01' @ 10.84 hrs Surf.Area= 225 sf Storage= 663 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 52.3 min calculated for 3,009 cf (100% of inflow)
Center-of-Mass det. time= 52.3 min (816.6 - 764.3)

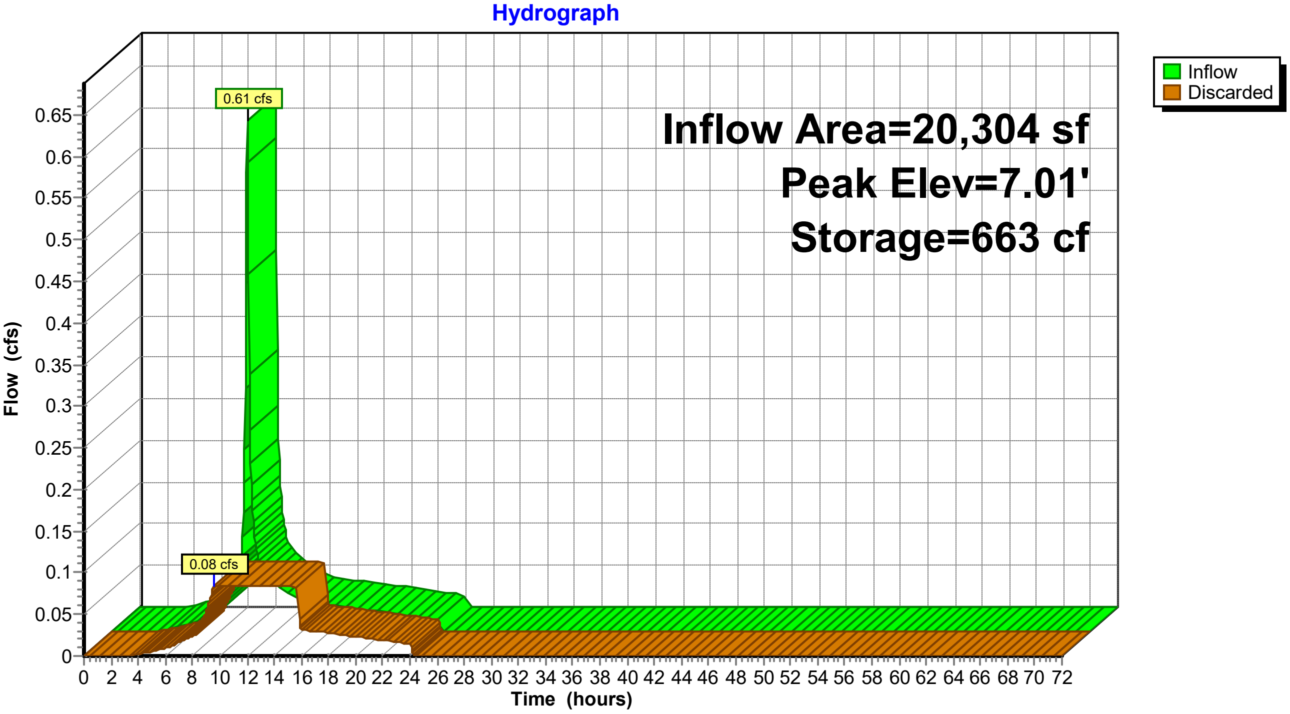
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.50 hrs HW=0.15' (Free Discharge)
└—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 24P: DW1.5



Summary for Pond 25P: DW1.6

```
Inflow Area =        22,550 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow      =      0.68 cfs @    9.95 hrs,  Volume=            3,344 cf
Outflow     =      0.08 cfs @    9.40 hrs,  Volume=            3,344 cf,  Atten= 88%,  Lag= 0.0 min
Discarded  =       0.08 cfs @    9.40 hrs,  Volume=            3,344 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.30' @ 11.02 hrs Surf.Area= 225 sf Storage= 785 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 66.8 min calculated for 3,341 cf (100% of inflow)
Center-of-Mass det. time= 66.8 min (831.1 - 764.3)

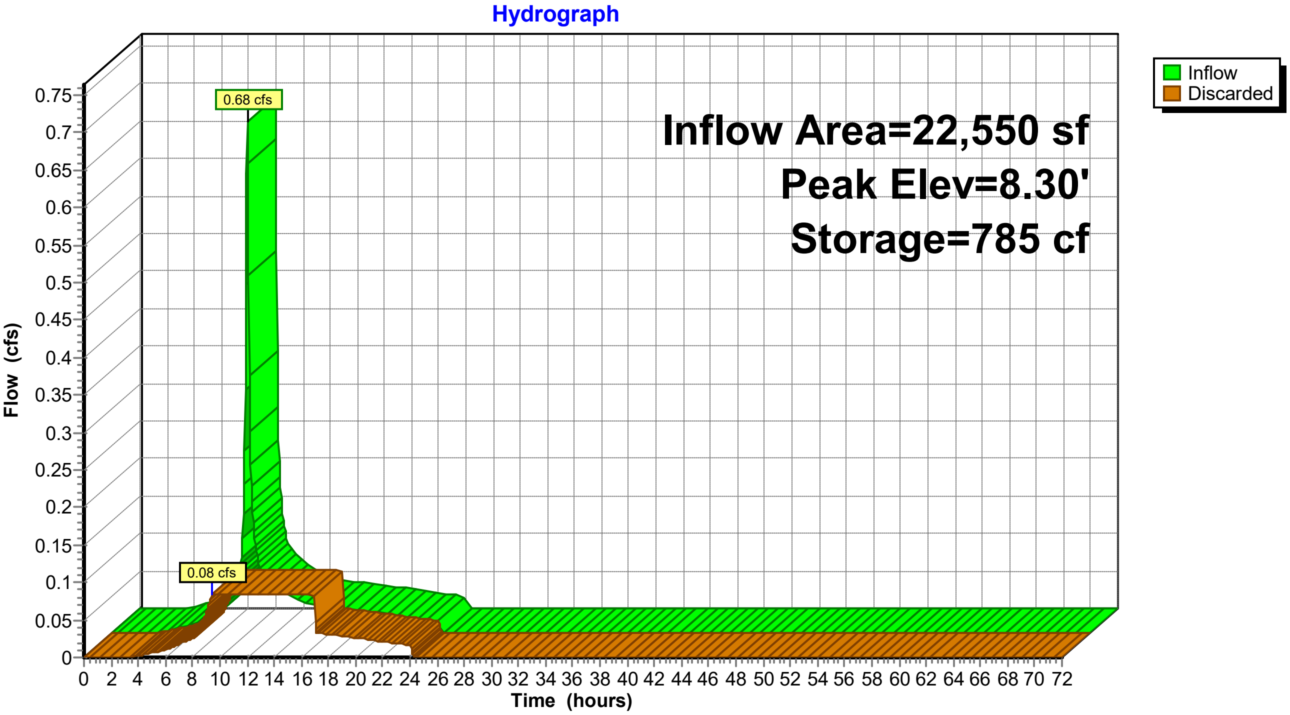
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 25P: DW1.6



Summary for Pond 26P: DW1.7

Inflow Area = 22,550 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.68 cfs @ 9.95 hrs, Volume= 3,344 cf
Outflow = 0.08 cfs @ 9.40 hrs, Volume= 3,344 cf, Atten= 88%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.40 hrs, Volume= 3,344 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.30' @ 11.02 hrs Surf.Area= 225 sf Storage= 785 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 66.8 min calculated for 3,341 cf (100% of inflow)
Center-of-Mass det. time= 66.8 min (831.1 - 764.3)

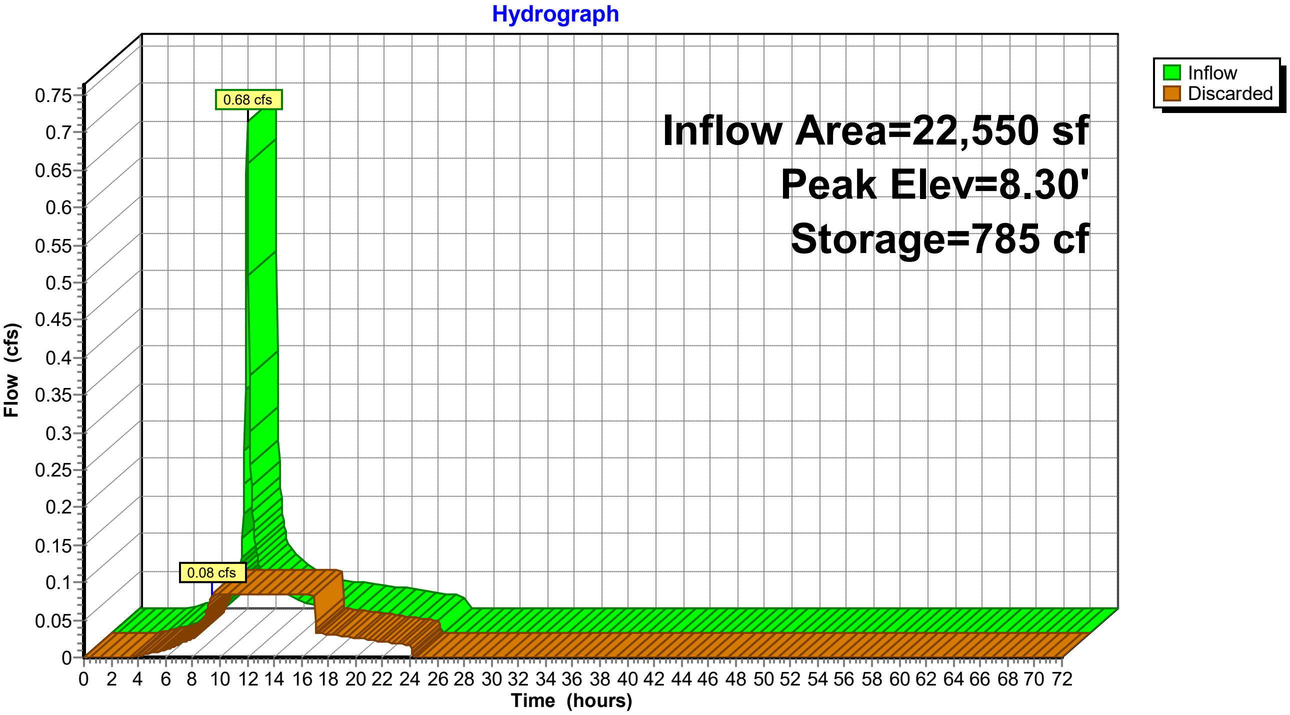
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 26P: DW1.7



Summary for Pond 27P: DW1.8

```
Inflow Area =          22,297 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow      =       0.67 cfs @    9.95 hrs,  Volume=             3,306 cf
Outflow     =       0.08 cfs @    9.40 hrs,  Volume=             3,306 cf,  Atten= 88%,  Lag= 0.0 min
Discarded  =        0.08 cfs @    9.40 hrs,  Volume=             3,306 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.15' @ 11.00 hrs Surf.Area= 225 sf Storage= 771 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 65.1 min calculated for 3,304 cf (100% of inflow)
Center-of-Mass det. time= 65.0 min (829.3 - 764.3)

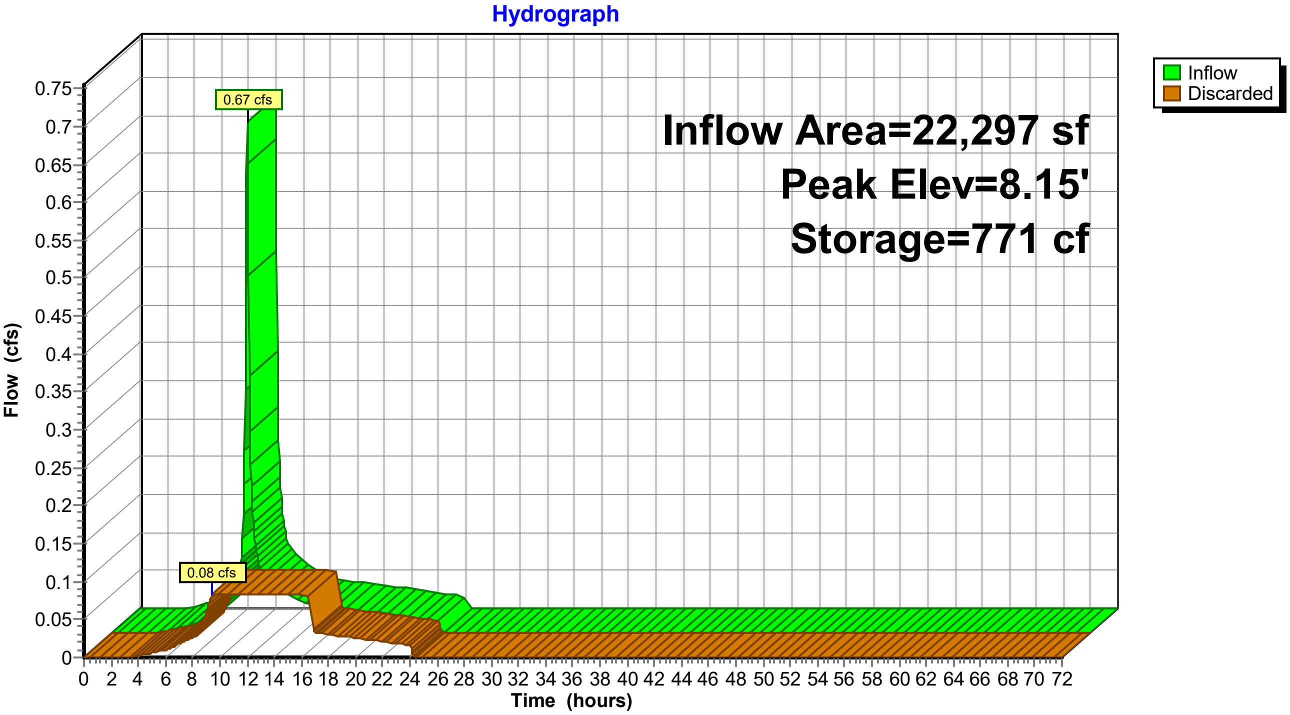
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 27P: DW1.8



Summary for Pond 28P: DW1.10

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf
Outflow = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf, Atten= 88%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.27' @ 11.02 hrs Surf.Area= 225 sf Storage= 783 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 66.5 min calculated for 3,334 cf (100% of inflow)
Center-of-Mass det. time= 66.4 min (830.7 - 764.3)

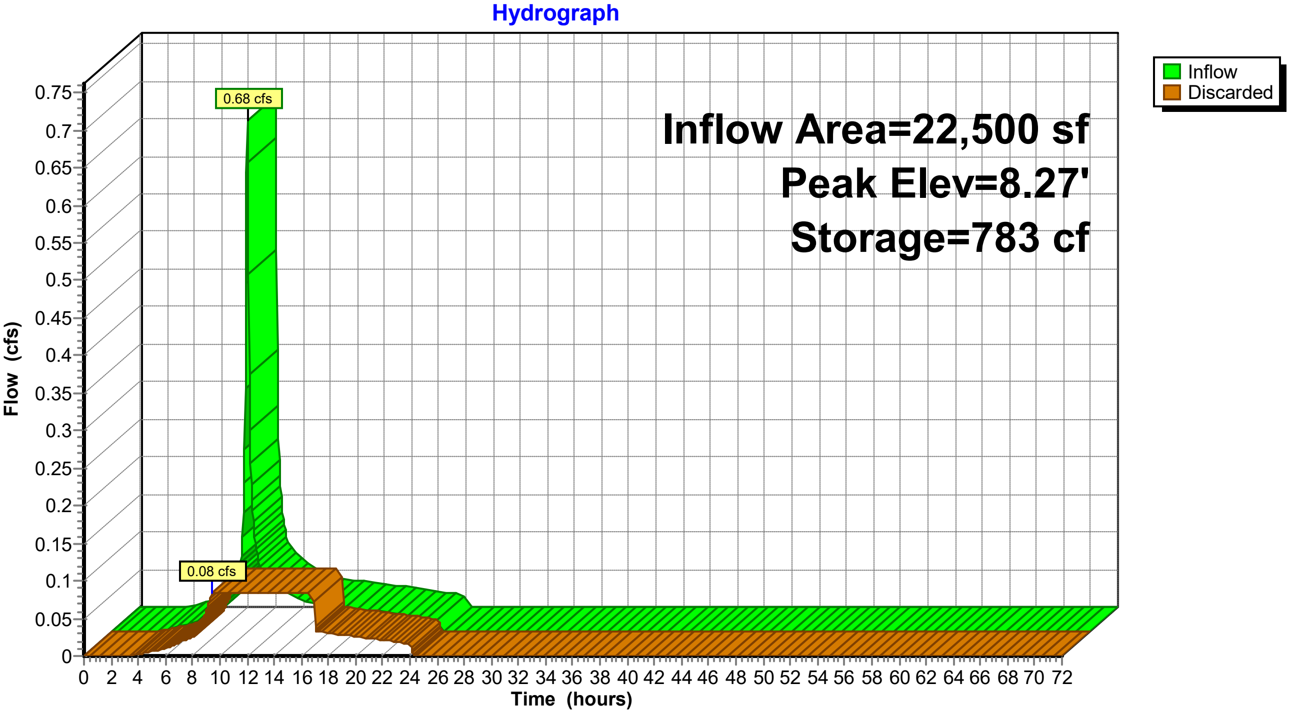
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

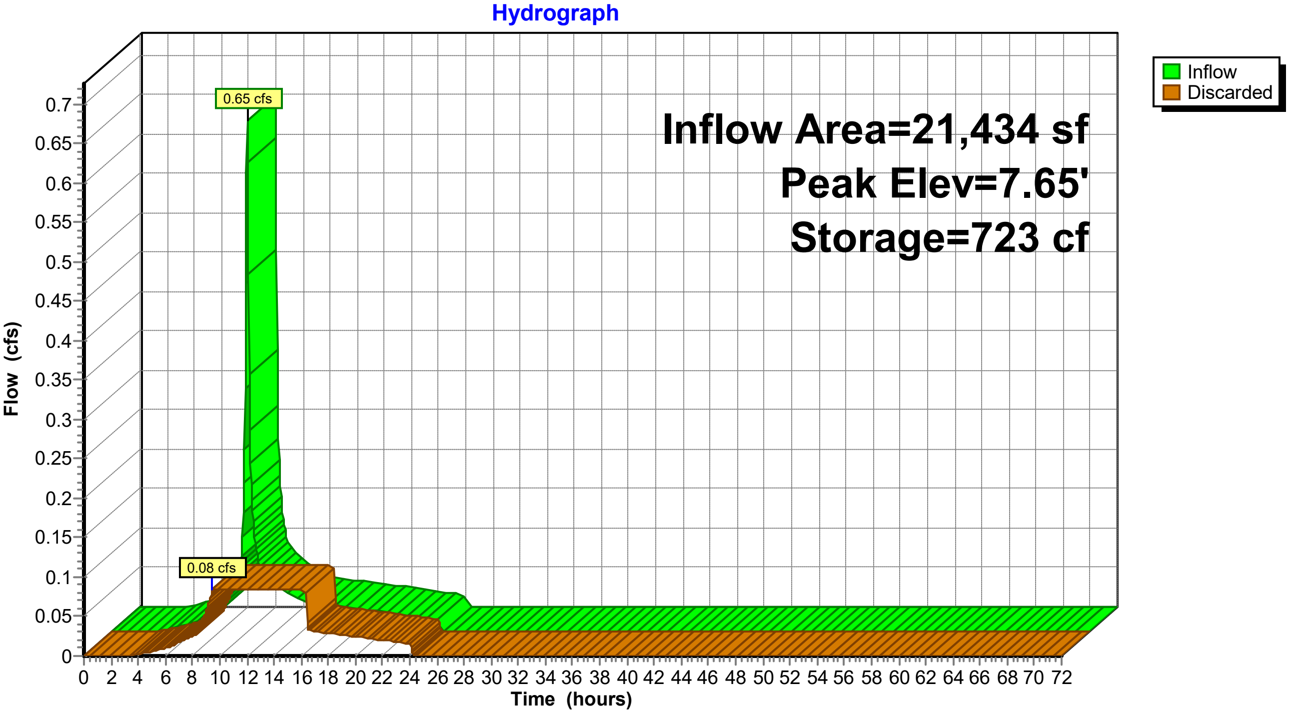
Pond 28P: DW1.10



Summary for Pond 29P: DW1.11

```
Inflow Area =          21,434 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow       =       0.65 cfs @    9.95 hrs,  Volume=              3,178 cf
Outflow      =       0.08 cfs @    9.45 hrs,  Volume=              3,178 cf,  Atten= 87%,  Lag= 0.0 min
Discarded  =         0.08 cfs @    9.45 hrs,  Volume=              3,178 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 7.65' @ 10.93 hrs   Surf.Area= 225 sf   Storage= 723 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 59.3 min calculated for 3,176 cf (100% of inflow)
Center-of-Mass det. time= 59.3 min ( 823.6 - 764.3 )

Volume        Invert     Avail.Storage   Storage Description
    #1          0.00'           767 cf   DW (Pyramidal) Listed below
                                         2,166 cf Overall - 248 cf Embedded = 1,918 cf  x 40.0% Voids
    #2          1.00'           170 cf   4.00'D x 13.50'H Vertical Cone/Cylinder  Inside #1
                                         248 cf Overall - 5.0" Wall Thickness = 170 cf
                                937 cf   Total Available Storage

 Elevation          Surf.Area           Inc.Store          Cum.Store          Wet.Area
    (feet)              (sq-ft)       (cubic-feet)       (cubic-feet)             (sq-ft)
      0.00                  225                  0                  0                 225
      9.00                  225              2,025              2,025                 765
      9.50                   18                 51              2,076                 973
     14.50                   18                 90              2,166               1,058

Device    Routing             Invert    Outlet Devices
    #1    Discarded            0.00'    16.000 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.08 cfs @ 9.45 hrs  HW=0.15'   (Free Discharge)
└─1=Exfiltration  (Exfiltration Controls 0.08 cfs)
```

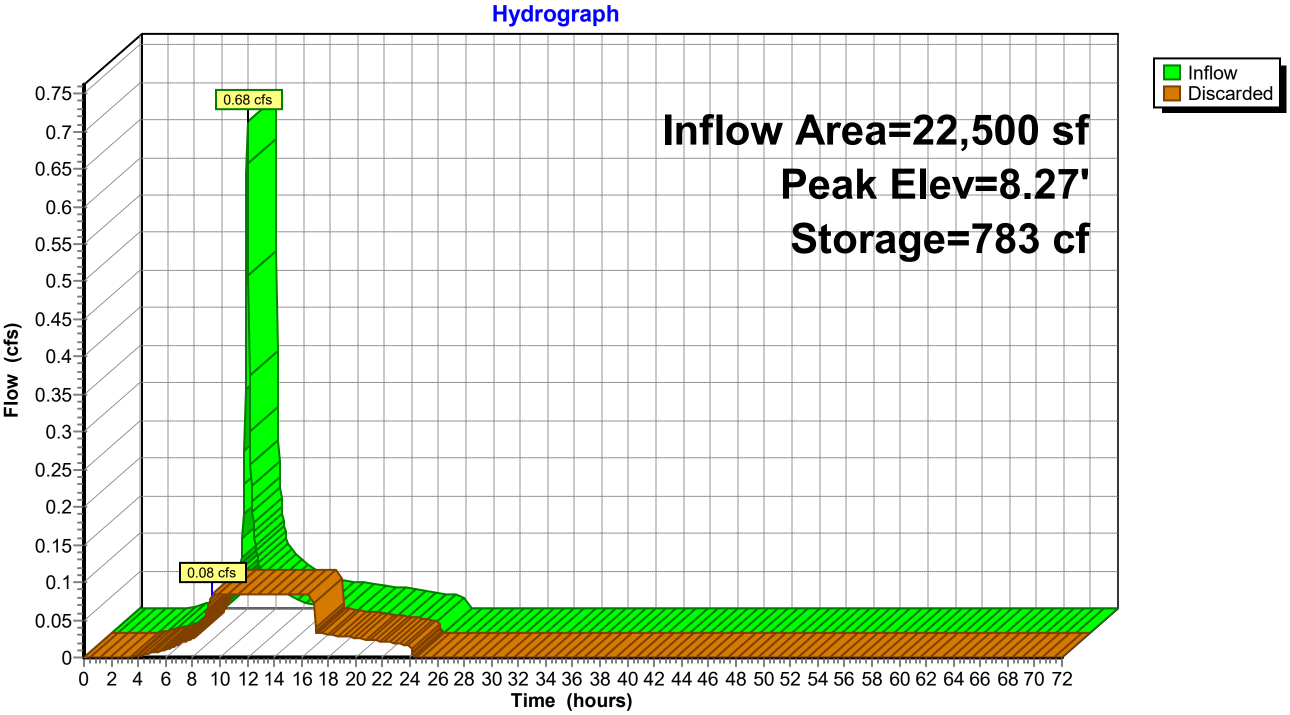
Pond 29P: DW1.11



Summary for Pond 30P: DW1.12

```
Inflow Area =          22,500 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow      =        0.68 cfs @    9.95 hrs,  Volume=             3,336 cf
Outflow     =        0.08 cfs @    9.40 hrs,  Volume=             3,336 cf,  Atten= 88%,  Lag= 0.0 min
Discarded  =        0.08 cfs @    9.40 hrs,  Volume=             3,336 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.27' @ 11.02 hrs   Surf.Area= 225 sf   Storage= 783 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 66.5 min calculated for 3,334 cf (100% of inflow)
Center-of-Mass det. time= 66.4 min ( 830.7 - 764.3 )

Volume        Invert     Avail.Storage   Storage Description
   #1          0.00'            767 cf   DW (Pyramidal) Listed below
                                         2,166 cf Overall - 248 cf Embedded = 1,918 cf  x 40.0% Voids
   #2          1.00'            170 cf   4.00'D x 13.50'H Vertical Cone/Cylinder  Inside #1
                                         248 cf Overall - 5.0" Wall Thickness = 170 cf
                                937 cf   Total Available Storage

 Elevation        Surf.Area          Inc.Store          Cum.Store           Wet.Area
    (feet)           (sq-ft)       (cubic-feet)       (cubic-feet)             (sq-ft)
      0.00               225                  0                  0                 225
      9.00               225              2,025              2,025                 765
      9.50                18                 51              2,076                 973
     14.50                18                 90              2,166               1,058

Device   Routing            Invert   Outlet Devices
   #1    Discarded           0.00'   16.000 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.08 cfs @ 9.40 hrs  HW=0.15'   (Free Discharge)
└─1=Exfiltration  (Exfiltration Controls 0.08 cfs)
```

Pond 30P: DW1.12



Summary for Pond 31P: DW1.13

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf
Outflow = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf, Atten= 88%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.27' @ 11.02 hrs Surf.Area= 225 sf Storage= 783 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 66.5 min calculated for 3,334 cf (100% of inflow)
Center-of-Mass det. time= 66.4 min (830.7 - 764.3)

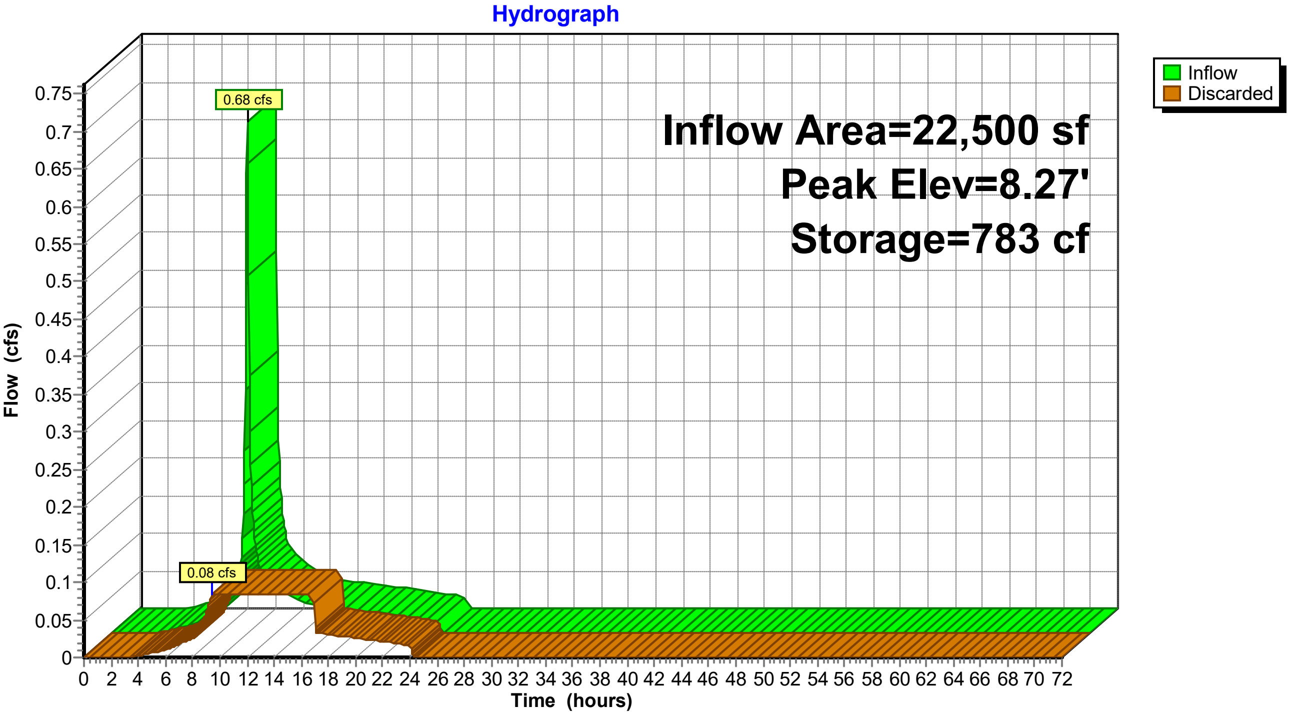
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 31P: DW1.13



Summary for Pond 32P: DW1.14

```
Inflow Area =          22,500 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow      =        0.68 cfs @    9.95 hrs,  Volume=             3,336 cf
Outflow     =        0.08 cfs @    9.40 hrs,  Volume=             3,336 cf,  Atten= 88%,  Lag= 0.0 min
Discarded  =        0.08 cfs @    9.40 hrs,  Volume=             3,336 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.27' @ 11.02 hrs   Surf.Area= 225 sf   Storage= 783 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 66.5 min calculated for 3,334 cf (100% of inflow)
Center-of-Mass det. time= 66.4 min (830.7 - 764.3)

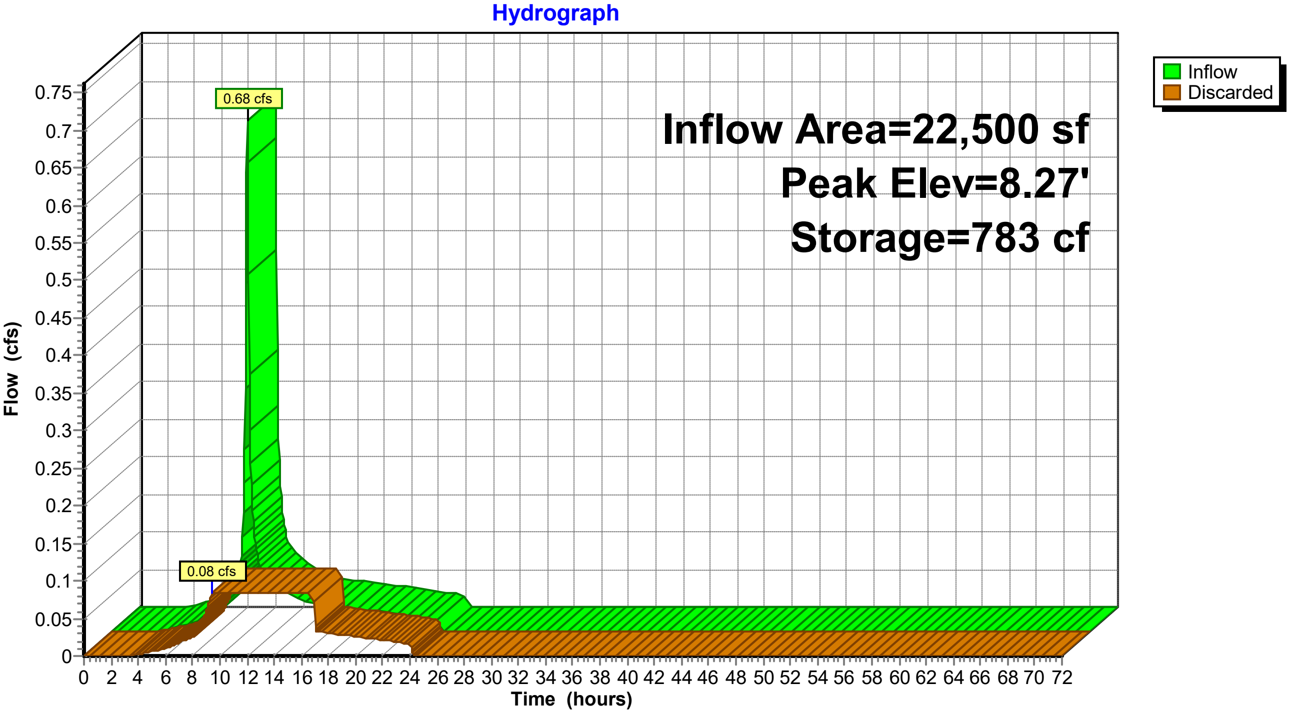
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15'   (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 32P: DW1.14



Summary for Pond 33P: DW1.15

```
Inflow Area =          22,500 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow       =       0.68 cfs @    9.95 hrs,  Volume=             3,336 cf
Outflow      =       0.08 cfs @    9.40 hrs,  Volume=             3,336 cf,  Atten= 88%,  Lag= 0.0 min
Discarded  =         0.08 cfs @    9.40 hrs,  Volume=             3,336 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.27' @ 11.02 hrs   Surf.Area= 225 sf   Storage= 783 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 66.5 min calculated for 3,334 cf (100% of inflow)
Center-of-Mass det. time= 66.4 min (830.7 - 764.3)

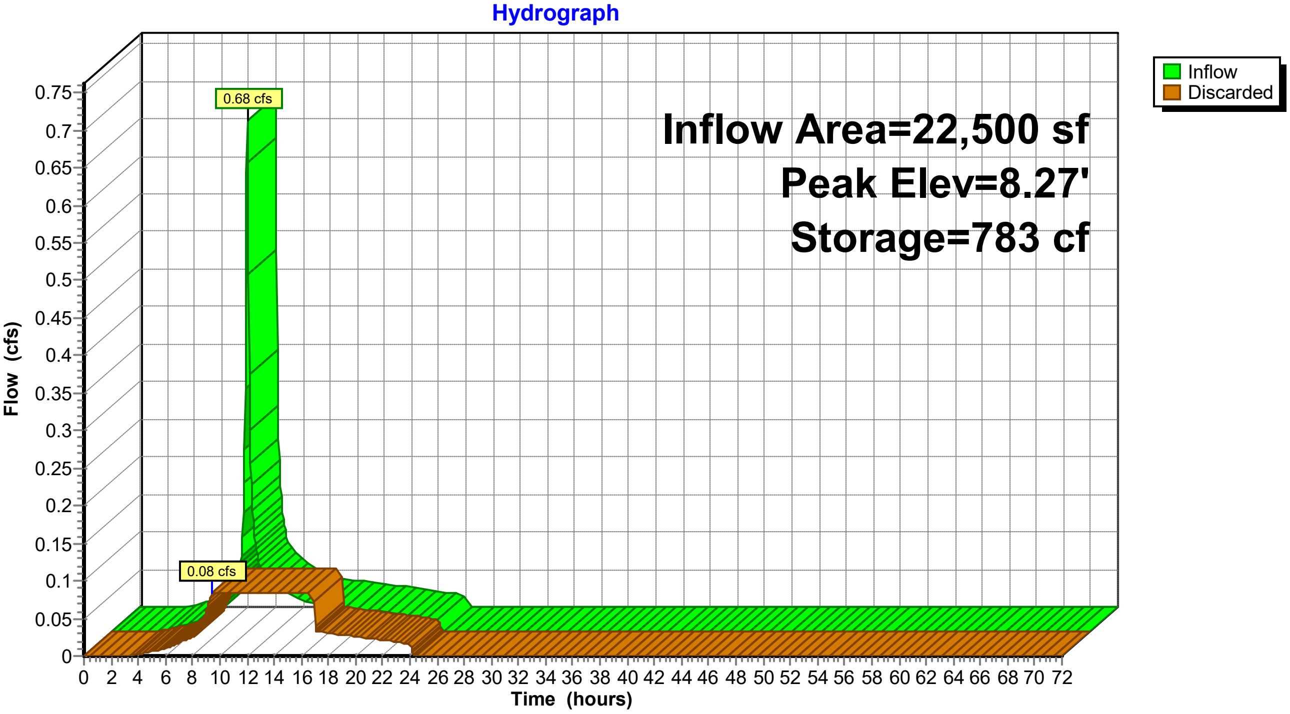
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

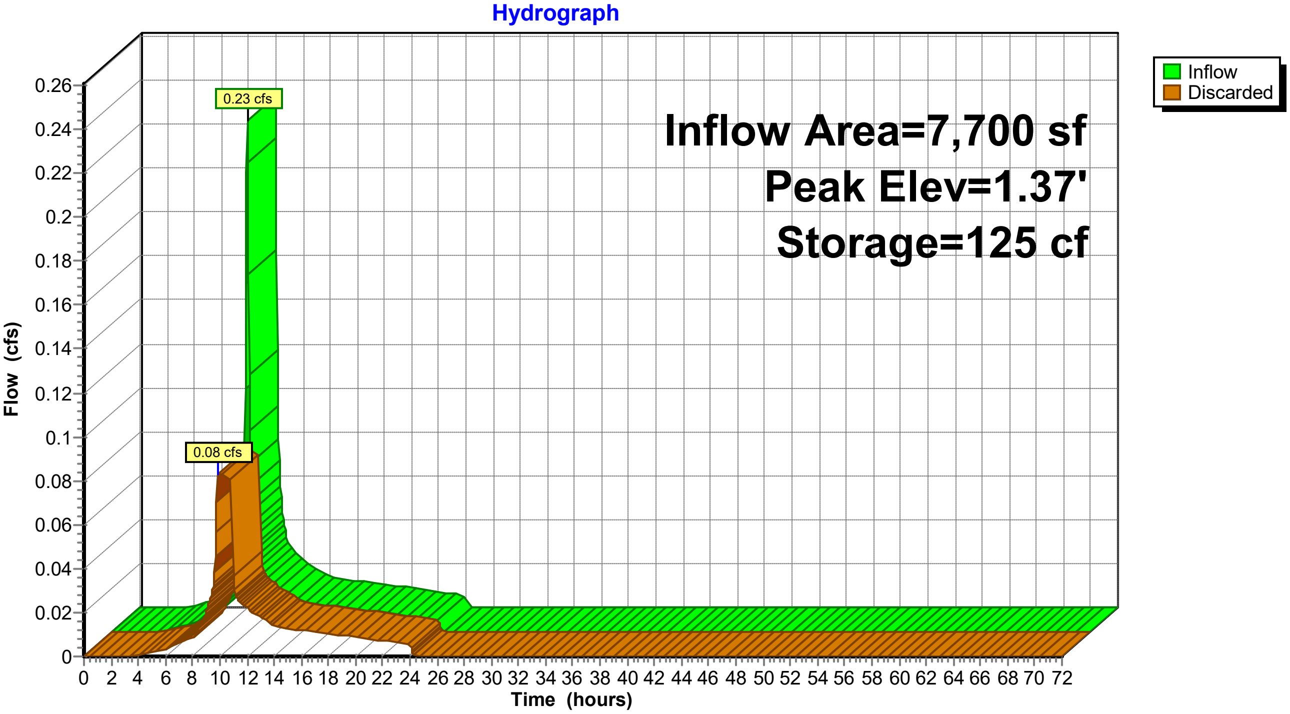
Pond 33P: DW1.15



Summary for Pond 69P: DW2.1

```
Inflow Area =          7,700 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow      =       0.23 cfs @    9.95 hrs,  Volume=             1,142 cf
Outflow     =       0.08 cfs @    9.80 hrs,  Volume=             1,142 cf,  Atten= 64%,  Lag= 0.0 min
Discarded  =        0.08 cfs @    9.80 hrs,  Volume=             1,142 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 1.37' @ 10.18 hrs   Surf.Area= 225 sf   Storage= 125 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 6.7 min calculated for 1,141 cf (100% of inflow)
Center-of-Mass det. time= 6.7 min ( 771.0 - 764.3 )

Volume      Invert    Avail.Storage   Storage Description
   #1        0.00'          767 cf    DW (Pyramidal) Listed below
                                      2,166 cf Overall - 248 cf Embedded = 1,918 cf  x 40.0% Voids
   #2        1.00'          170 cf    4.00'D x 13.50'H Vertical Cone/Cylinder  Inside #1
                                      248 cf Overall - 5.0" Wall Thickness = 170 cf
                            937 cf    Total Available Storage

 Elevation       Surf.Area        Inc.Store        Cum.Store        Wet.Area
    (feet)         (sq-ft)     (cubic-feet)     (cubic-feet)         (sq-ft)
      0.00             225                0                0             225
      9.00             225            2,025            2,025             765
      9.50              18               51            2,076             973
     14.50              18               90            2,166           1,058

Device   Routing         Invert   Outlet Devices
   #1    Discarded        0.00'   16.000 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.08 cfs @ 9.80 hrs  HW=0.16'   (Free Discharge)
└─1=Exfiltration  (Exfiltration Controls 0.08 cfs)
```

Pond 69P: DW2.1



Summary for Pond 70P: DW2.4

Inflow Area = 17,300 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.52 cfs @ 9.95 hrs, Volume= 2,565 cf
Outflow = 0.08 cfs @ 9.60 hrs, Volume= 2,565 cf, Atten= 84%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.60 hrs, Volume= 2,565 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 5.45' @ 10.61 hrs Surf.Area= 225 sf Storage= 514 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 36.4 min calculated for 2,564 cf (100% of inflow)
Center-of-Mass det. time= 36.4 min (800.7 - 764.3)

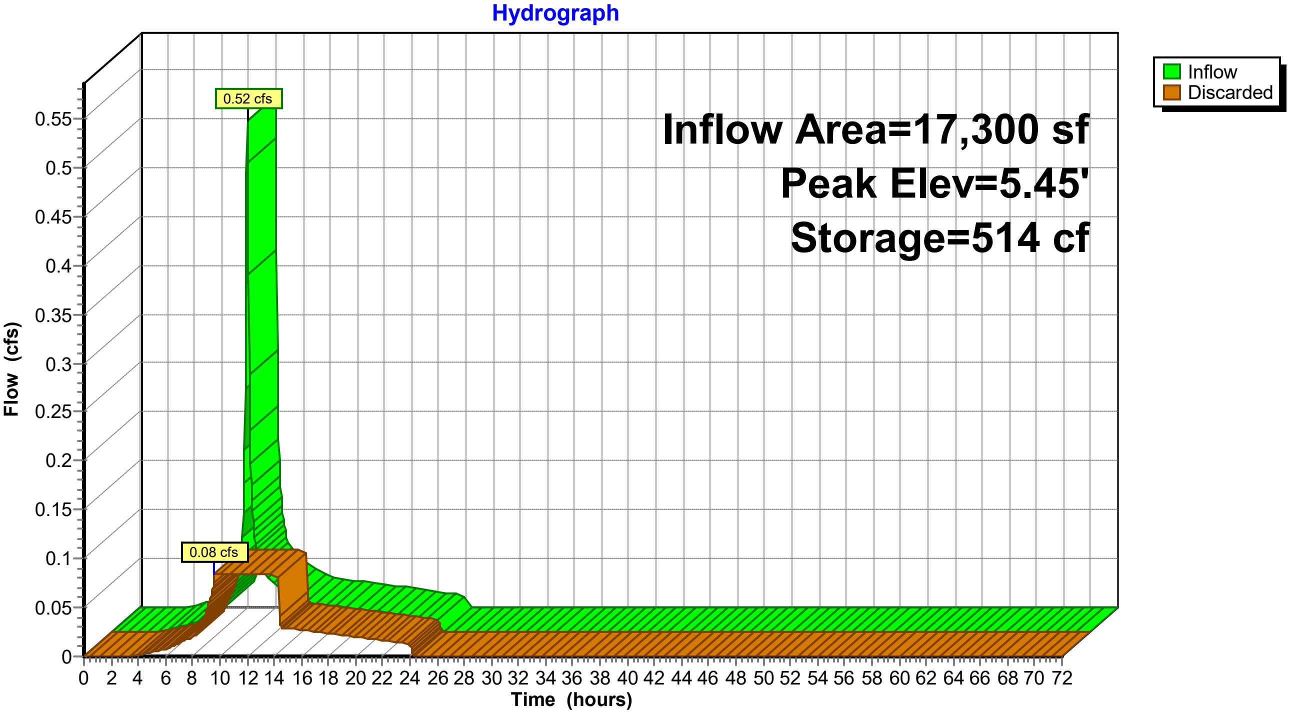
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.60 hrs HW=0.15' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 70P: DW2.4



Summary for Subcatchment 71S: F2.2

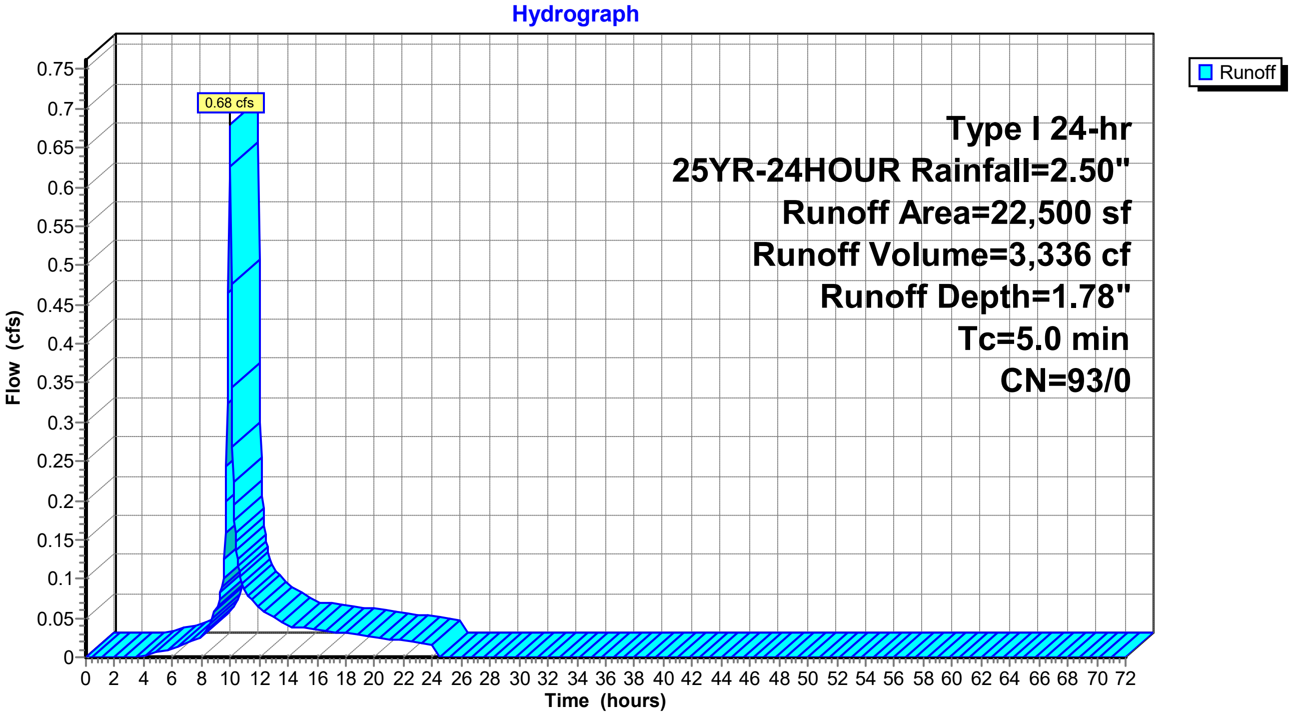
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf, Depth= 1.78"
Routed to Pond 74P : DW2.2

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 71S: F2.2



Summary for Subcatchment 72S: F2.3

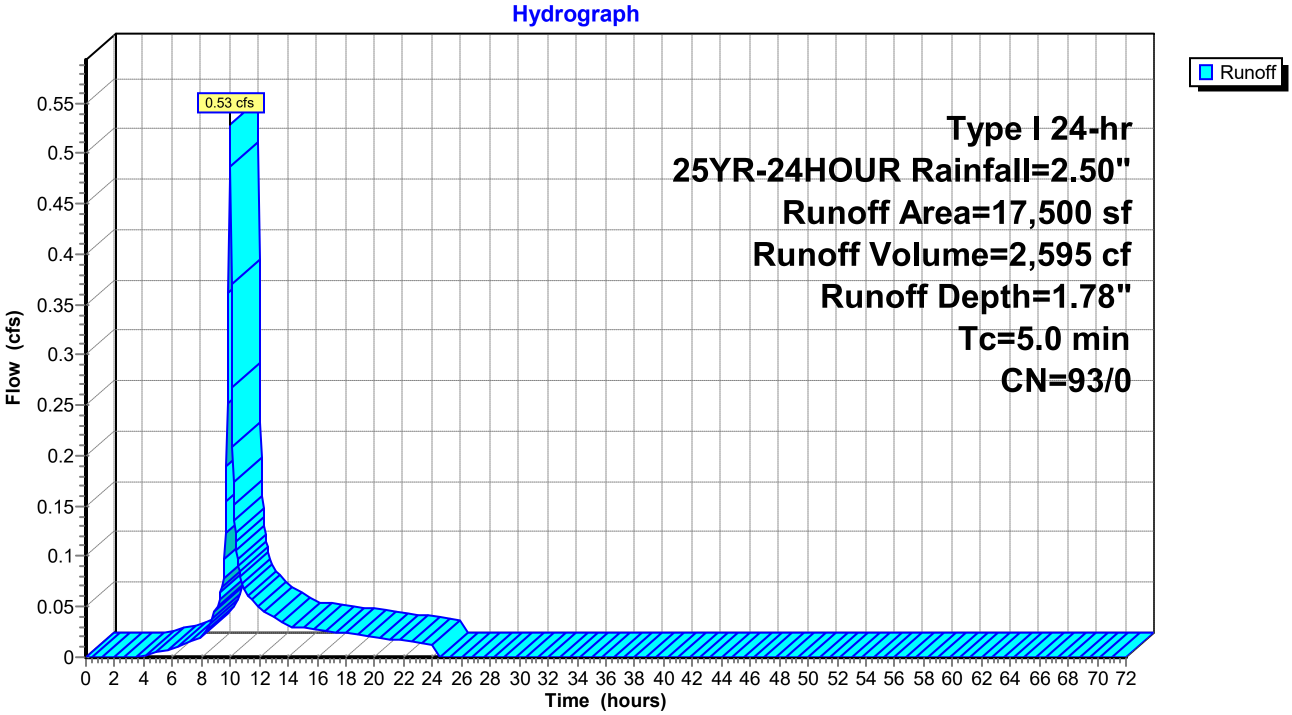
```
Runoff      =        0.53 cfs @    9.95 hrs,  Volume=           2,595 cf,  Depth=  1.78"
    Routed to Pond 75P : DW2.3
```

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	17,500	93	Paved roads w/curbs & sewers, HSG A
	17,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 72S: F2.3



Summary for Subcatchment 73S: F2.4

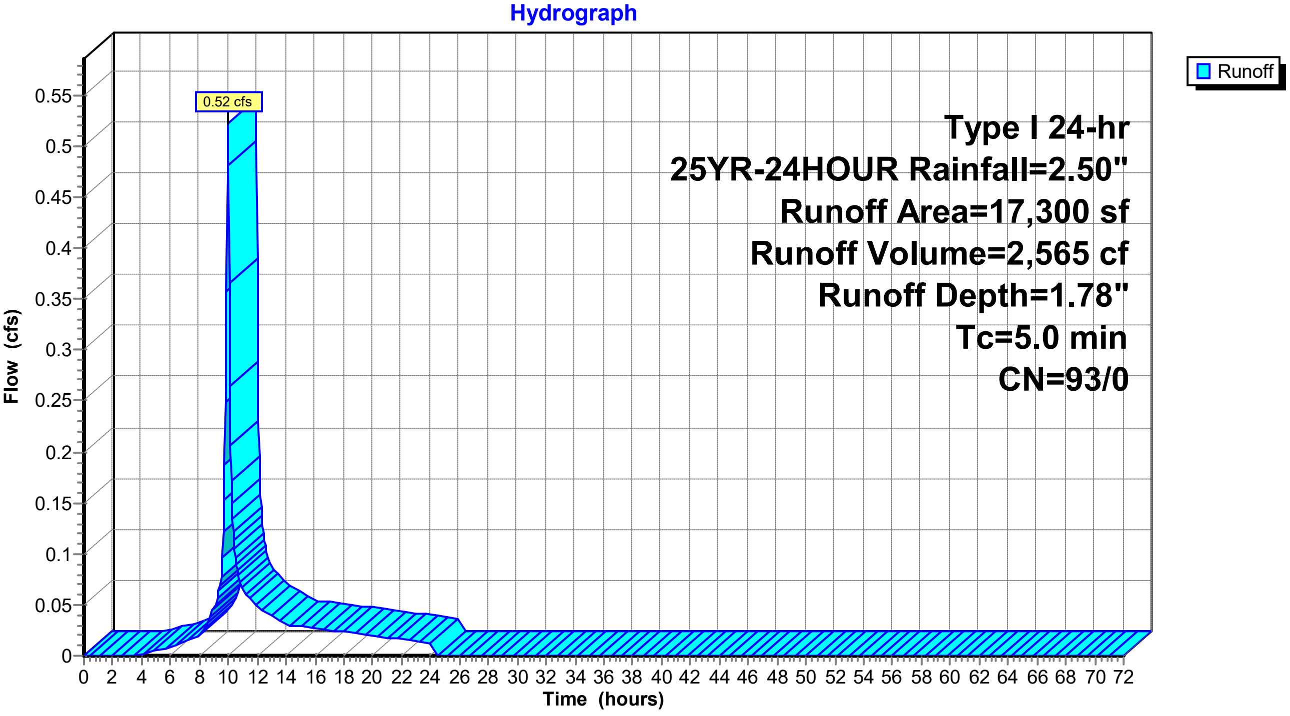
Runoff = 0.52 cfs @ 9.95 hrs, Volume= 2,565 cf, Depth= 1.78"
Routed to Pond 70P : DW2.4

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	17,300	93	Paved roads w/curbs & sewers, HSG A
	17,300	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 73S: F2.4



Summary for Pond 74P: DW2.2

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf
Outflow = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf, Atten= 88%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.27' @ 11.02 hrs Surf.Area= 225 sf Storage= 783 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 66.5 min calculated for 3,334 cf (100% of inflow)
Center-of-Mass det. time= 66.4 min (830.7 - 764.3)

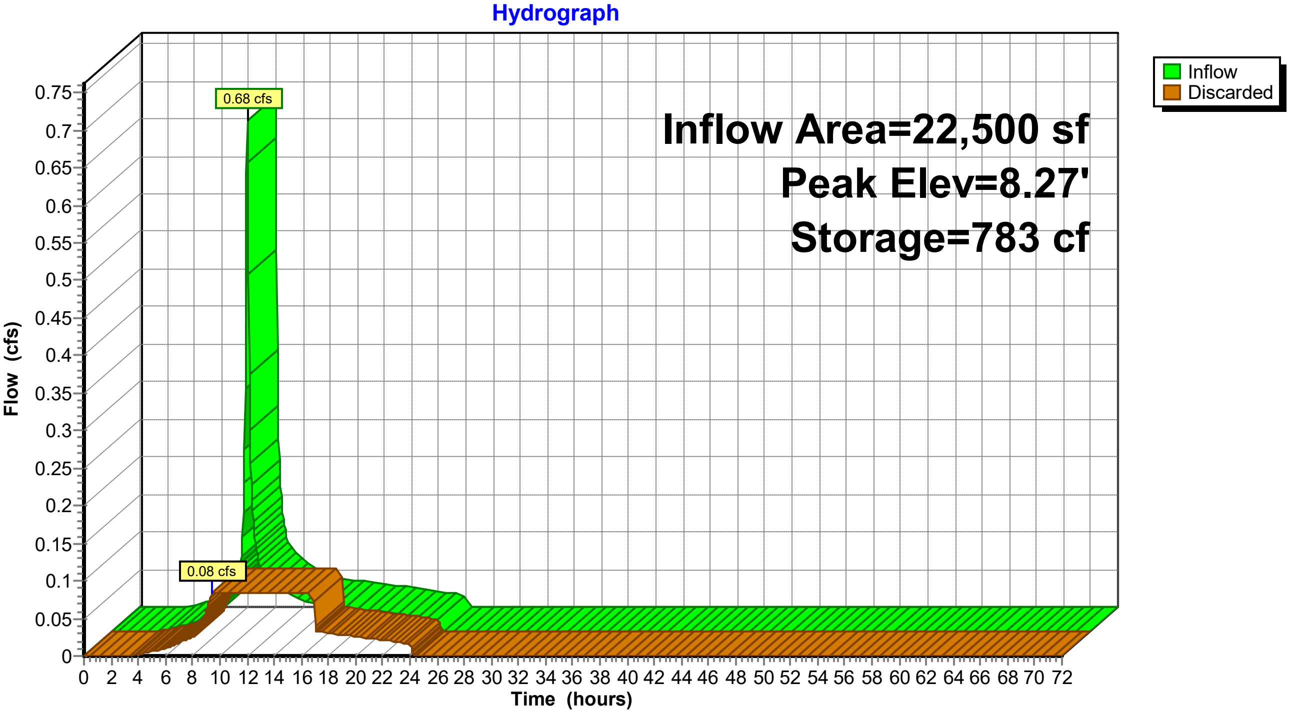
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 74P: DW2.2



Summary for Pond 75P: DW2.3

Inflow Area = 17,500 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.53 cfs @ 9.95 hrs, Volume= 2,595 cf
Outflow = 0.08 cfs @ 9.60 hrs, Volume= 2,595 cf, Atten= 84%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.60 hrs, Volume= 2,595 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 5.55' @ 10.62 hrs Surf.Area= 225 sf Storage= 523 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 37.4 min calculated for 2,593 cf (100% of inflow)
Center-of-Mass det. time= 37.3 min (801.6 - 764.3)

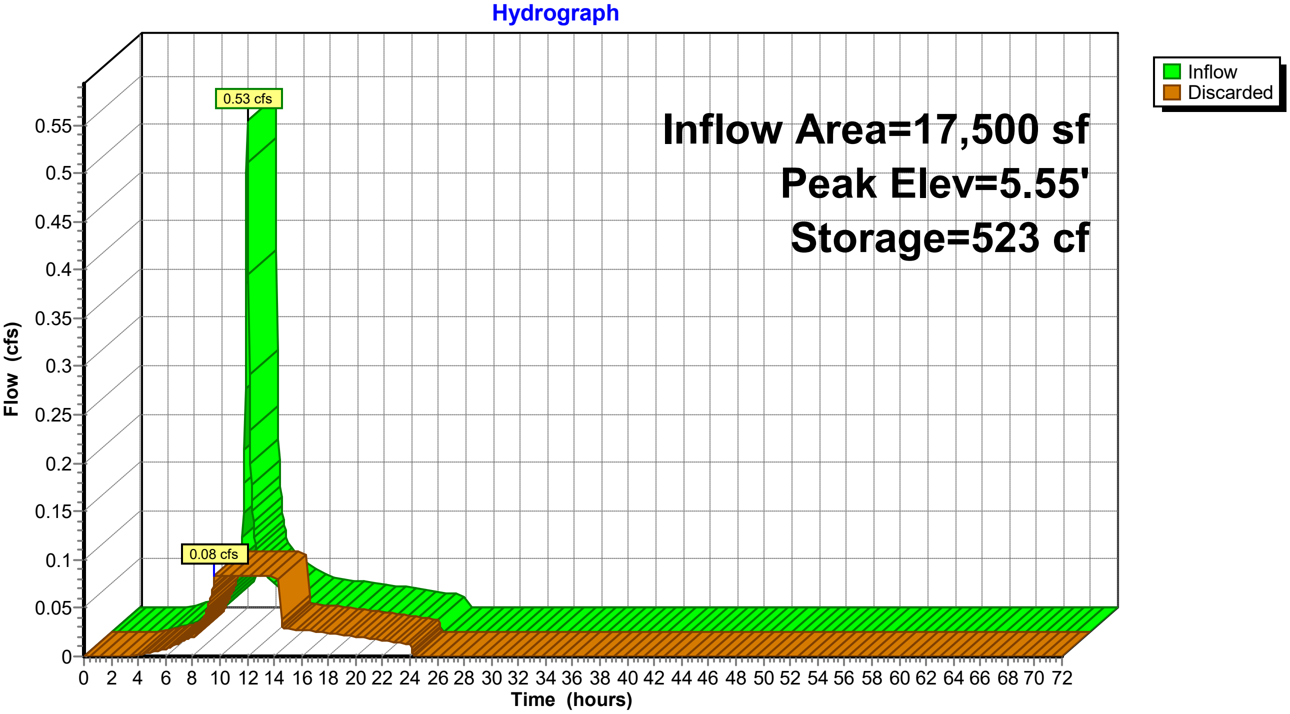
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.60 hrs HW=0.15' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 75P: DW2.3



Summary for Pond 78P: DW2.5

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf
Outflow = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf, Atten= 88%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.27' @ 11.02 hrs Surf.Area= 225 sf Storage= 783 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 66.5 min calculated for 3,334 cf (100% of inflow)
Center-of-Mass det. time= 66.4 min (830.7 - 764.3)

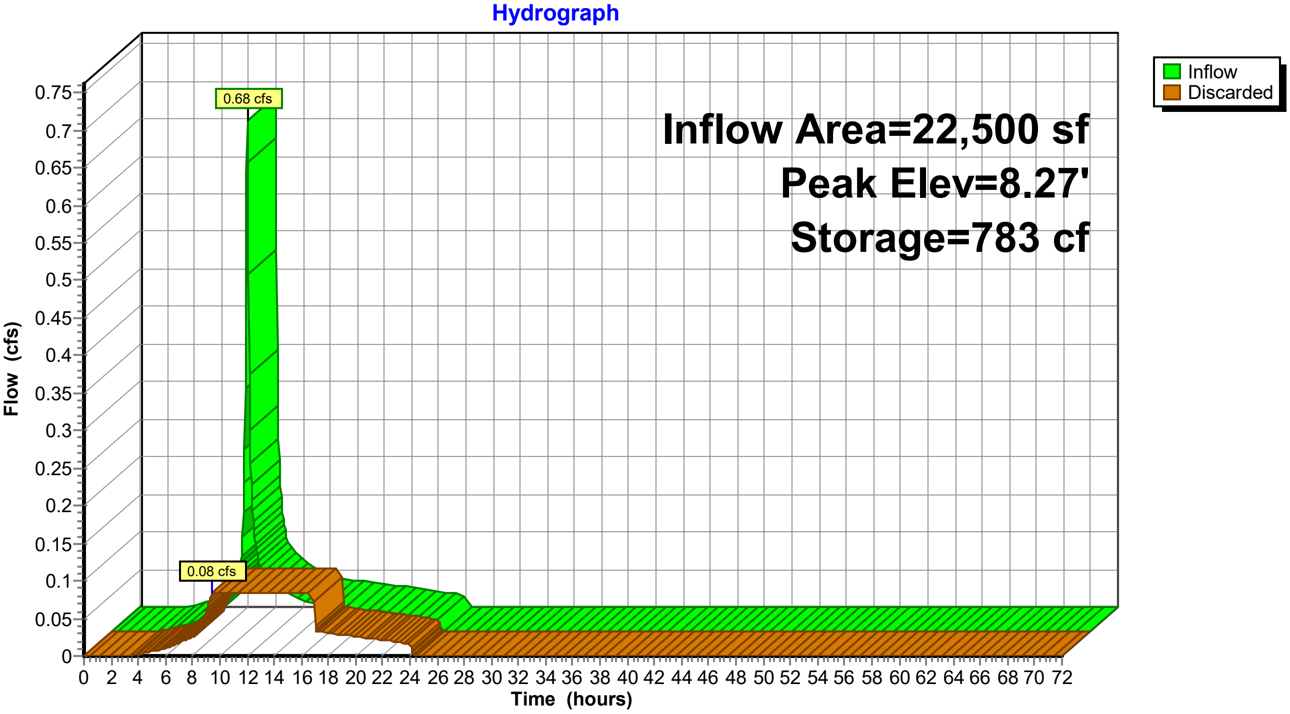
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 78P: DW2.5



Summary for Subcatchment F2.1: F2.1

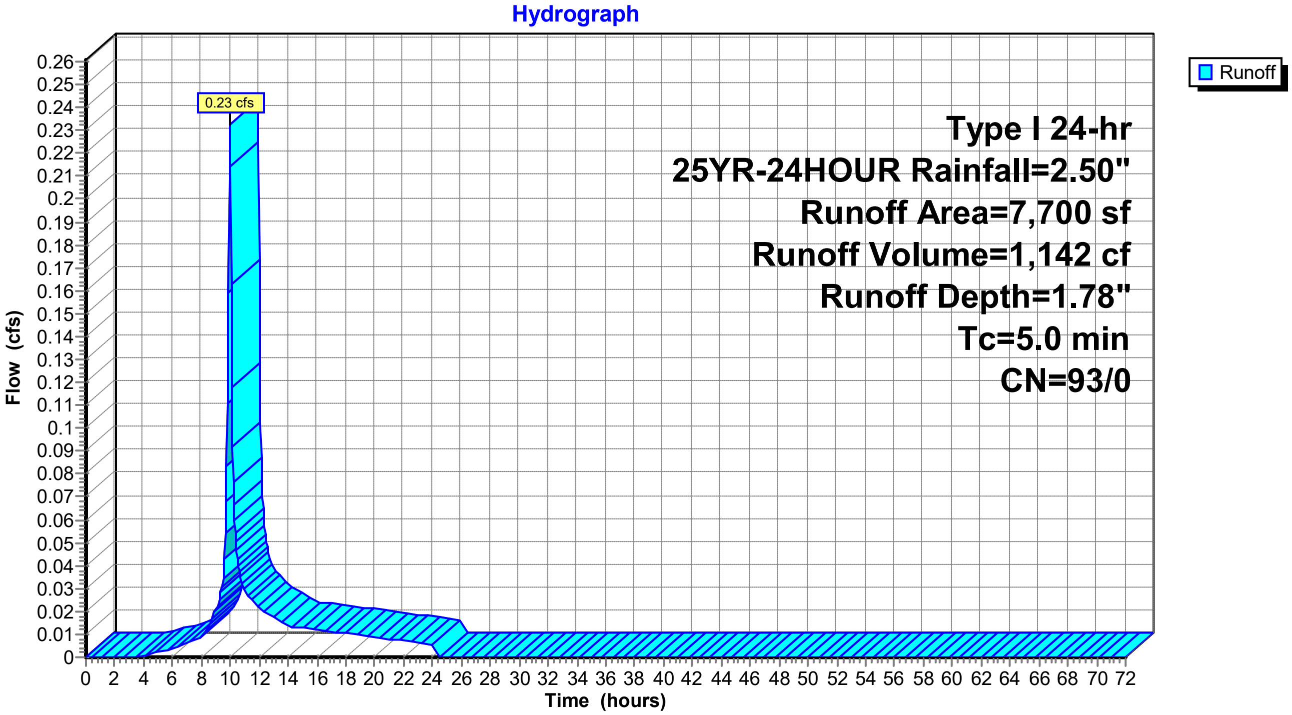
Runoff = 0.23 cfs @ 9.95 hrs, Volume= 1,142 cf, Depth= 1.78"
Routed to Pond 69P : DW2.1

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	7,700	93	Paved roads w/curbs & sewers, HSG A
	7,700	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment F2.1: F2.1



Summary for Subcatchment F2.5: F2.5

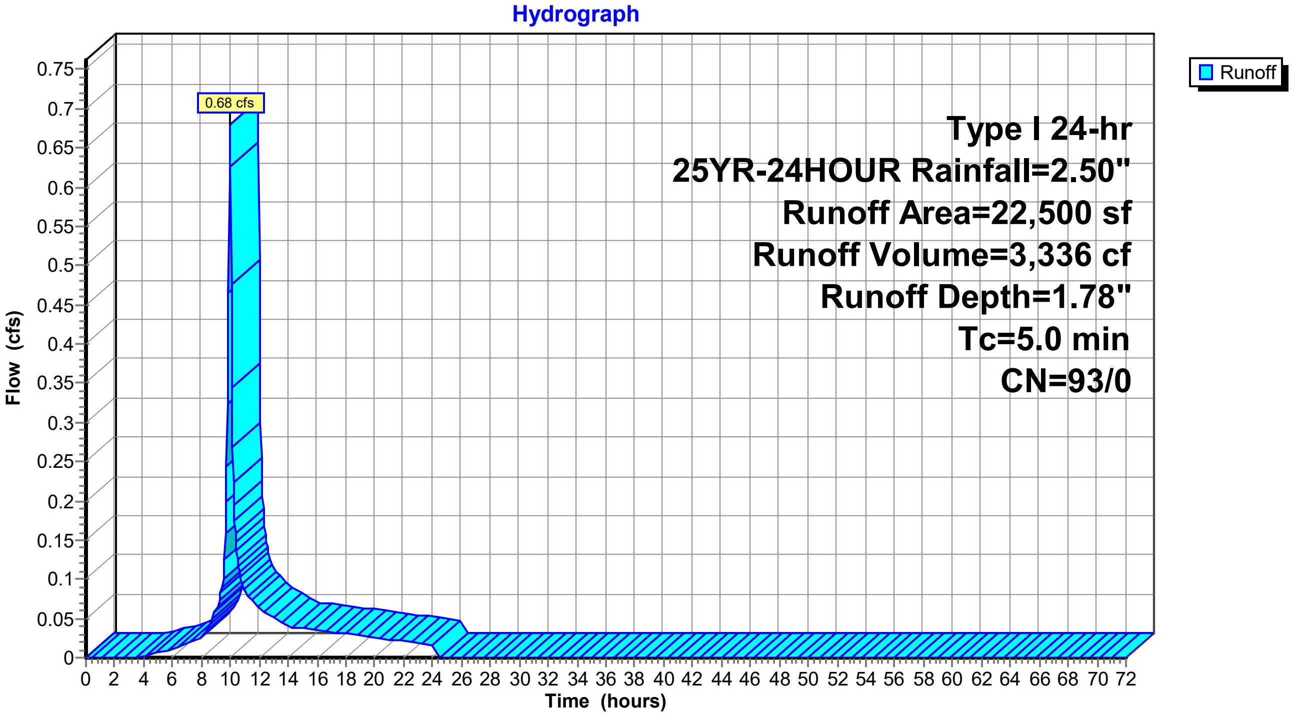
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf, Depth= 1.78"
Routed to Pond 78P : DW2.5

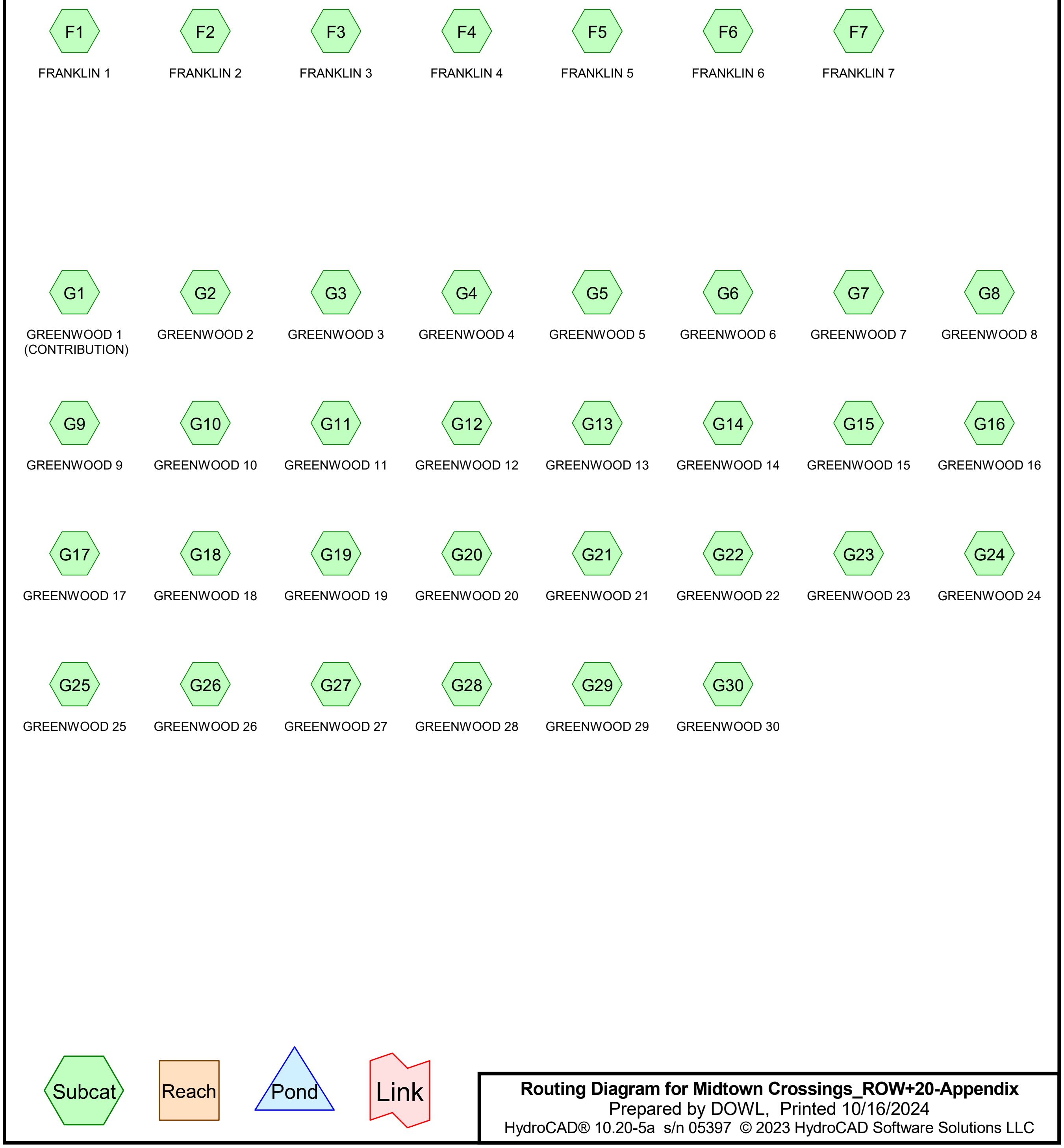
Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment F2.5: F2.5





Routing Diagram for Midtown Crossings_ROW+20-Appendix
Prepared by DOWL, Printed 10/16/2024
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Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	6MO-24HOUR	Type I 24-hr		Default	24.00	1	1.00	2
2	25YR-24HOUR	Type I 24-hr		Default	24.00	1	2.50	2
3	100YR-24HOUR	Type I 24-hr		Default	24.00	1	3.00	2

Summary for Subcatchment F1: FRANKLIN 1

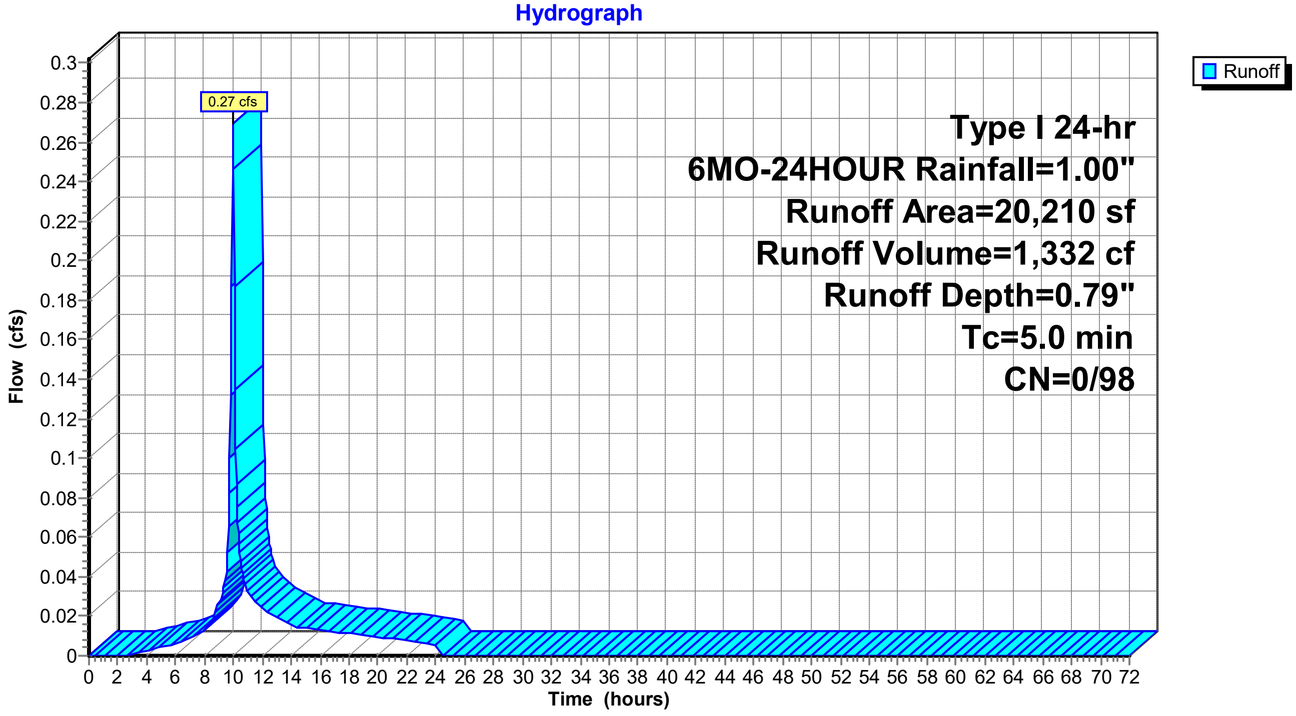
Runoff = 0.27 cfs @ 9.95 hrs, Volume= 1,332 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
20,210	98	Paved roads w/curbs & sewers, HSG A
20,210	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment F1: FRANKLIN 1



Summary for Subcatchment F2: FRANKLIN 2

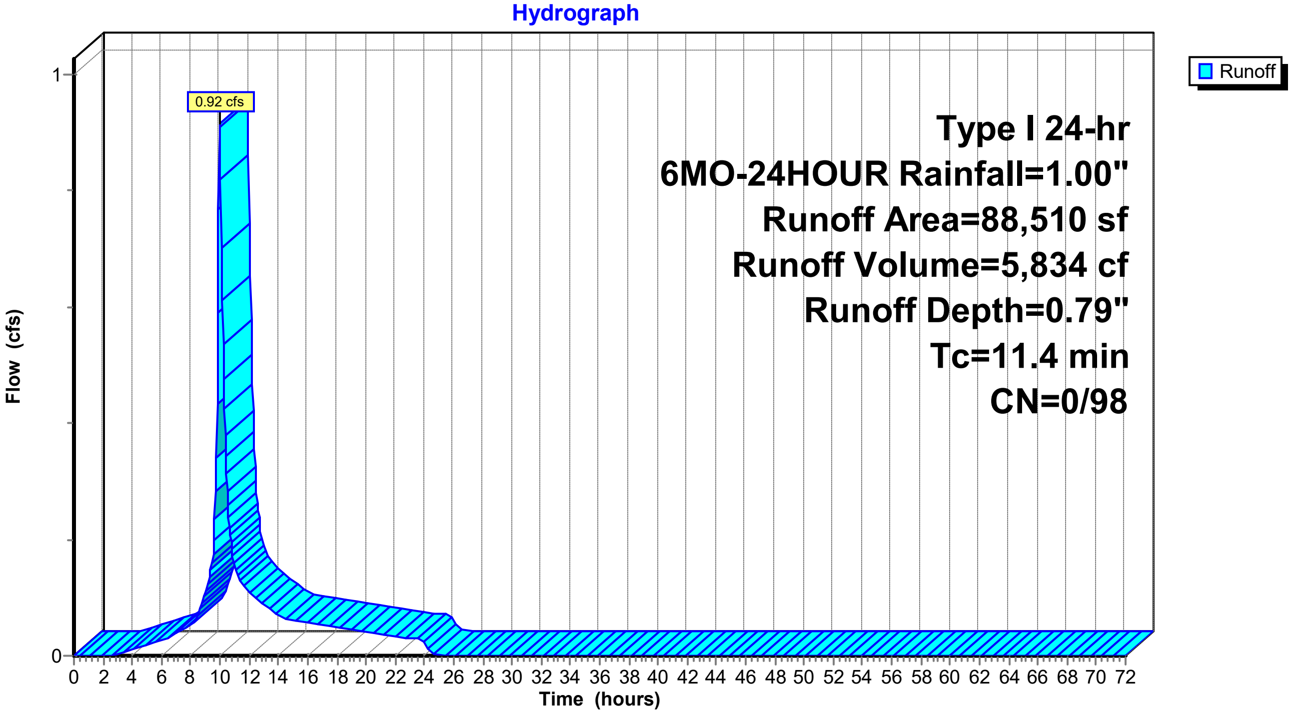
Runoff = 0.92 cfs @ 9.98 hrs, Volume= 5,834 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
88,510	98	Paved roads w/curbs & sewers, HSG A
88,510	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.4					**Direct Entry,**

Subcatchment F2: FRANKLIN 2



Summary for Subcatchment F3: FRANKLIN 3

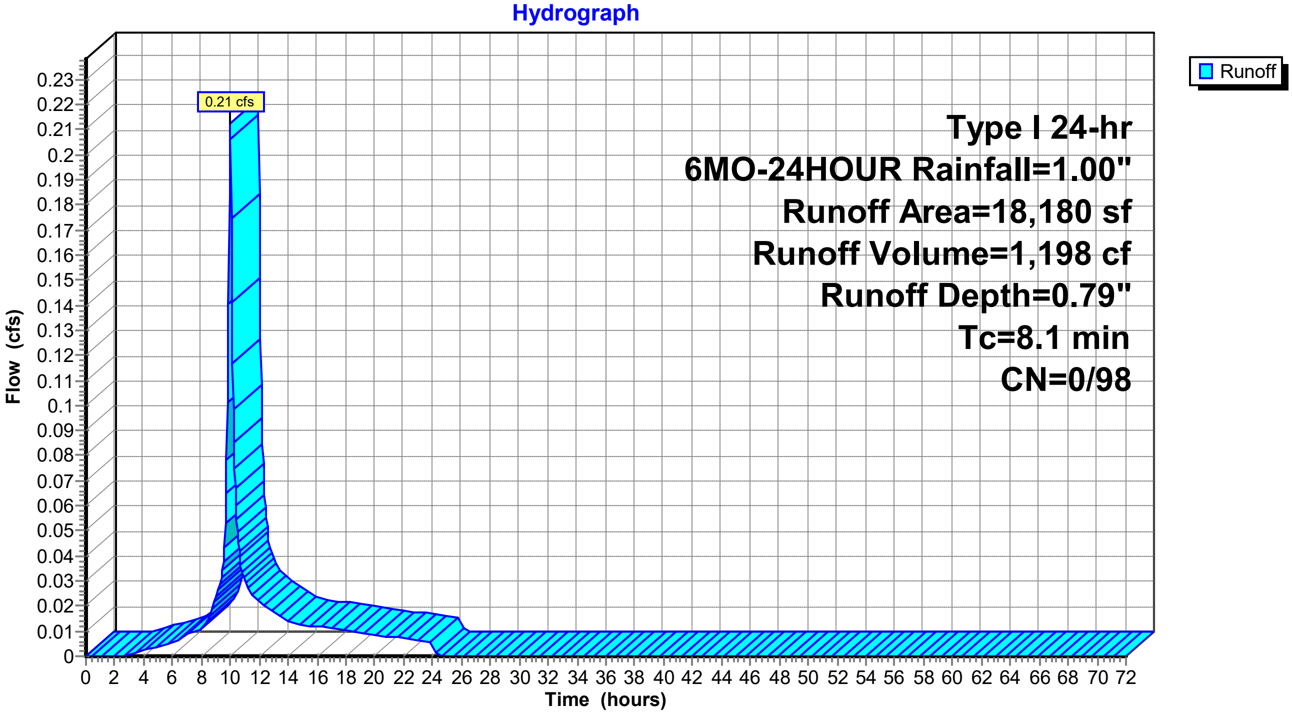
Runoff = 0.21 cfs @ 9.97 hrs, Volume= 1,198 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
18,180	98	Paved roads w/curbs & sewers, HSG A
18,180	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.1					**Direct Entry,**

Subcatchment F3: FRANKLIN 3



Summary for Subcatchment F4: FRANKLIN 4

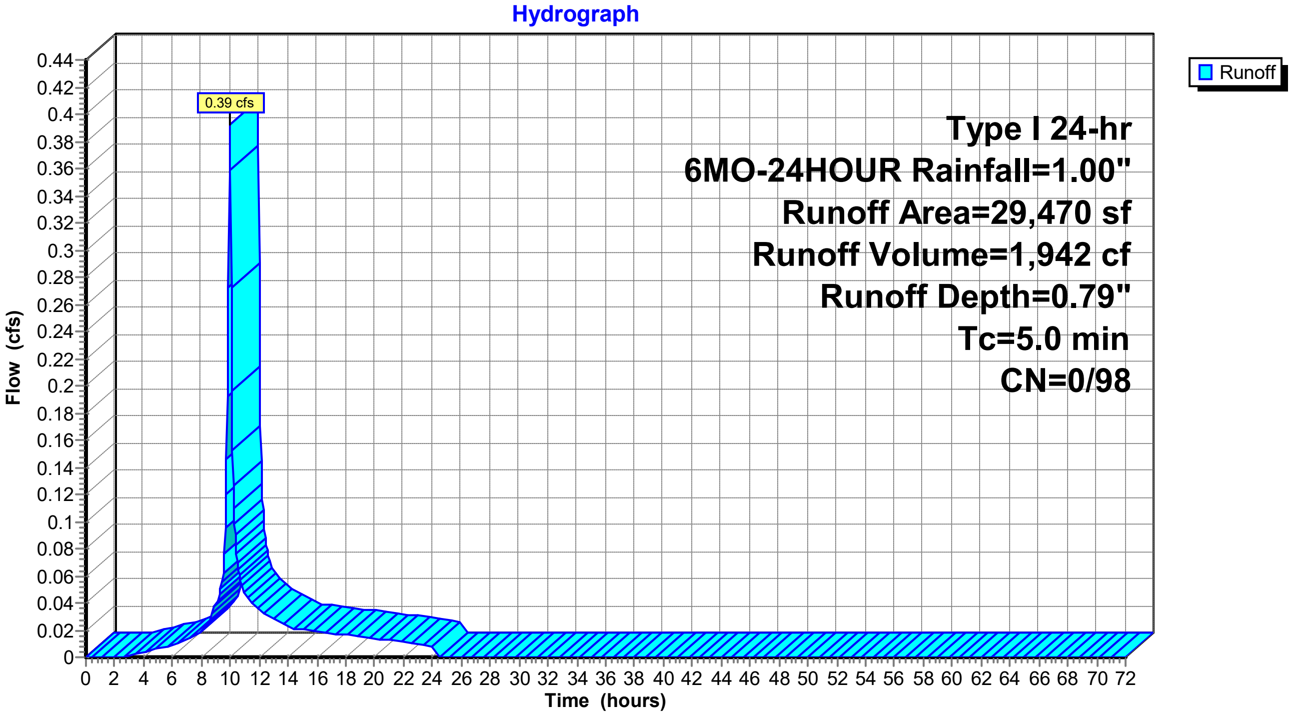
Runoff = 0.39 cfs @ 9.95 hrs, Volume= 1,942 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
29,470	98	Paved roads w/curbs & sewers, HSG A
29,470	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment F4: FRANKLIN 4



Summary for Subcatchment F5: FRANKLIN 5

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Runoff      =       0.78 cfs @  10.01 hrs,  Volume=          7,375 cf,  Depth=  0.79"
    Routed to nonexistent node DW-1A-B
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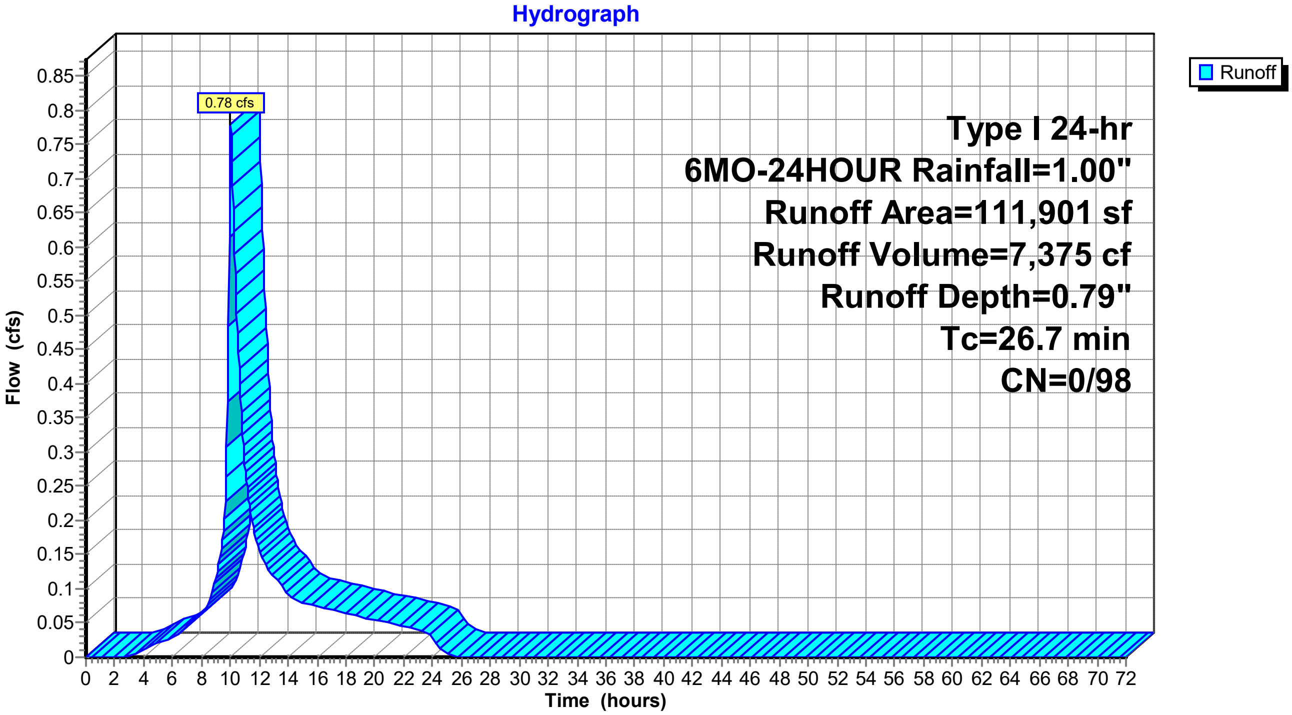
Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
111,901	98	Paved roads w/curbs & sewers, HSG A
111,901	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.7					**Direct Entry,**

Subcatchment F5: FRANKLIN 5



Summary for Subcatchment F6: FRANKLIN 6

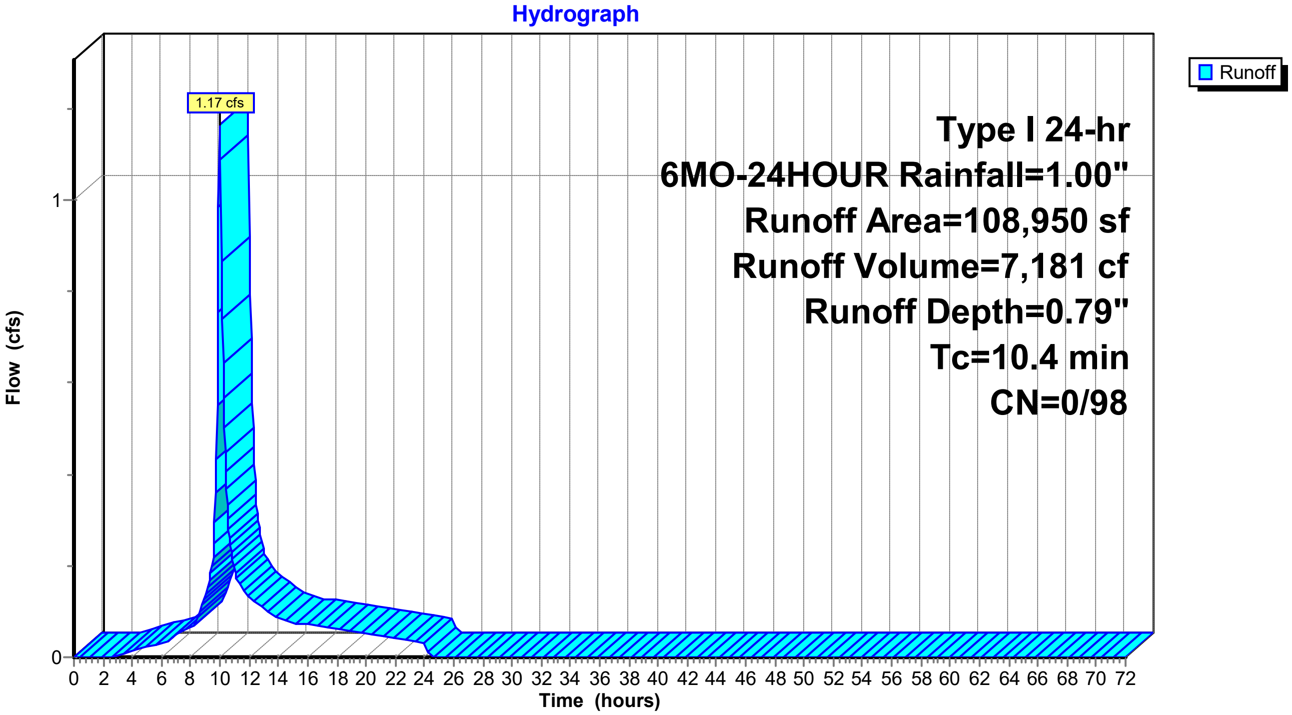
Runoff = 1.17 cfs @ 9.98 hrs, Volume= 7,181 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
108,950	98	Paved roads w/curbs & sewers, HSG A
108,950	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.4					**Direct Entry,**

Subcatchment F6: FRANKLIN 6



Summary for Subcatchment F7: FRANKLIN 7

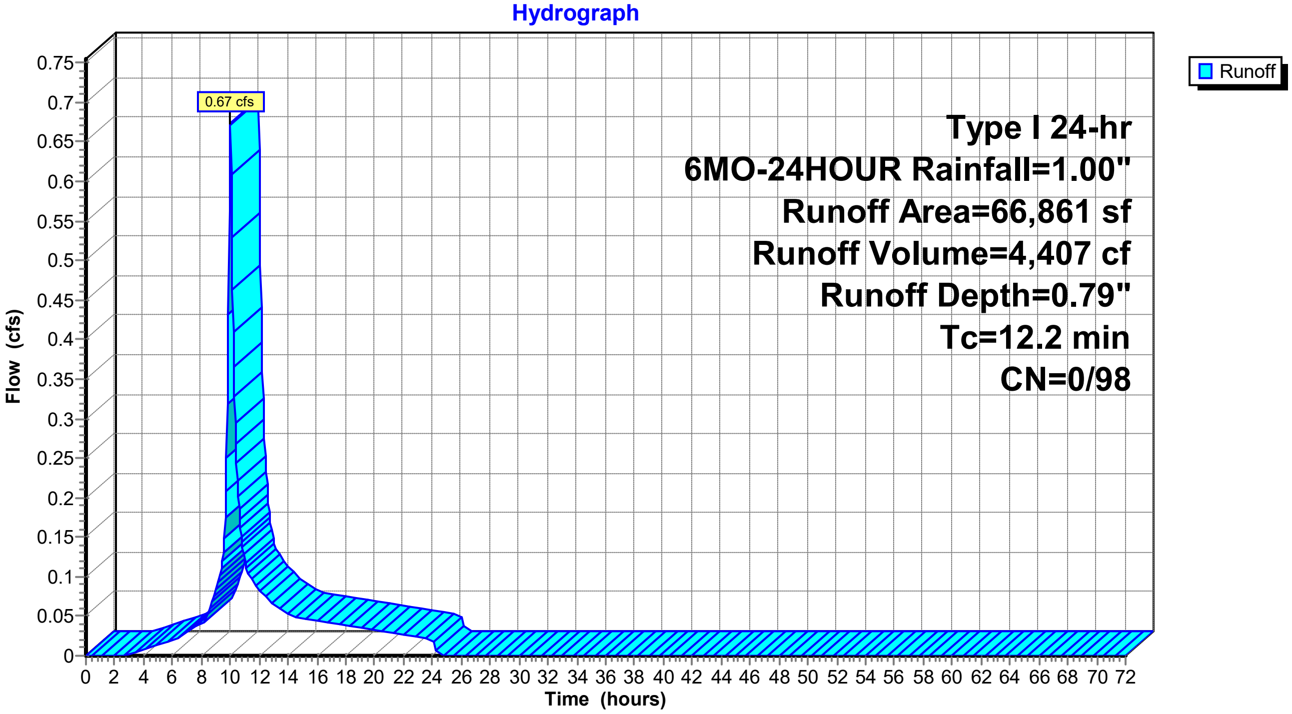
Runoff = 0.67 cfs @ 9.98 hrs, Volume= 4,407 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
66,861	98	Paved roads w/curbs & sewers, HSG A
66,861	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.2					**Direct Entry,**

Subcatchment F7: FRANKLIN 7



Summary for Subcatchment G1: GREENWOOD 1 (CONTRIBUTION)

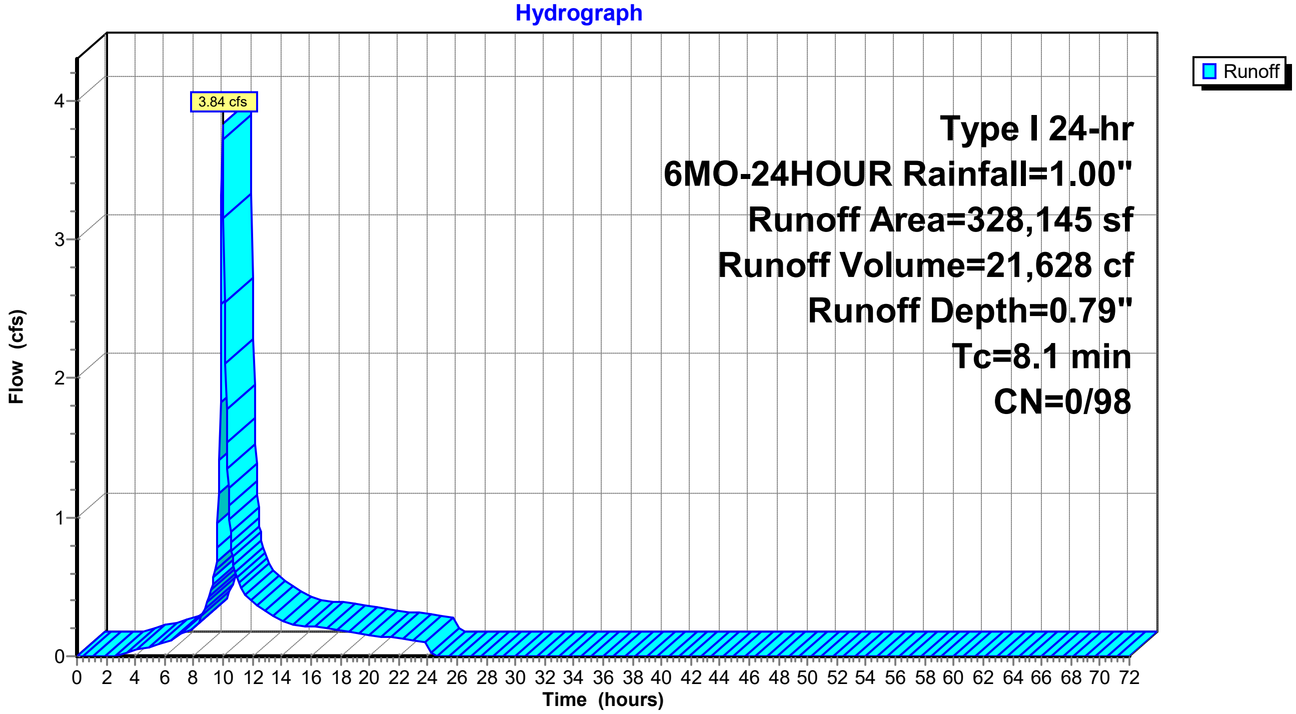
Runoff = 3.84 cfs @ 9.97 hrs, Volume= 21,628 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
328,145	98	Paved roads w/curbs & sewers, HSG A
328,145	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.1					**Direct Entry,**

Subcatchment G1: GREENWOOD 1 (CONTRIBUTION)



Summary for Subcatchment G10: GREENWOOD 10

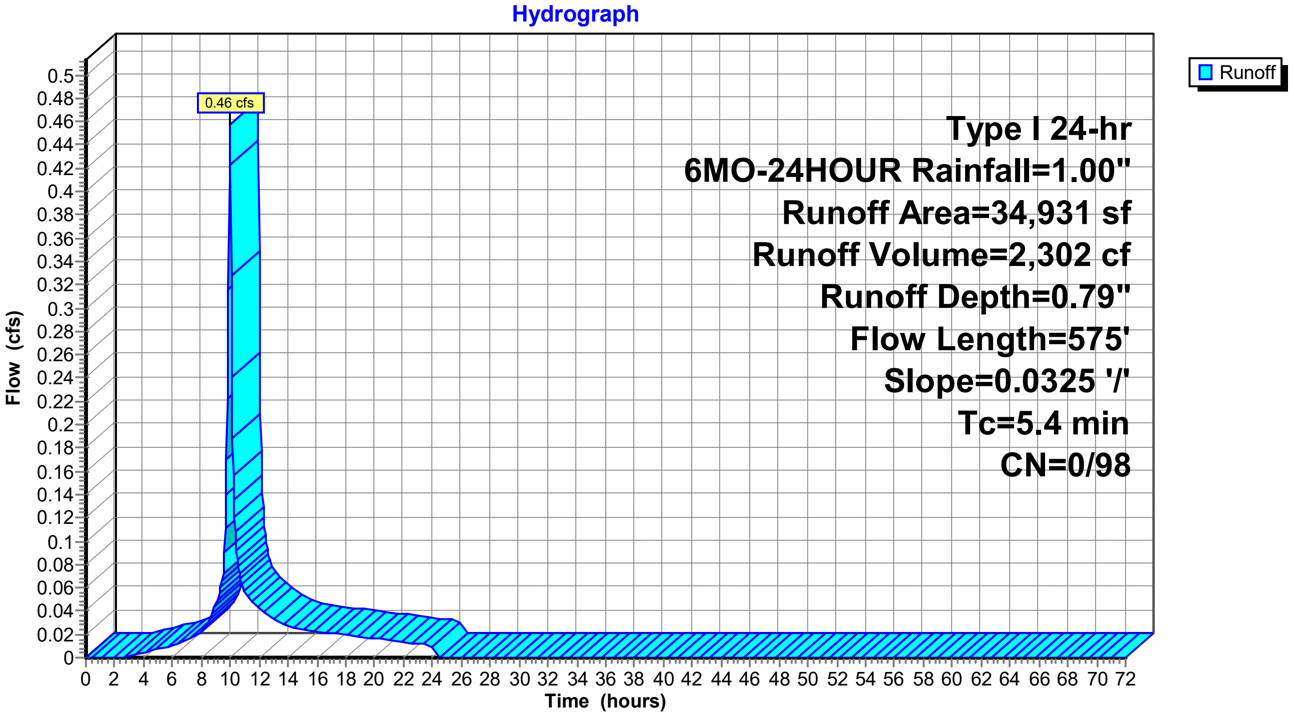
Runoff = 0.46 cfs @ 9.95 hrs, Volume= 2,302 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
34,931	98	Paved roads w/curbs & sewers, HSG A
34,931	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.4	575	0.0325	1.79		**Lag/CN Method,**

Subcatchment G10: GREENWOOD 10



Summary for Subcatchment G11: GREENWOOD 11

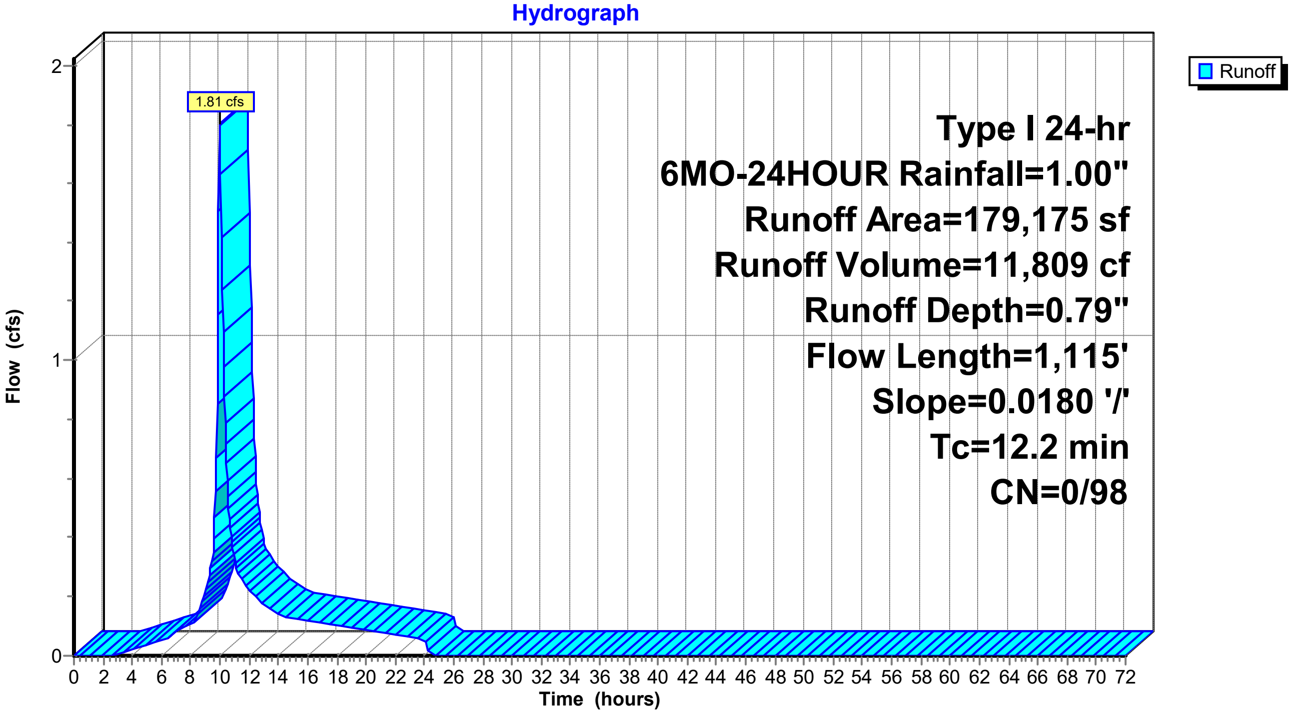
Runoff = 1.81 cfs @ 9.98 hrs, Volume= 11,809 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
179,175	98	Paved roads w/curbs & sewers, HSG A
179,175	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.2	1,115	0.0180	1.52		**Lag/CN Method,**

Subcatchment G11: GREENWOOD 11



Summary for Subcatchment G12: GREENWOOD 12

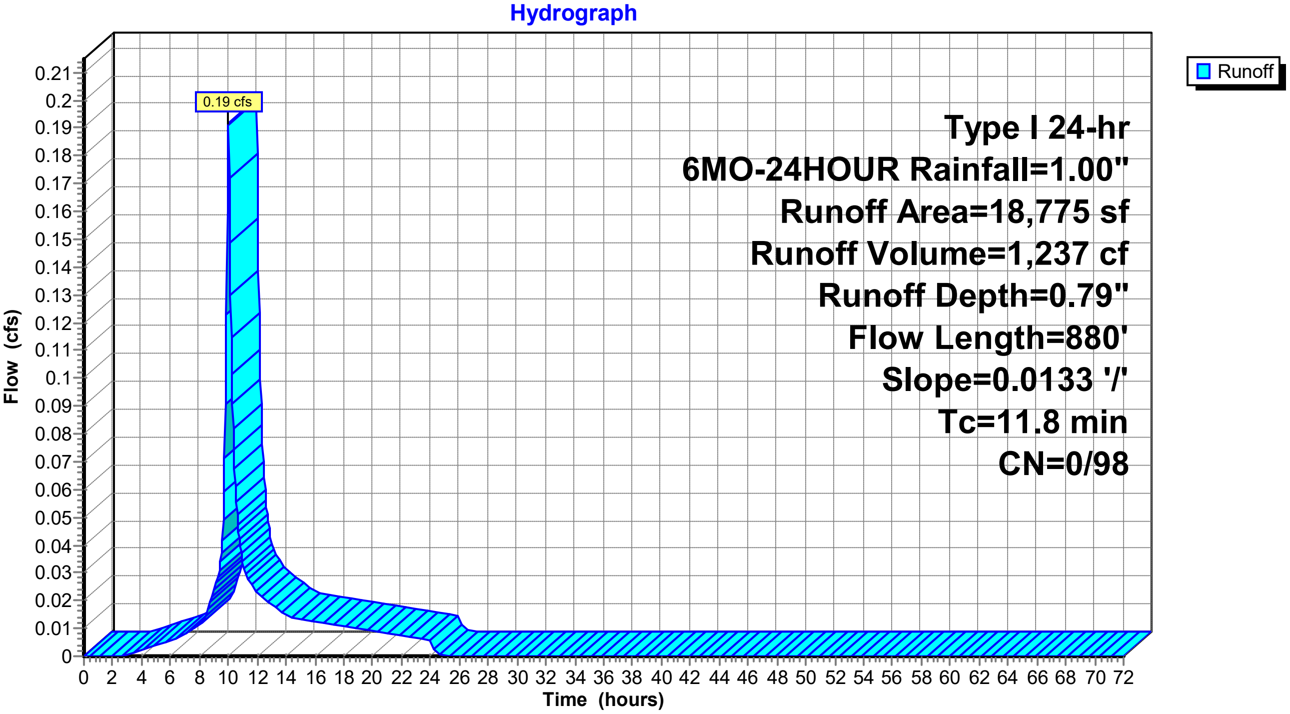
Runoff = 0.19 cfs @ 9.98 hrs, Volume= 1,237 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
18,775	98	Paved roads w/curbs & sewers, HSG A
18,775	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.8	880	0.0133	1.24		**Lag/CN Method,**

Subcatchment G12: GREENWOOD 12



Summary for Subcatchment G13: GREENWOOD 13

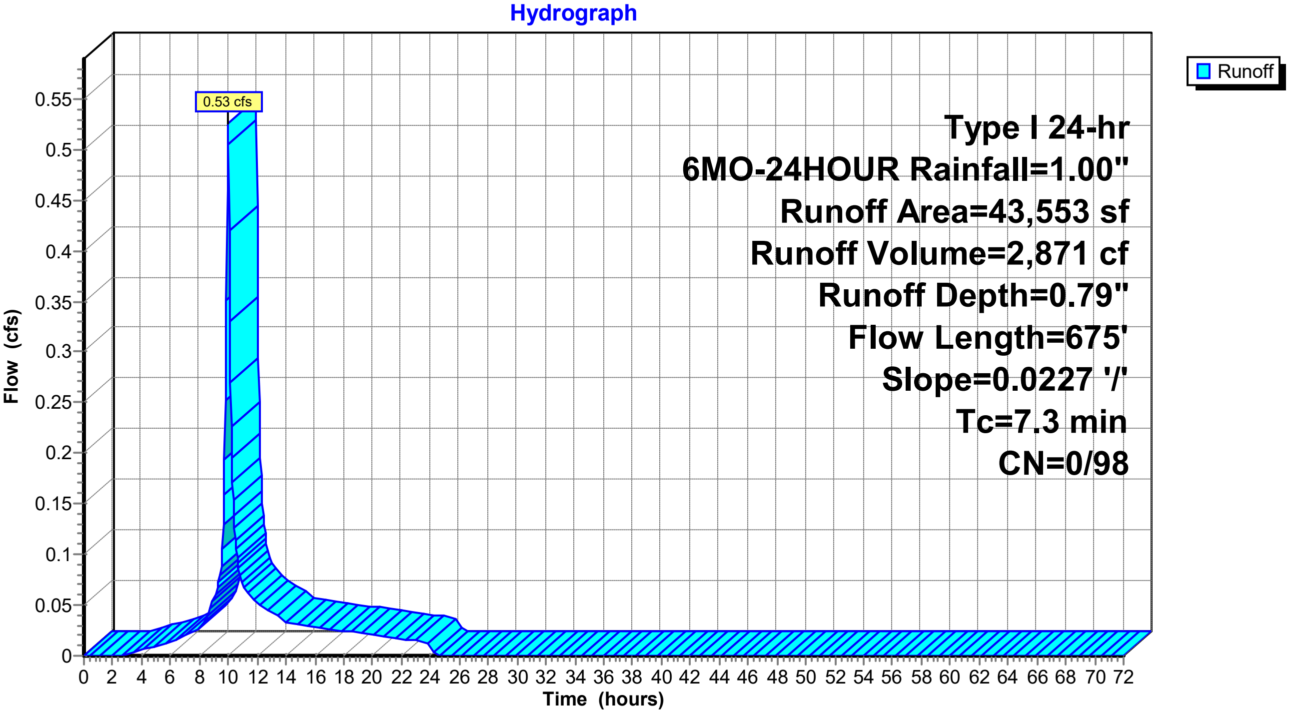
Runoff = 0.53 cfs @ 9.96 hrs, Volume= 2,871 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
43,553	98	Paved roads w/curbs & sewers, HSG A
43,553	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	675	0.0227	1.54		**Lag/CN Method,**

Subcatchment G13: GREENWOOD 13



Summary for Subcatchment G14: GREENWOOD 14

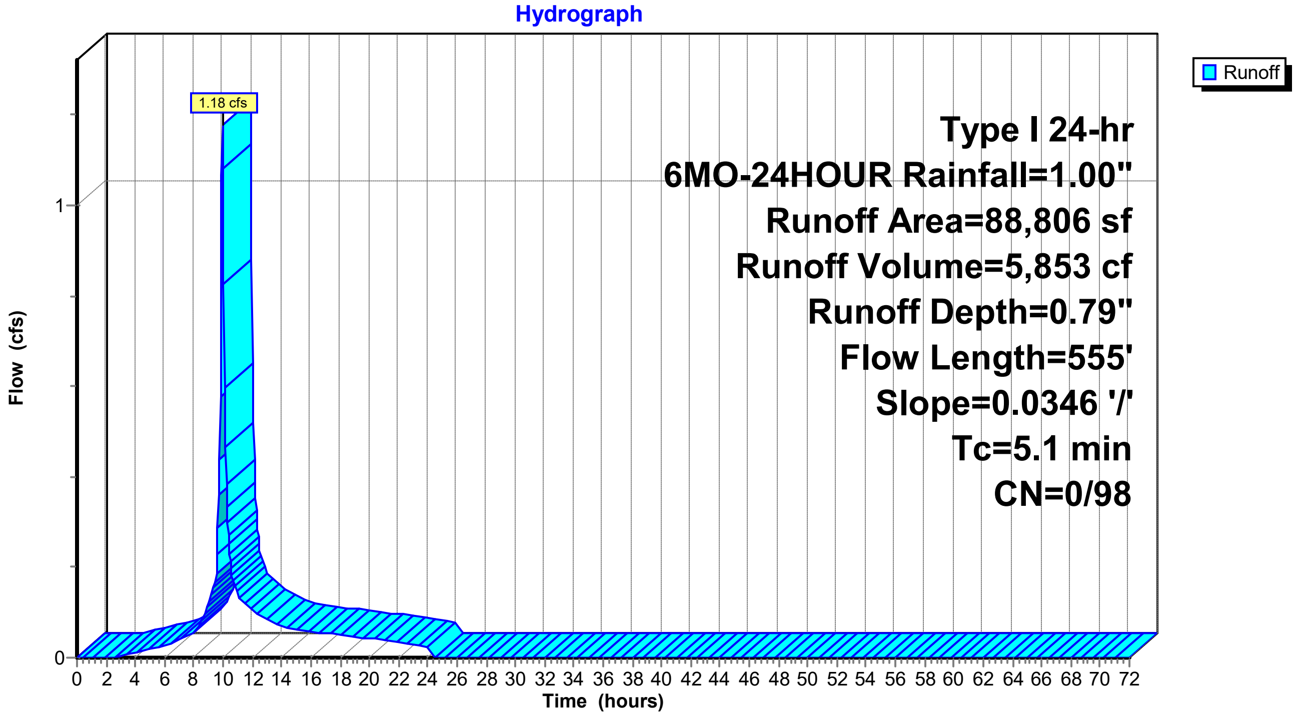
Runoff = 1.18 cfs @ 9.95 hrs, Volume= 5,853 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
88,806	98	Paved roads w/curbs & sewers, HSG A
88,806	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.1	555	0.0346	1.83		**Lag/CN Method,**

Subcatchment G14: GREENWOOD 14



Summary for Subcatchment G15: GREENWOOD 15

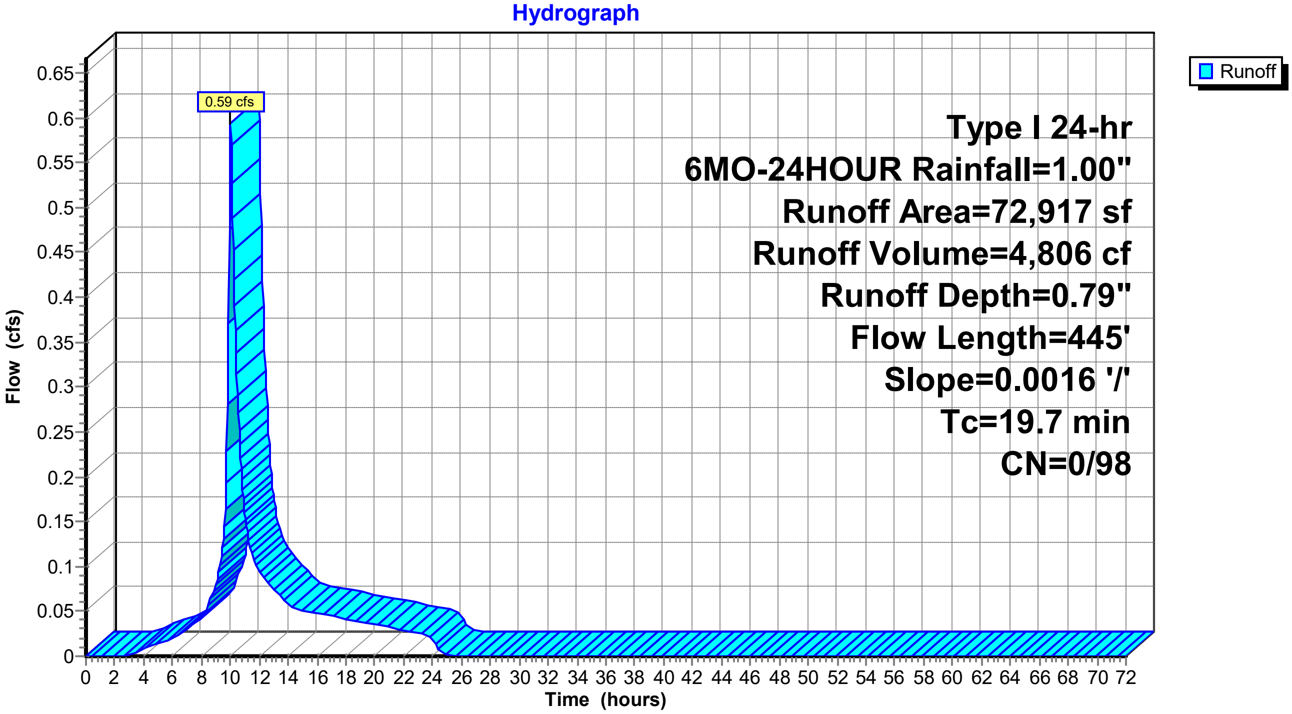
Runoff = 0.59 cfs @ 10.00 hrs, Volume= 4,806 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
72,917	98	Paved roads w/curbs & sewers, HSG A
72,917	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.7	445	0.0016	0.38		**Lag/CN Method,**

Subcatchment G15: GREENWOOD 15



Summary for Subcatchment G16: GREENWOOD 16

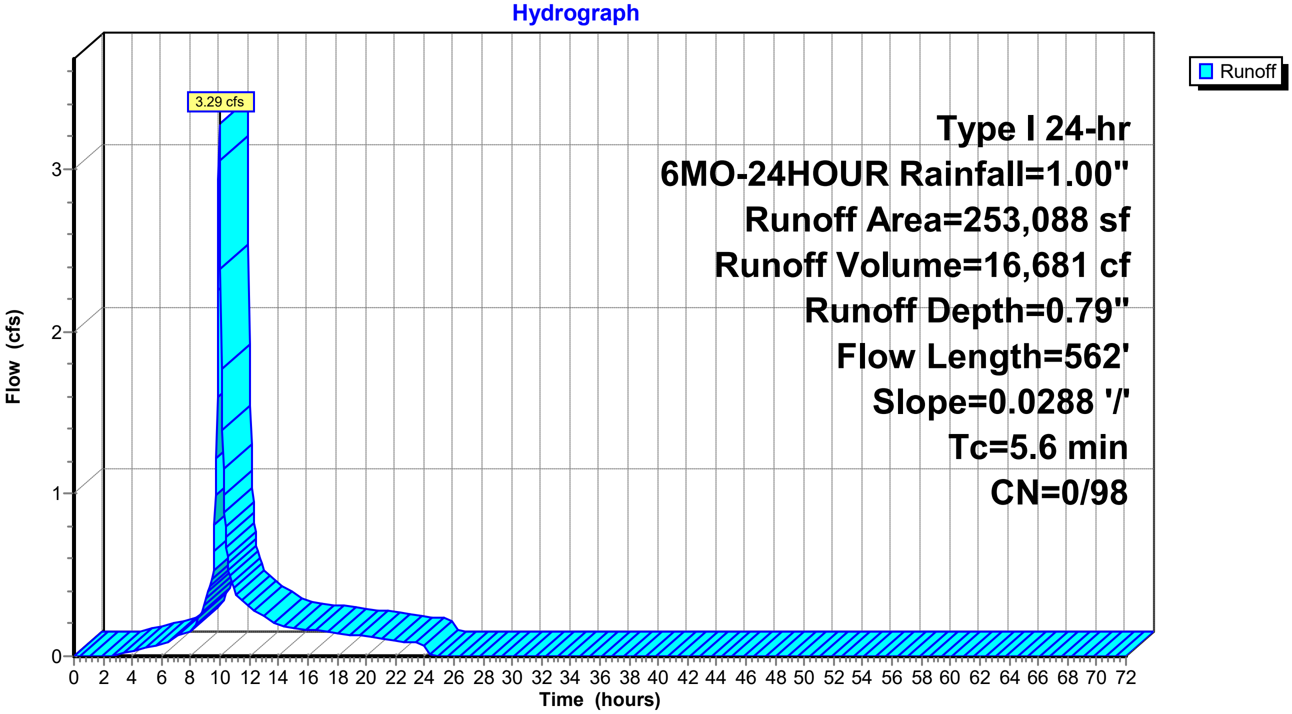
Runoff = 3.29 cfs @ 9.95 hrs, Volume= 16,681 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
253,088	98	Paved roads w/curbs & sewers, HSG A
253,088	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	562	0.0288	1.67		**Lag/CN Method,**

Subcatchment G16: GREENWOOD 16



Summary for Subcatchment G17: GREENWOOD 17

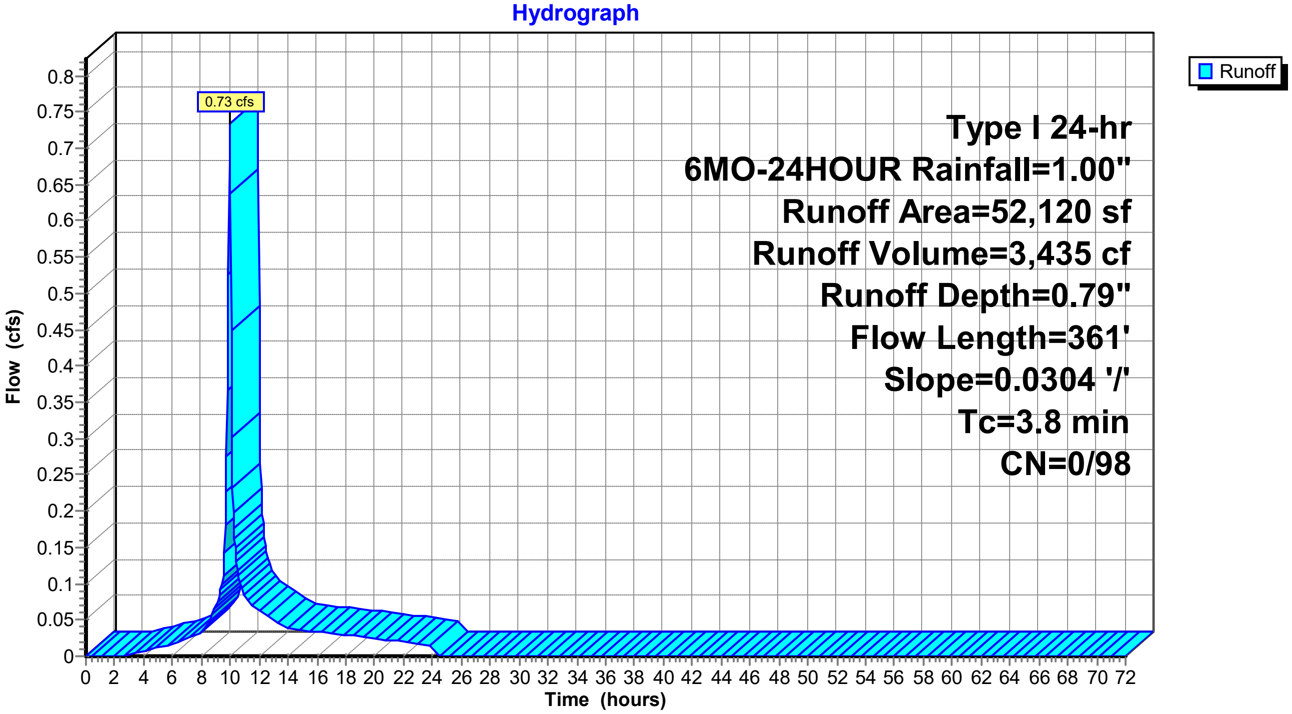
Runoff = 0.73 cfs @ 9.94 hrs, Volume= 3,435 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
52,120	98	Paved roads w/curbs & sewers, HSG A
52,120	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	361	0.0304	1.57		**Lag/CN Method,**

Subcatchment G17: GREENWOOD 17



Summary for Subcatchment G18: GREENWOOD 18

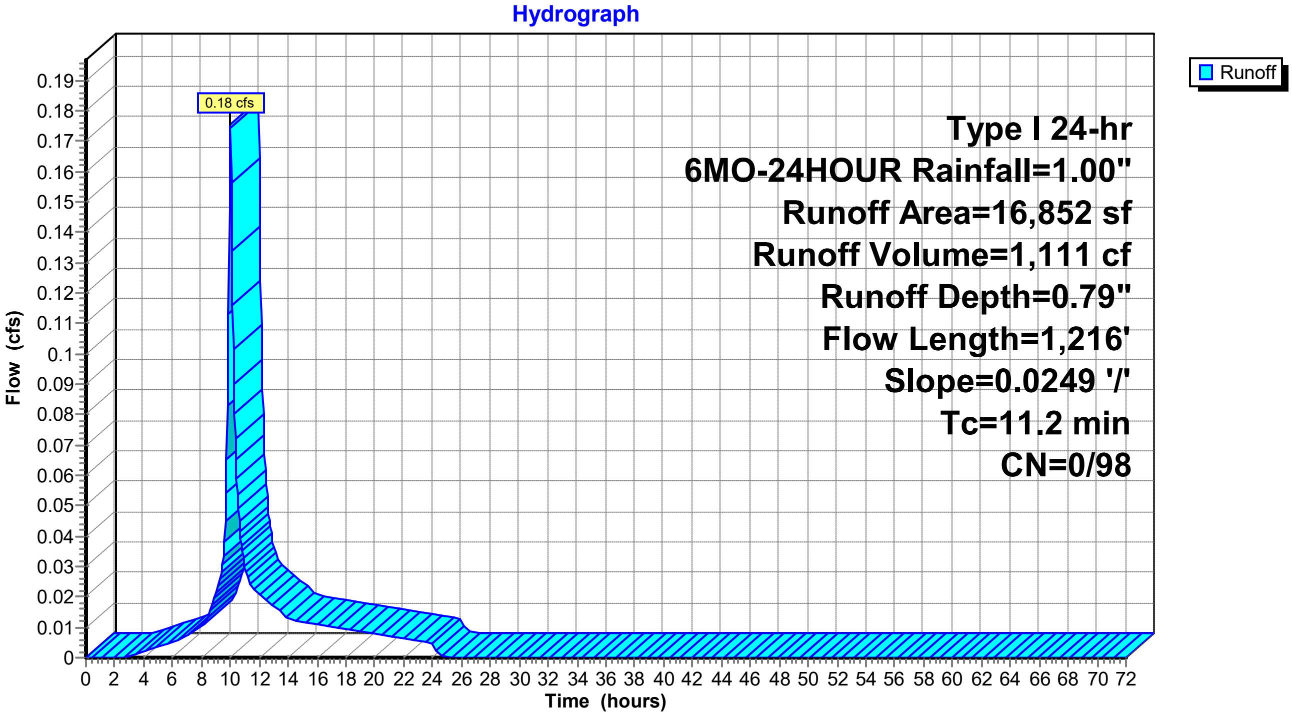
Runoff = 0.18 cfs @ 9.98 hrs, Volume= 1,111 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
16,852	98	Paved roads w/curbs & sewers, HSG A
16,852	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.2	1,216	0.0249	1.82		**Lag/CN Method,**

Subcatchment G18: GREENWOOD 18



Summary for Subcatchment G19: GREENWOOD 19

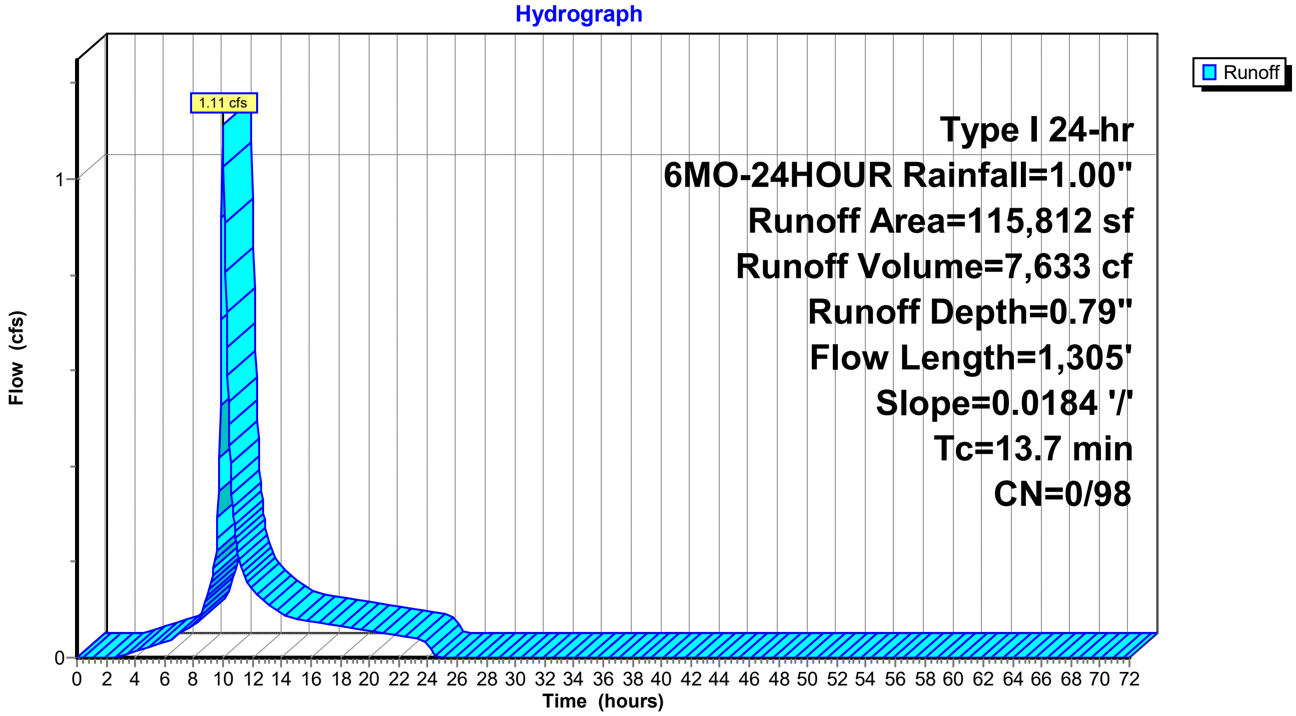
Runoff = 1.11 cfs @ 9.99 hrs, Volume= 7,633 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
115,812	98	Paved roads w/curbs & sewers, HSG A
115,812	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.7	1,305	0.0184	1.58		**Lag/CN Method,**

Subcatchment G19: GREENWOOD 19



Summary for Subcatchment G2: GREENWOOD 2

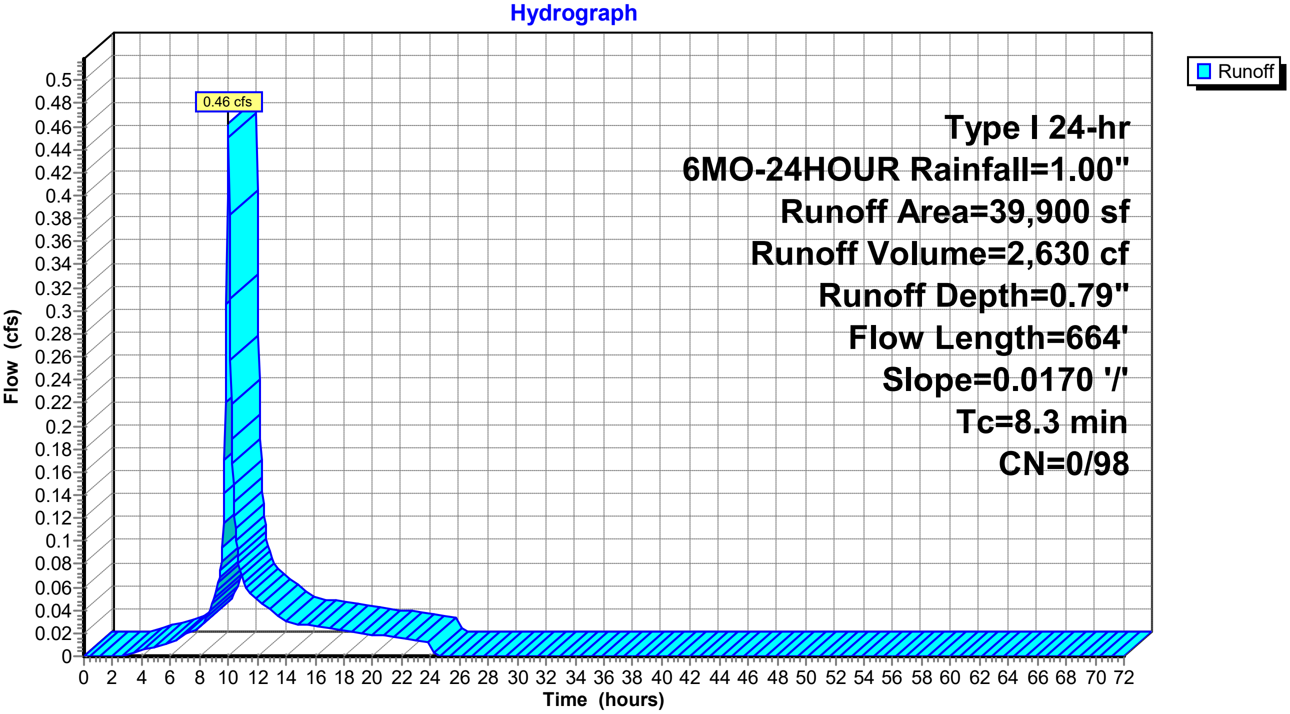
Runoff = 0.46 cfs @ 9.97 hrs, Volume= 2,630 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
39,900	98	Paved roads w/curbs & sewers, HSG A
39,900	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.3	664	0.0170	1.33		**Lag/CN Method,**

Subcatchment G2: GREENWOOD 2



Summary for Subcatchment G20: GREENWOOD 20

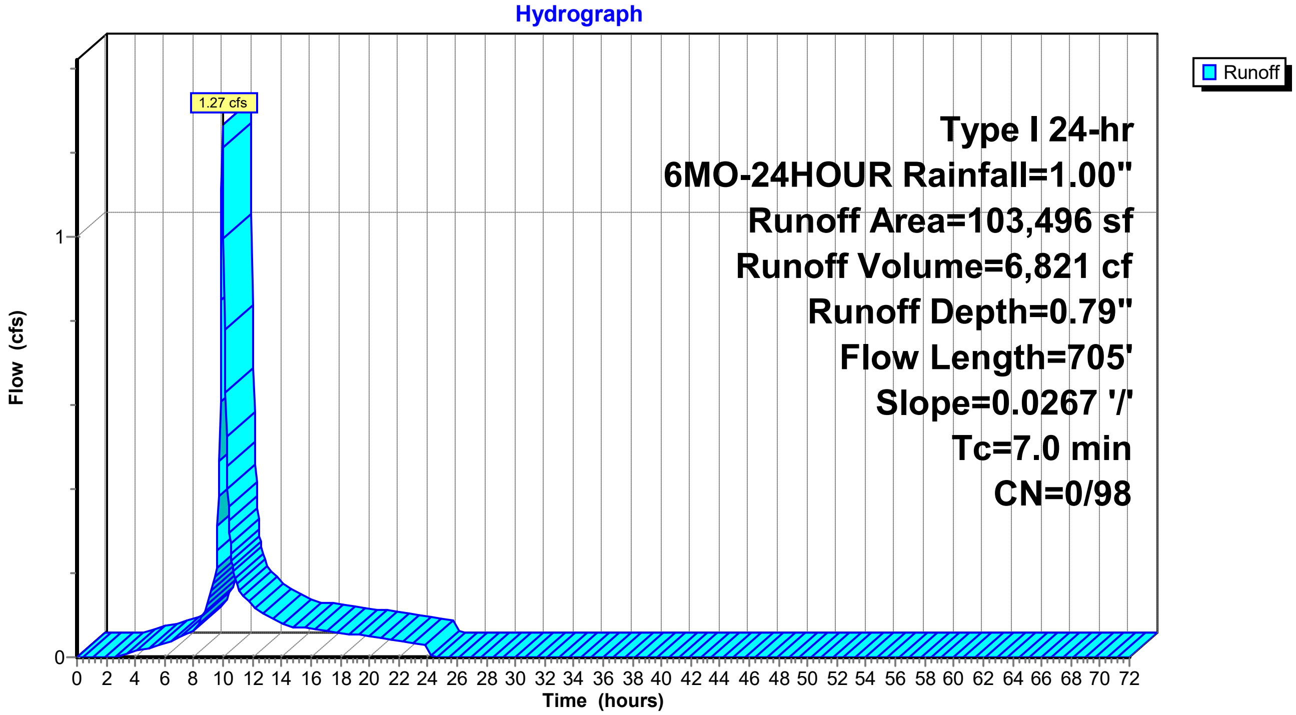
Runoff = 1.27 cfs @ 9.96 hrs, Volume= 6,821 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
103,496	98	Paved roads w/curbs & sewers, HSG A
103,496	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	705	0.0267	1.69		**Lag/CN Method,**

Subcatchment G20: GREENWOOD 20



Summary for Subcatchment G21: GREENWOOD 21

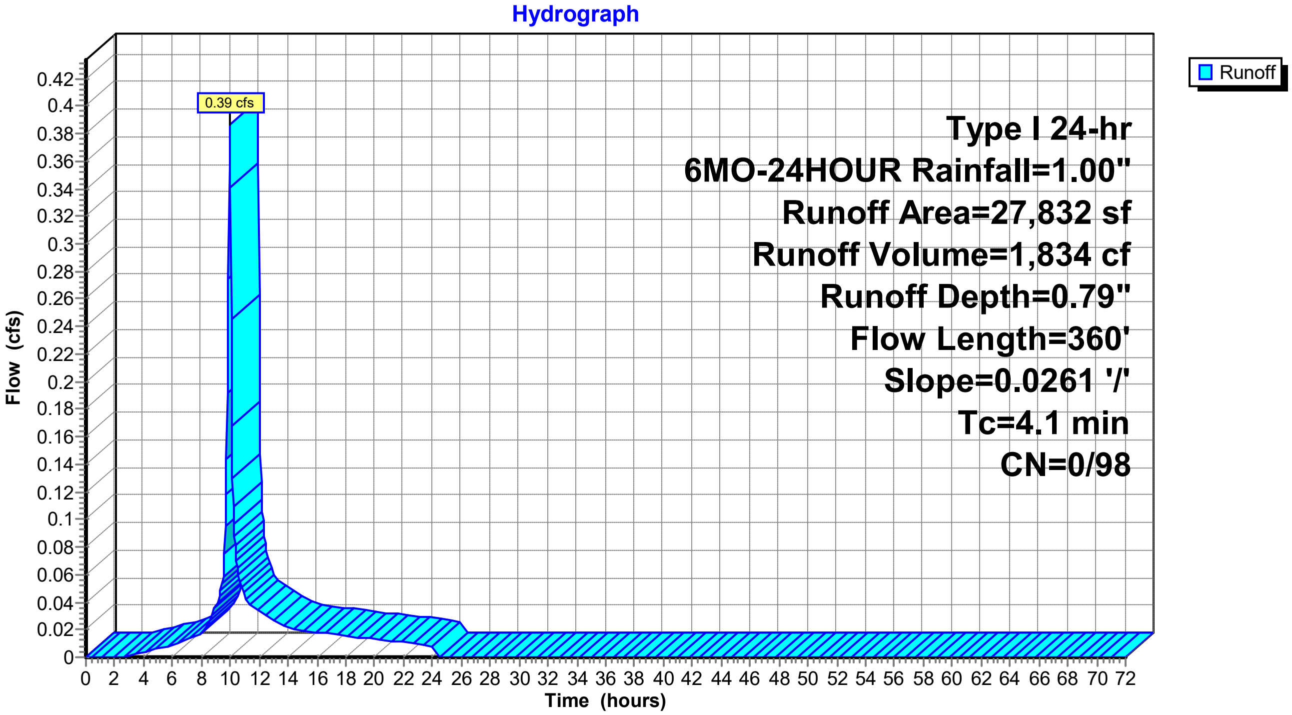
Runoff = 0.39 cfs @ 9.94 hrs, Volume= 1,834 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
27,832	98	Paved roads w/curbs & sewers, HSG A
27,832	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.1	360	0.0261	1.46		**Lag/CN Method,**

Subcatchment G21: GREENWOOD 21



Summary for Subcatchment G22: GREENWOOD 22

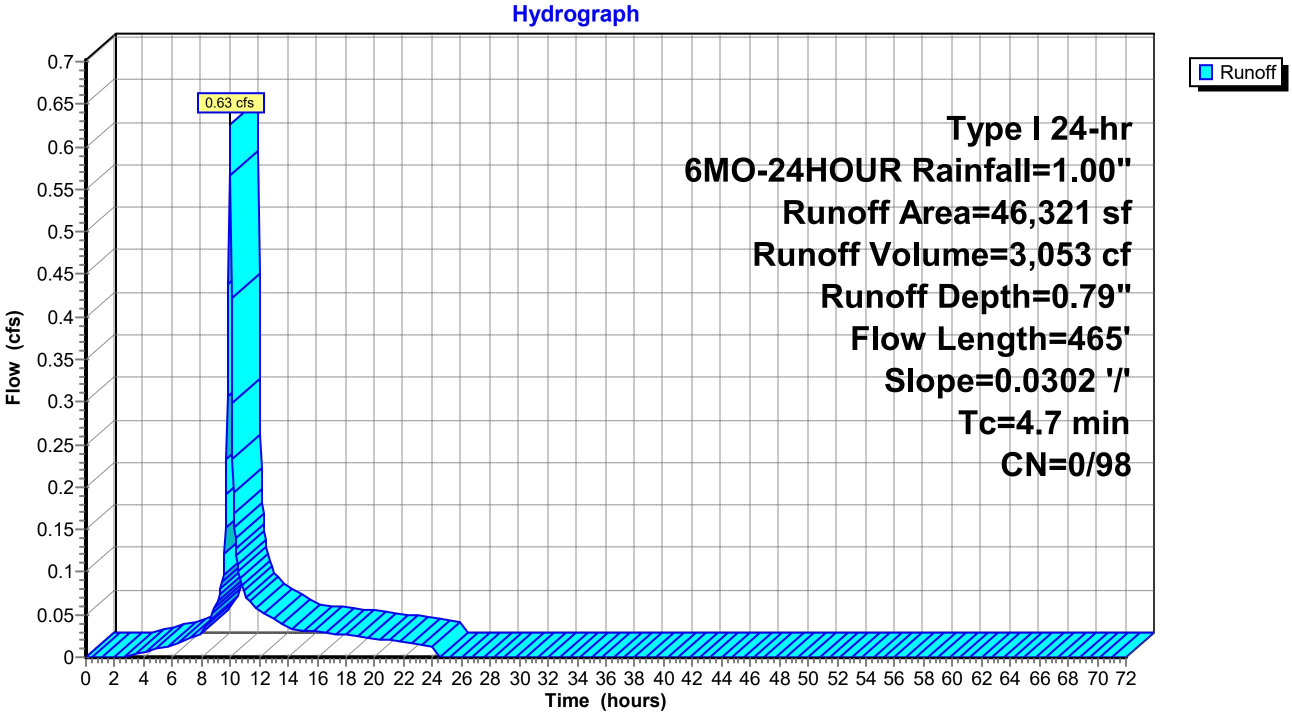
Runoff = 0.63 cfs @ 9.95 hrs, Volume= 3,053 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
46,321	98	Paved roads w/curbs & sewers, HSG A
46,321	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.7	465	0.0302	1.65		**Lag/CN Method,**

Subcatchment G22: GREENWOOD 22



Summary for Subcatchment G23: GREENWOOD 23

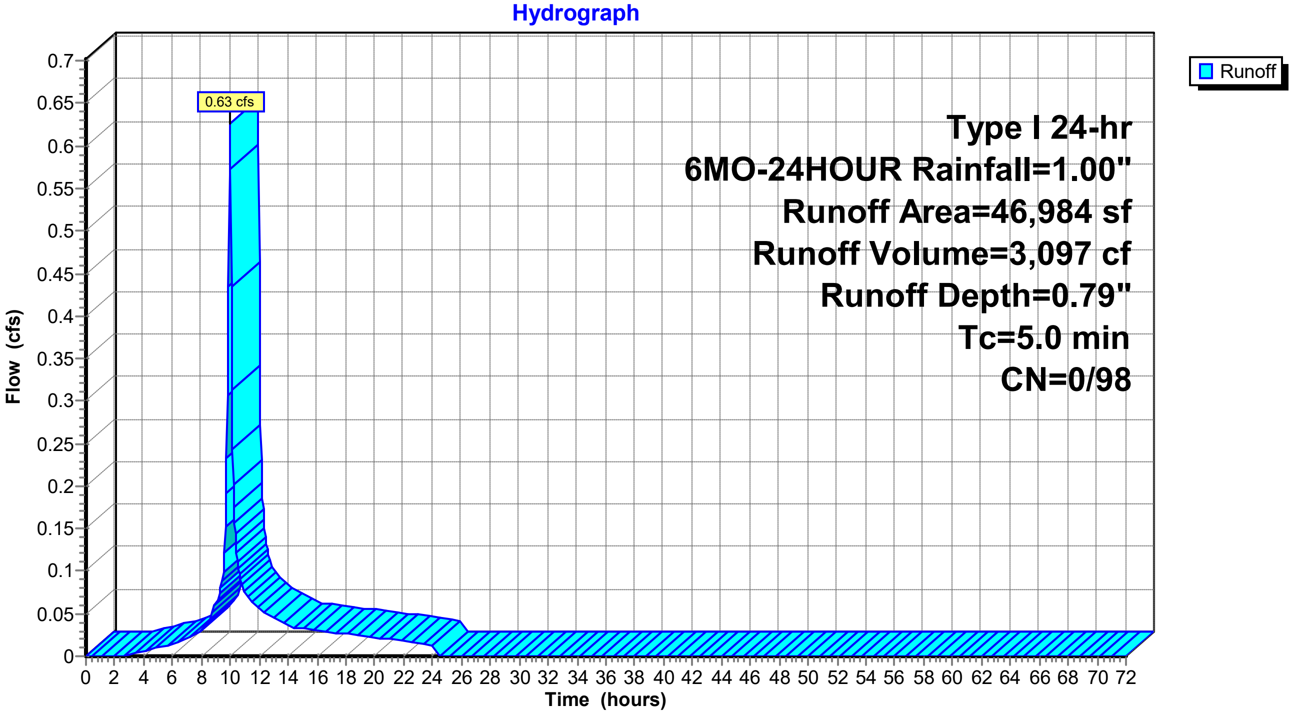
Runoff = 0.63 cfs @ 9.95 hrs, Volume= 3,097 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
46,984	98	Paved roads w/curbs & sewers, HSG A
46,984	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment G23: GREENWOOD 23



Summary for Subcatchment G24: GREENWOOD 24

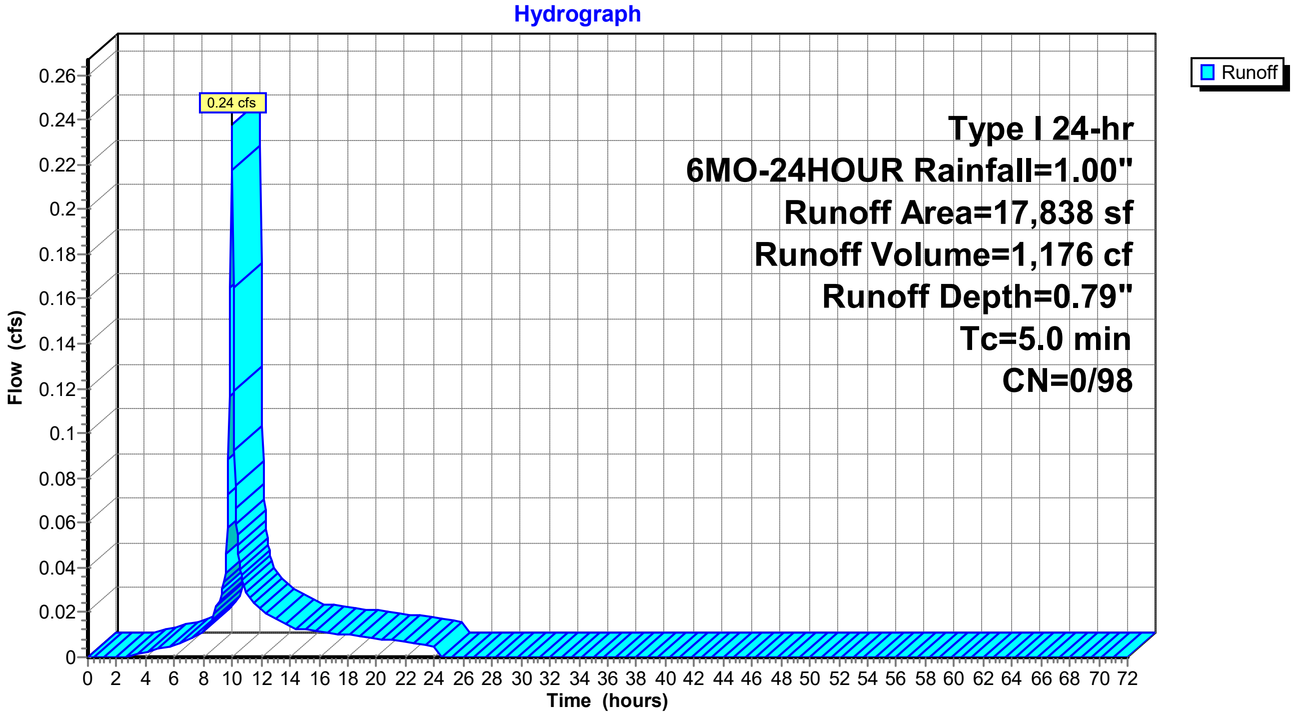
Runoff = 0.24 cfs @ 9.95 hrs, Volume= 1,176 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
17,838	98	Paved roads w/curbs & sewers, HSG A
17,838	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment G24: GREENWOOD 24



Summary for Subcatchment G25: GREENWOOD 25

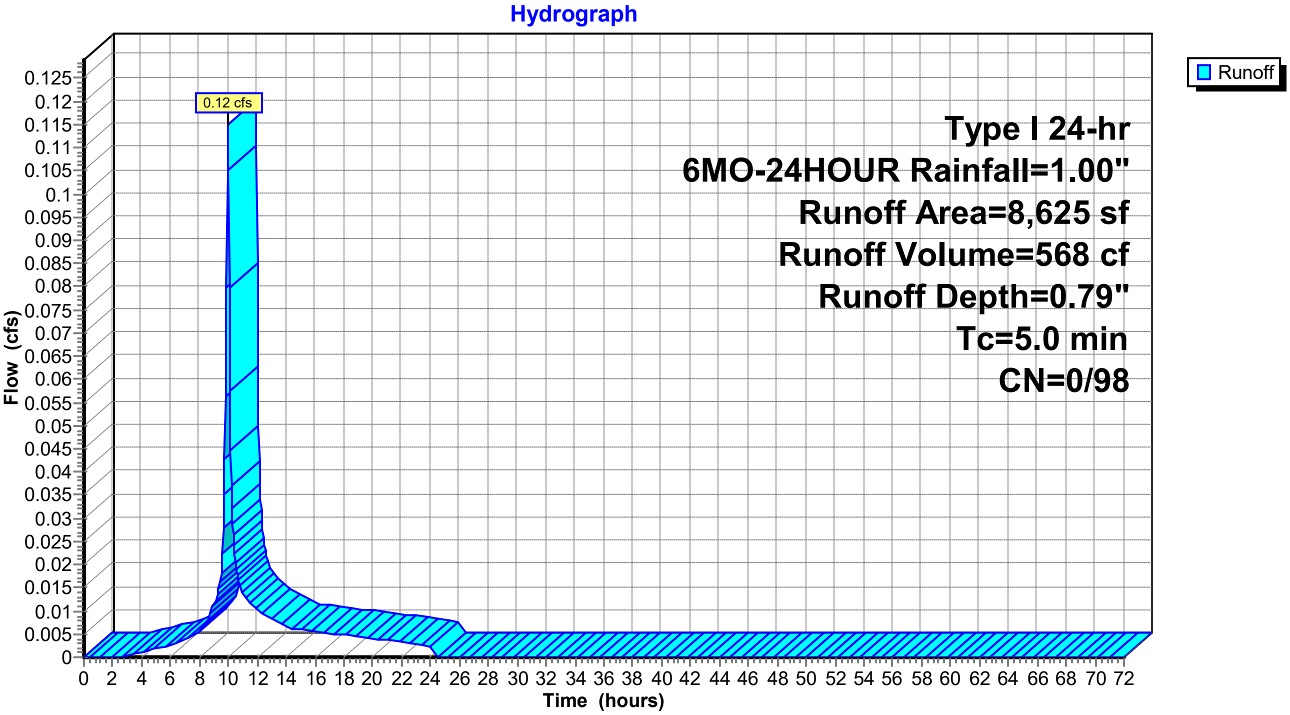
Runoff = 0.12 cfs @ 9.95 hrs, Volume= 568 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
8,625	98	Paved roads w/curbs & sewers, HSG A
8,625	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment G25: GREENWOOD 25



Summary for Subcatchment G26: GREENWOOD 26

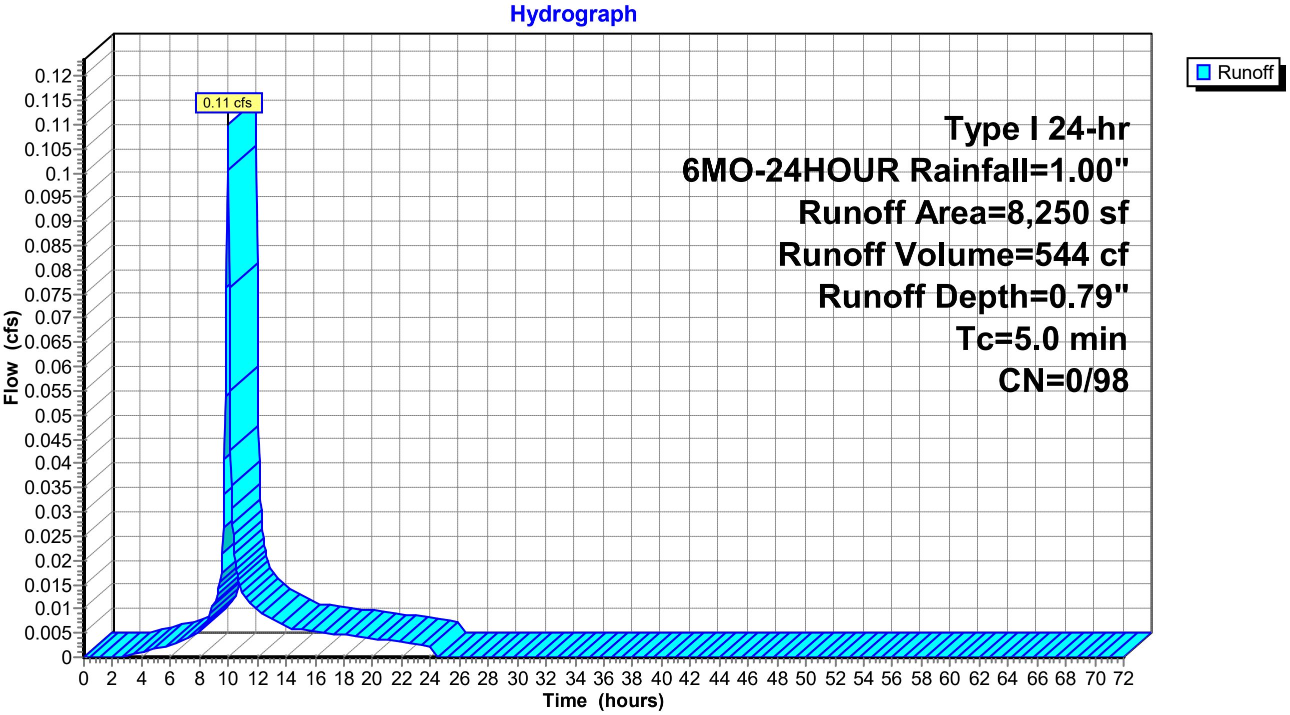
Runoff = 0.11 cfs @ 9.95 hrs, Volume= 544 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
8,250	98	Paved roads w/curbs & sewers, HSG A
8,250	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment G26: GREENWOOD 26



Summary for Subcatchment G27: GREENWOOD 27

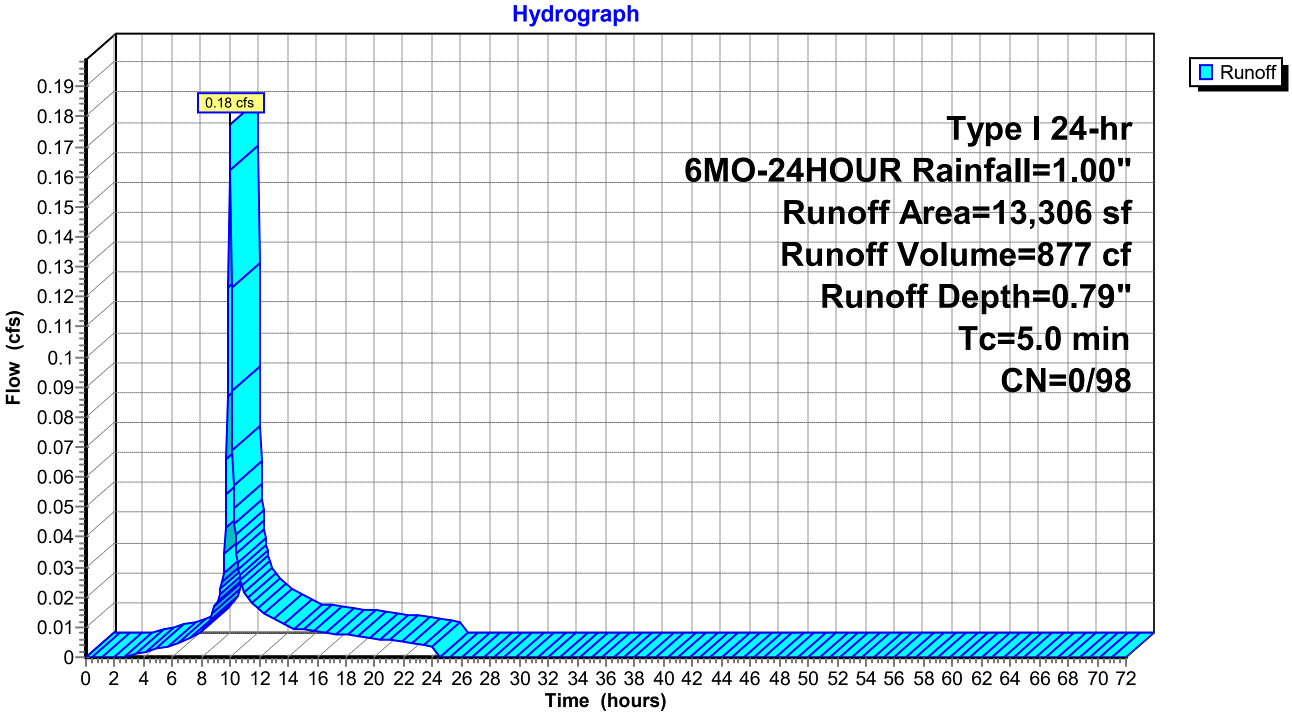
Runoff = 0.18 cfs @ 9.95 hrs, Volume= 877 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
13,306	98	Paved roads w/curbs & sewers, HSG A
13,306	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment G27: GREENWOOD 27



Summary for Subcatchment G28: GREENWOOD 28

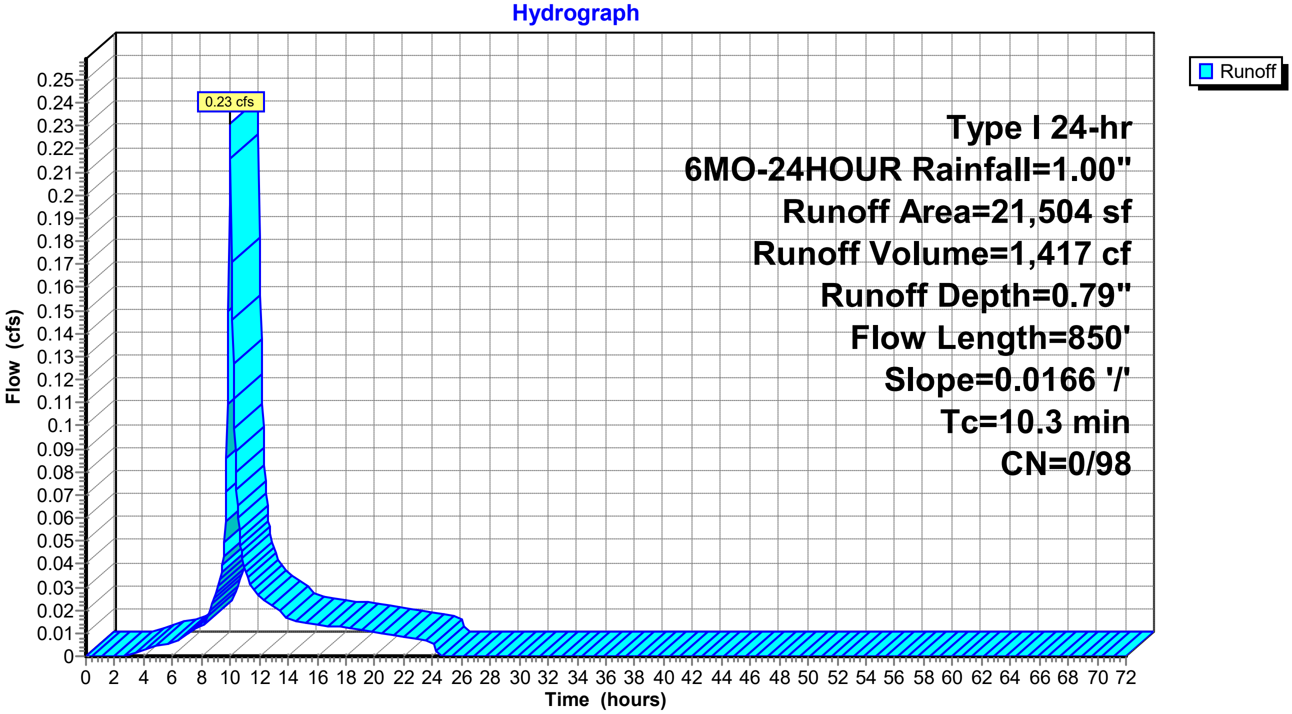
Runoff = 0.23 cfs @ 9.98 hrs, Volume= 1,417 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
21,504	98	Paved roads w/curbs & sewers, HSG A
21,504	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.3	850	0.0166	1.38		**Lag/CN Method,**

Subcatchment G28: GREENWOOD 28



Summary for Subcatchment G29: GREENWOOD 29

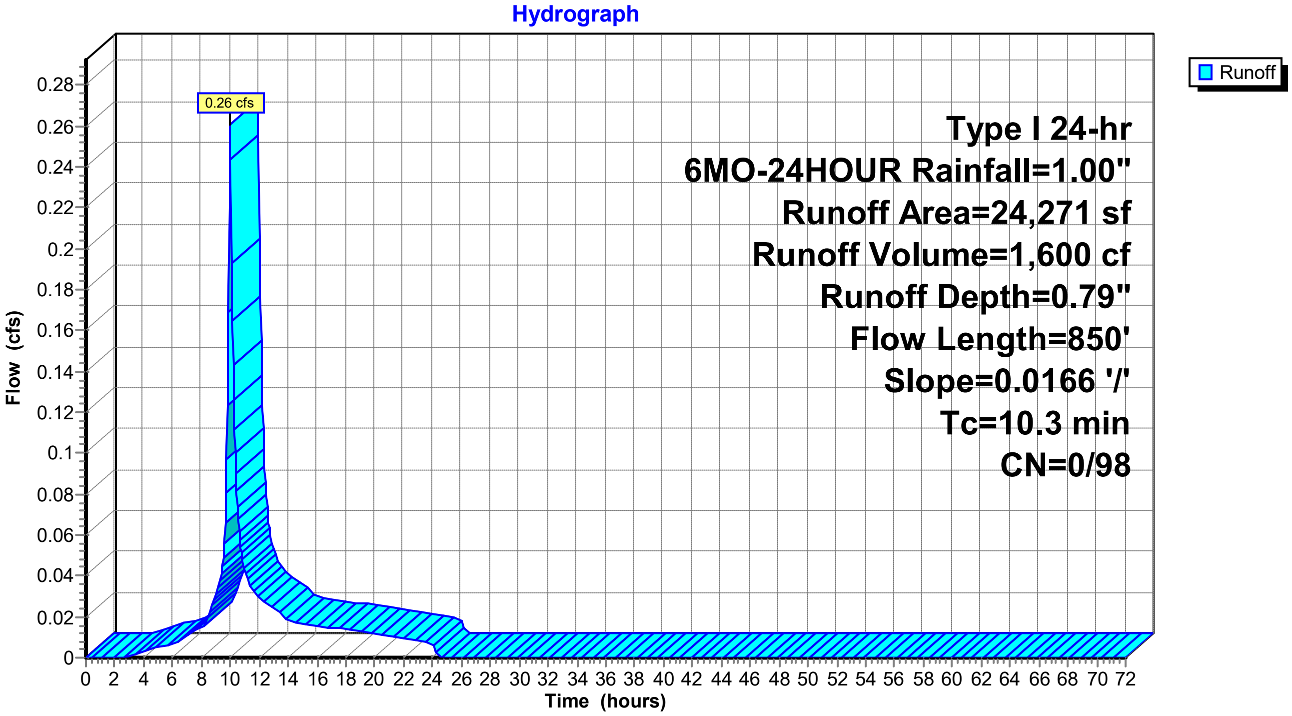
Runoff = 0.26 cfs @ 9.98 hrs, Volume= 1,600 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
24,271	98	Paved roads w/curbs & sewers, HSG A
24,271	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.3	850	0.0166	1.38		**Lag/CN Method,**

Subcatchment G29: GREENWOOD 29



Summary for Subcatchment G3: GREENWOOD 3

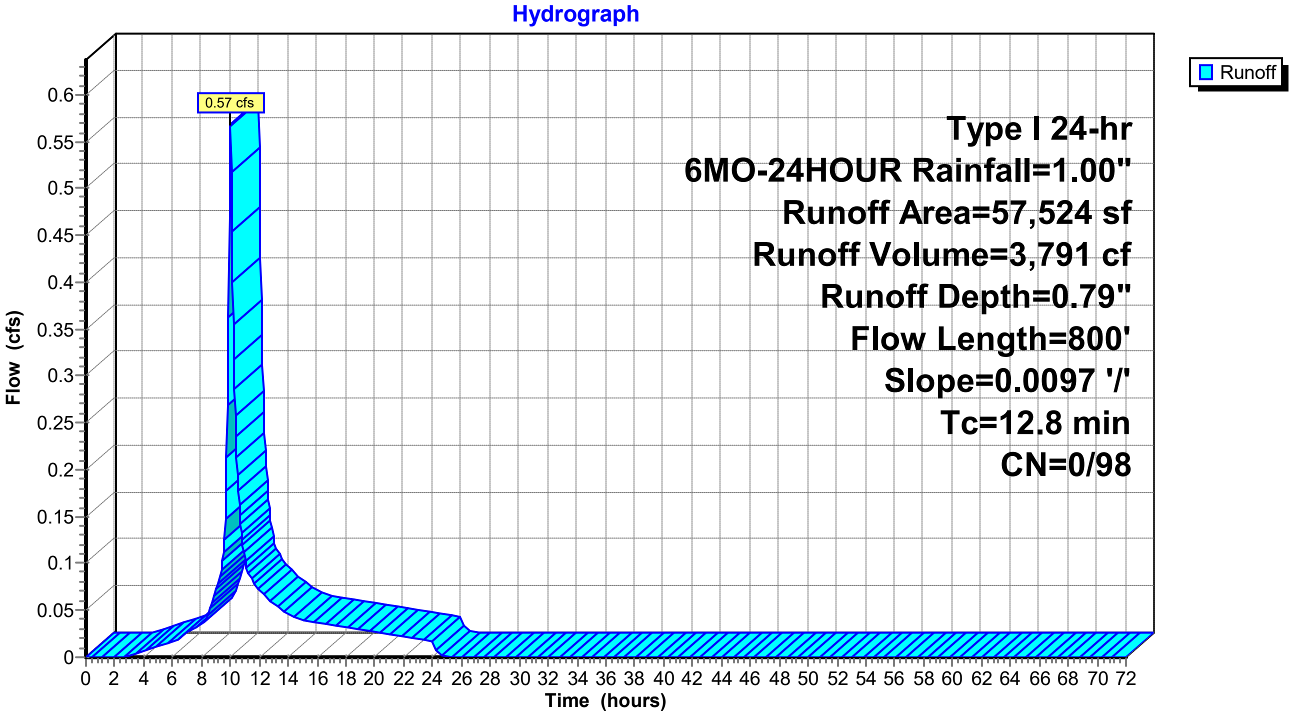
Runoff = 0.57 cfs @ 9.99 hrs, Volume= 3,791 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
57,524	98	Paved roads w/curbs & sewers, HSG A
57,524	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.8	800	0.0097	1.04		**Lag/CN Method,**

Subcatchment G3: GREENWOOD 3



Summary for Subcatchment G30: GREENWOOD 30

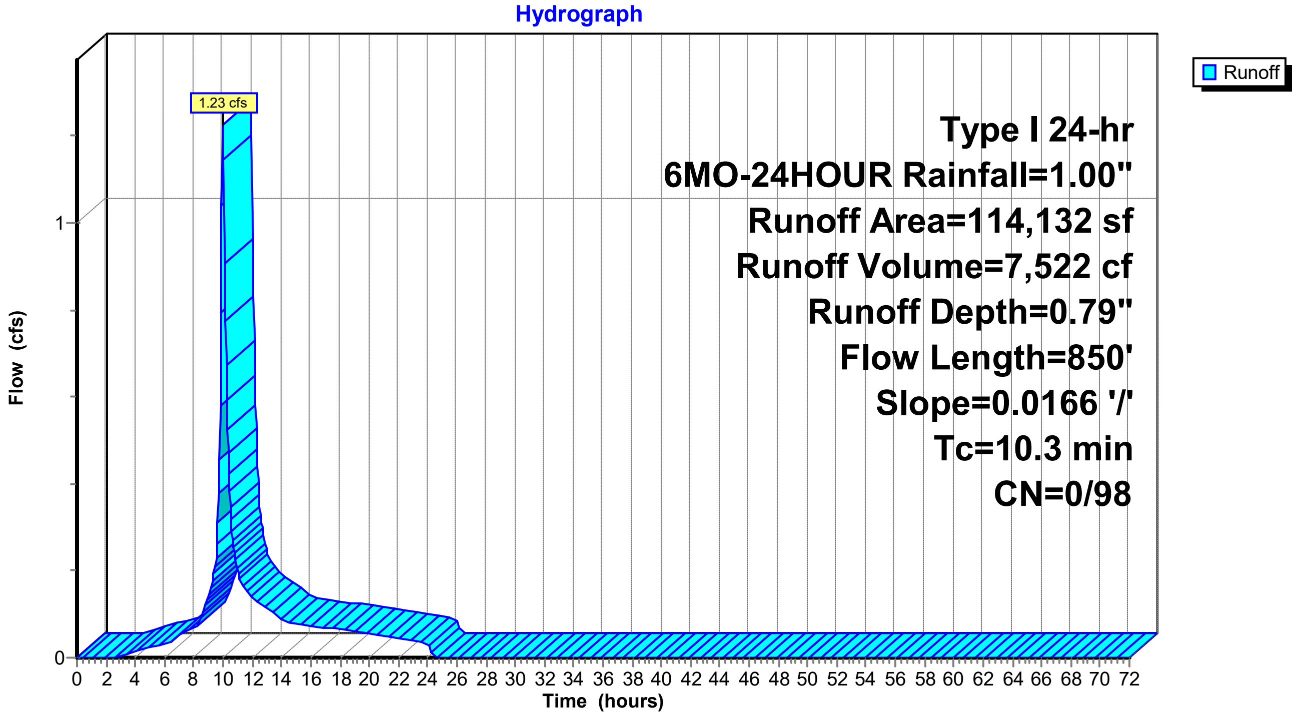
```
Runoff      =        1.23 cfs @    9.98 hrs,  Volume=            7,522 cf,  Depth=  0.79"
    Routed to nonexistent node DW-1A-B
```

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
114,132	98	Paved roads w/curbs & sewers, HSG A
114,132	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.3	850	0.0166	1.38		**Lag/CN Method,**

Subcatchment G30: GREENWOOD 30



Summary for Subcatchment G4: GREENWOOD 4

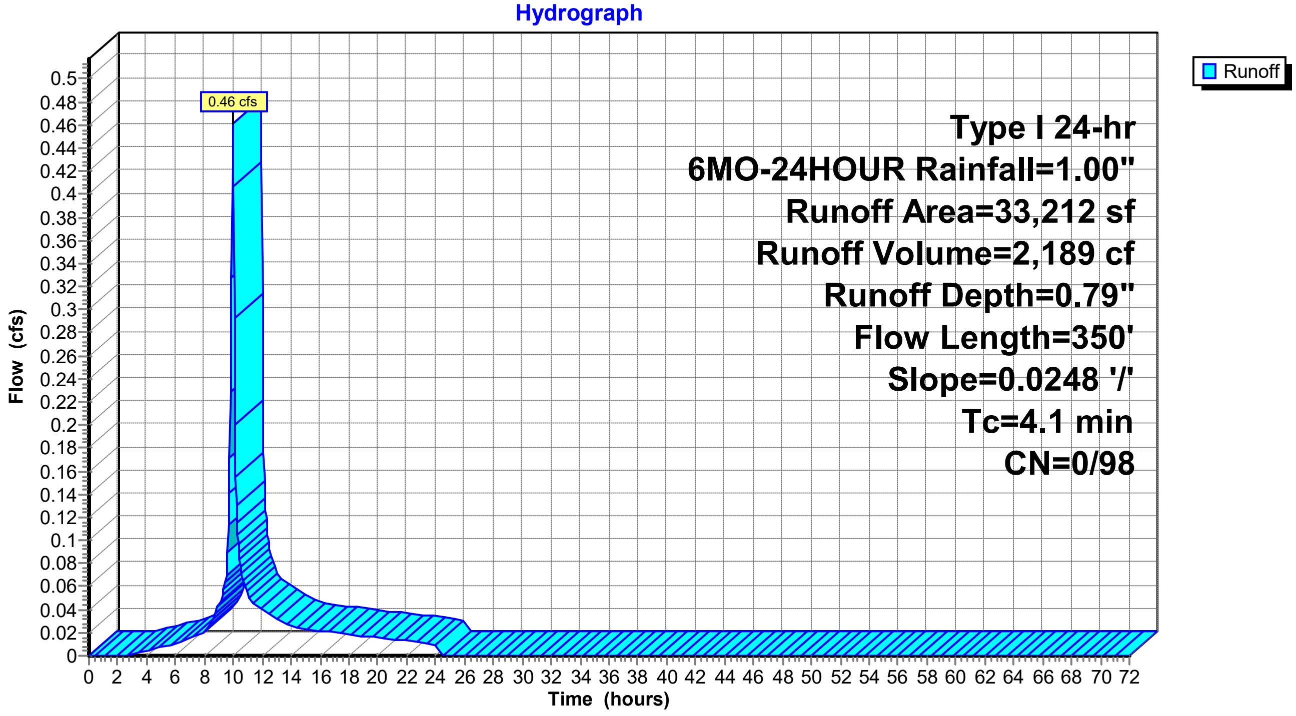
Runoff = 0.46 cfs @ 9.94 hrs, Volume= 2,189 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
33,212	98	Paved roads w/curbs & sewers, HSG A
33,212	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.1	350	0.0248	1.41		**Lag/CN Method,**

Subcatchment G4: GREENWOOD 4



Summary for Subcatchment G5: GREENWOOD 5

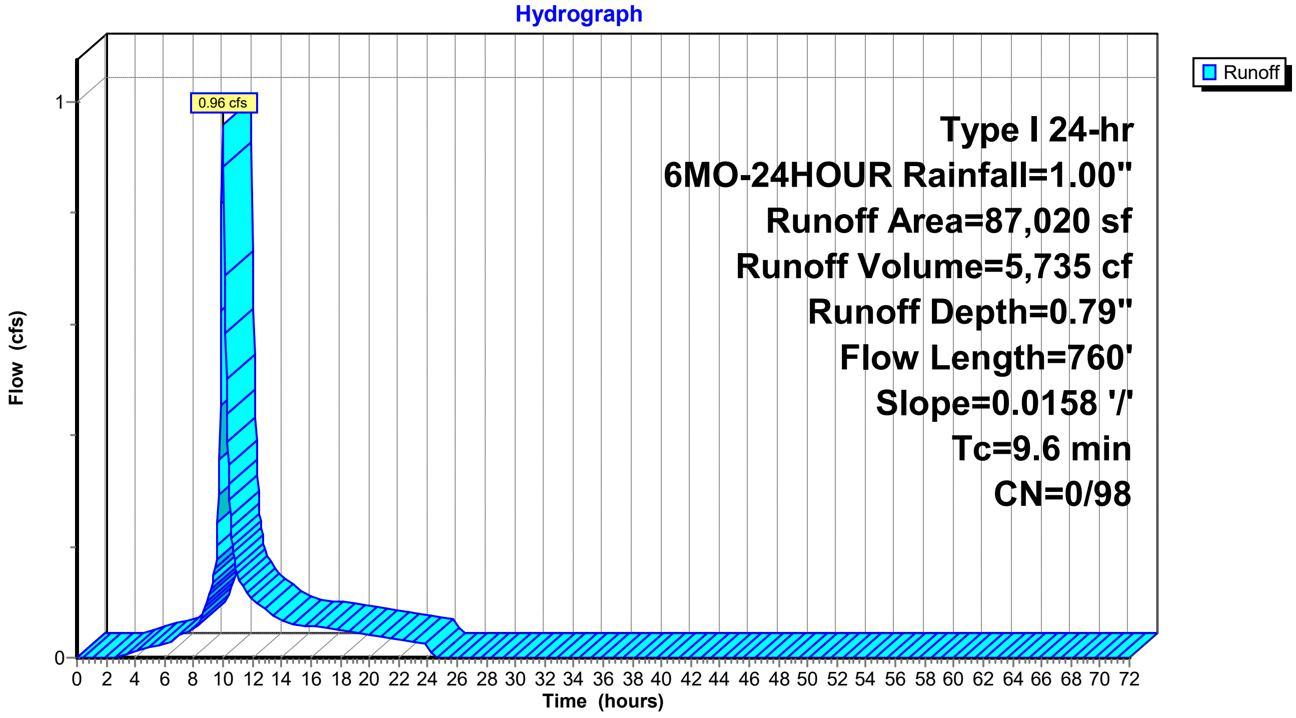
Runoff = 0.96 cfs @ 9.97 hrs, Volume= 5,735 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
87,020	98	Paved roads w/curbs & sewers, HSG A
87,020	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.6	760	0.0158	1.32		**Lag/CN Method,**

Subcatchment G5: GREENWOOD 5



Summary for Subcatchment G6: GREENWOOD 6

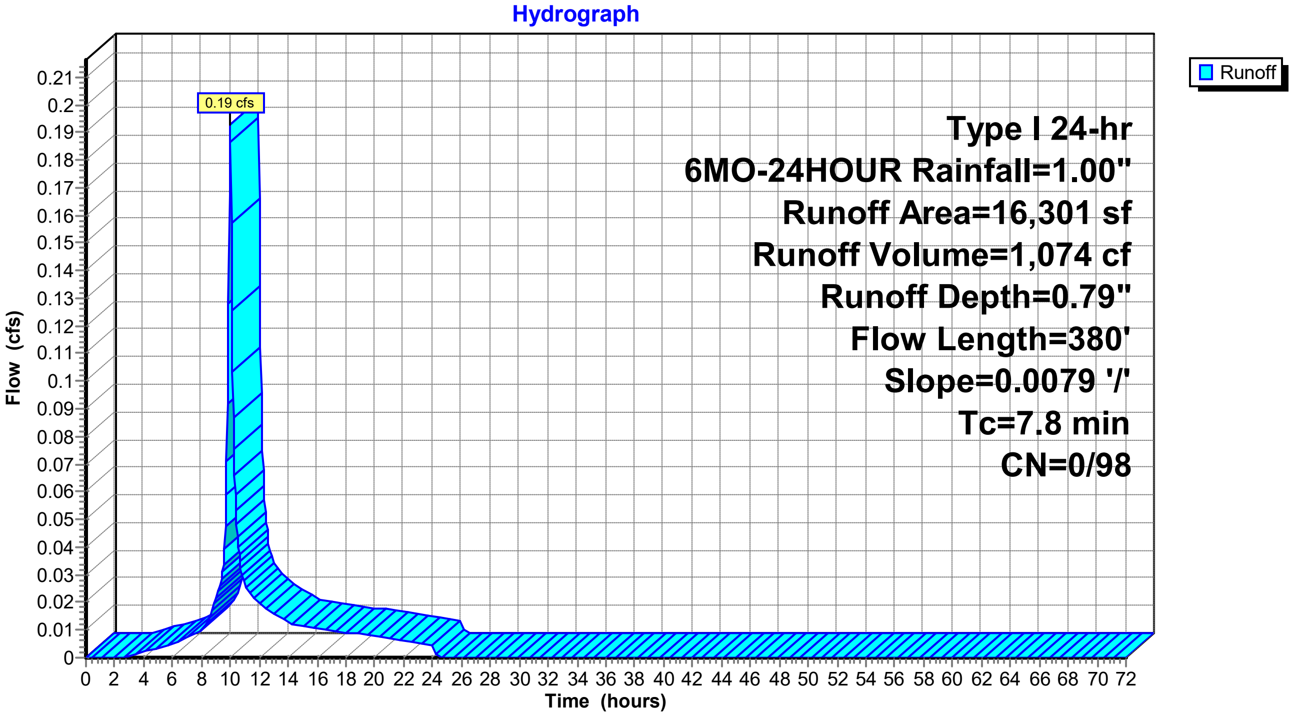
Runoff = 0.19 cfs @ 9.97 hrs, Volume= 1,074 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
16,301	98	Paved roads w/curbs & sewers, HSG A
16,301	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.8	380	0.0079	0.81		**Lag/CN Method,**

Subcatchment G6: GREENWOOD 6



Summary for Subcatchment G7: GREENWOOD 7

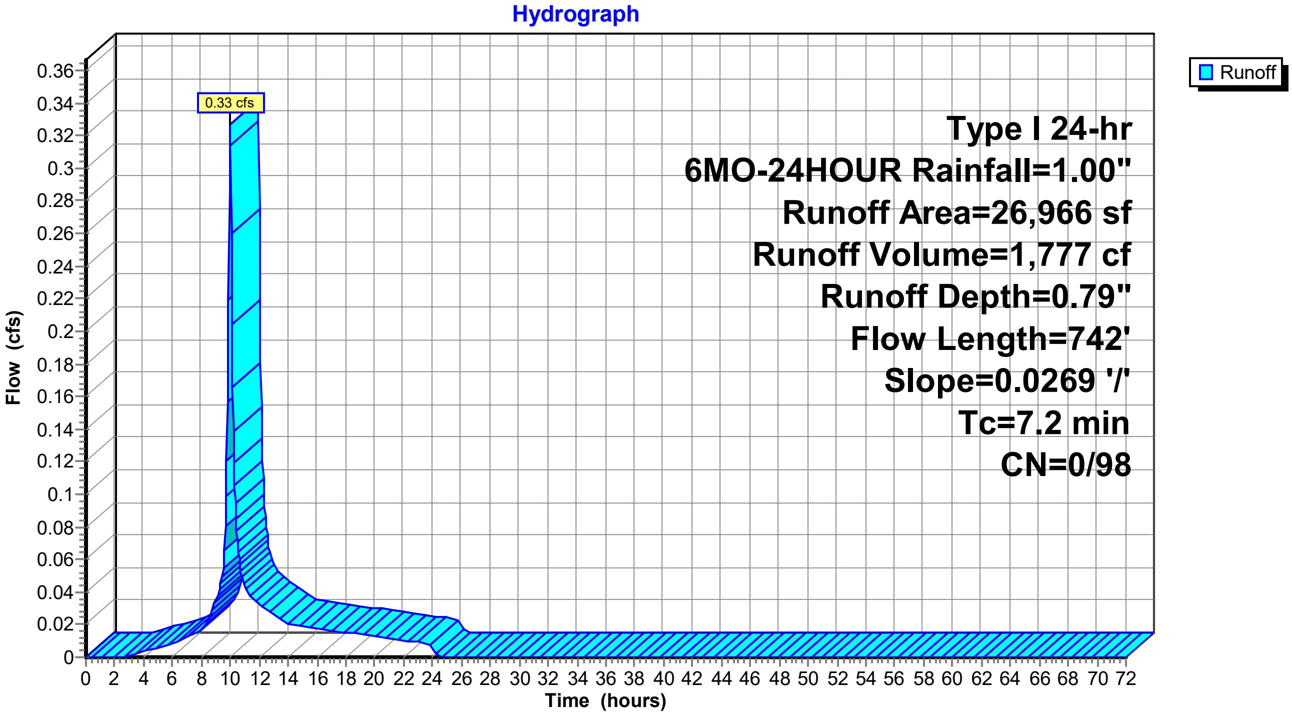
Runoff = 0.33 cfs @ 9.96 hrs, Volume= 1,777 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
26,966	98	Paved roads w/curbs & sewers, HSG A
26,966	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.2	742	0.0269	1.71		**Lag/CN Method,**

Subcatchment G7: GREENWOOD 7



Summary for Subcatchment G8: GREENWOOD 8

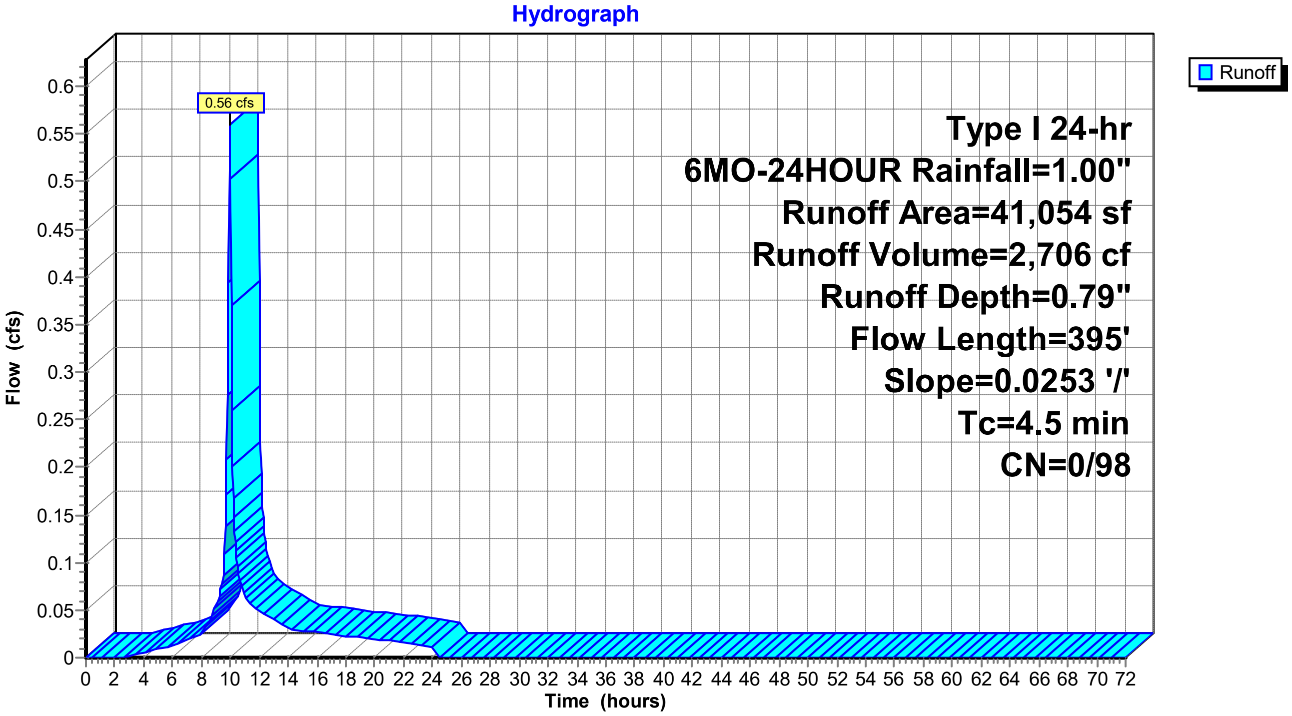
Runoff = 0.56 cfs @ 9.95 hrs, Volume= 2,706 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
41,054	98	Paved roads w/curbs & sewers, HSG A
41,054	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.5	395	0.0253	1.46		**Lag/CN Method,**

Subcatchment G8: GREENWOOD 8



Summary for Subcatchment G9: GREENWOOD 9

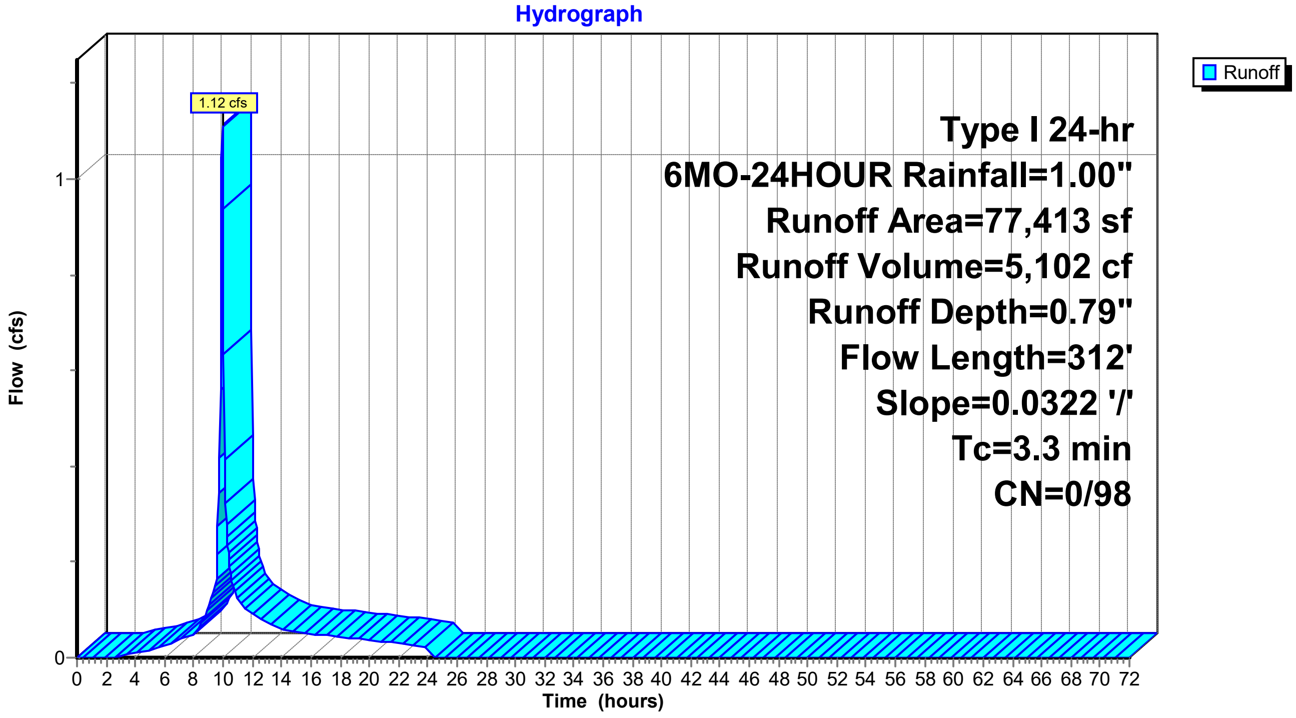
Runoff = 1.12 cfs @ 9.94 hrs, Volume= 5,102 cf, Depth= 0.79"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

Area (sf)	CN	Description
77,413	98	Paved roads w/curbs & sewers, HSG A
77,413	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.3	312	0.0322	1.57		**Lag/CN Method,**

Subcatchment G9: GREENWOOD 9



Summary for Subcatchment F1: FRANKLIN 1

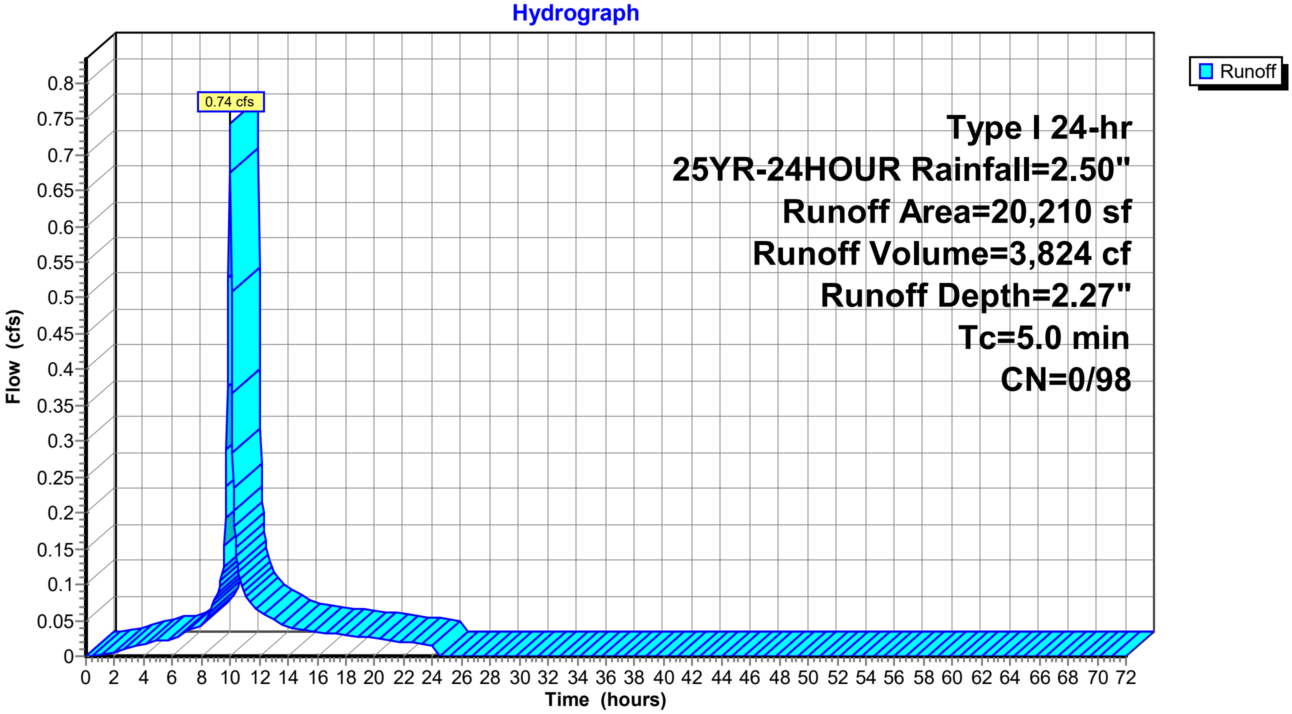
Runoff = 0.74 cfs @ 9.95 hrs, Volume= 3,824 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
20,210	98	Paved roads w/curbs & sewers, HSG A
20,210	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment F1: FRANKLIN 1



Summary for Subcatchment F2: FRANKLIN 2

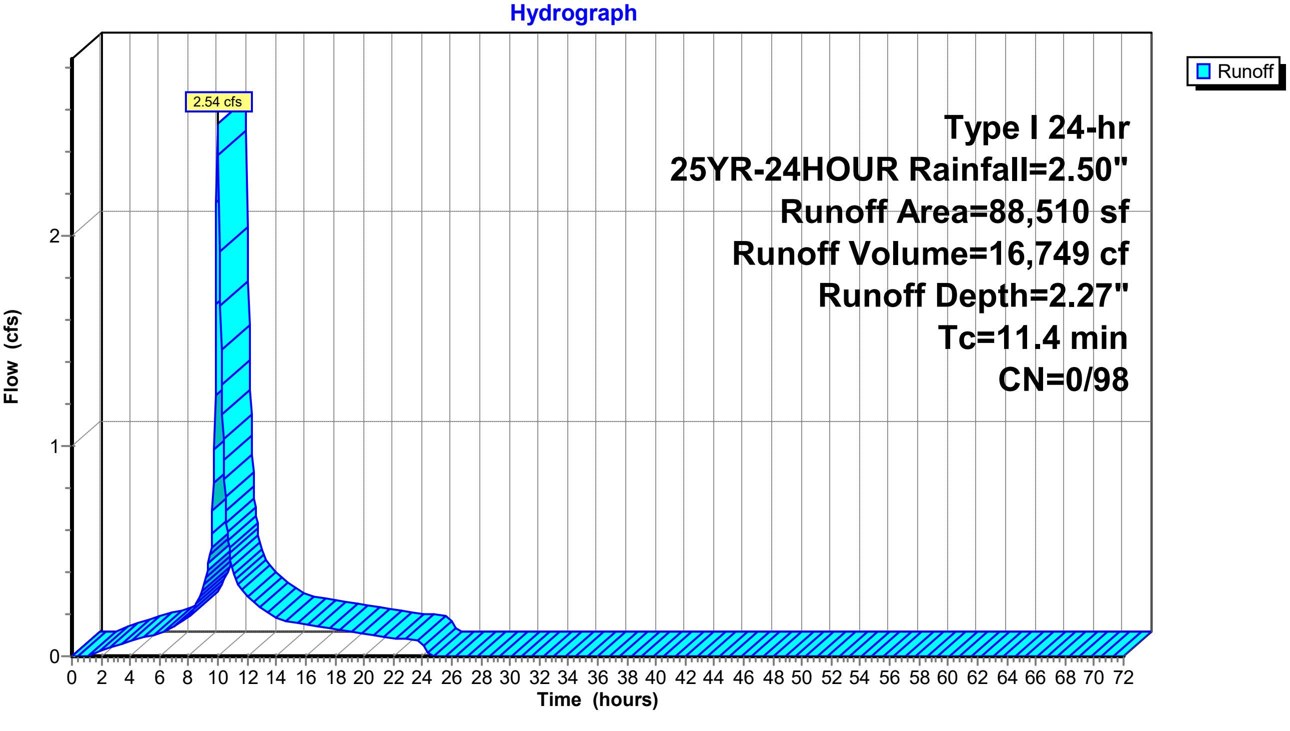
Runoff = 2.54 cfs @ 9.98 hrs, Volume= 16,749 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
88,510	98	Paved roads w/curbs & sewers, HSG A
88,510	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.4					**Direct Entry,**

Subcatchment F2: FRANKLIN 2



Summary for Subcatchment F3: FRANKLIN 3

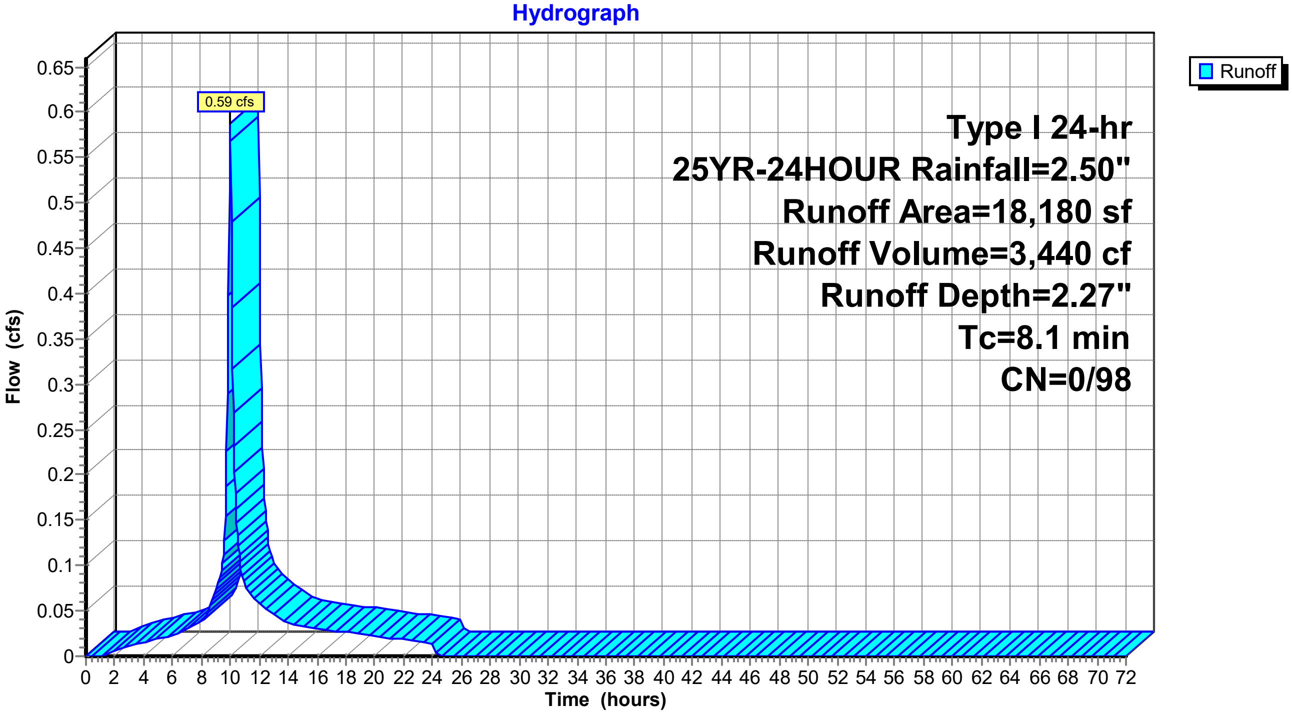
Runoff = 0.59 cfs @ 9.97 hrs, Volume= 3,440 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
18,180	98	Paved roads w/curbs & sewers, HSG A
18,180	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.1					**Direct Entry,**

Subcatchment F3: FRANKLIN 3



Summary for Subcatchment F4: FRANKLIN 4

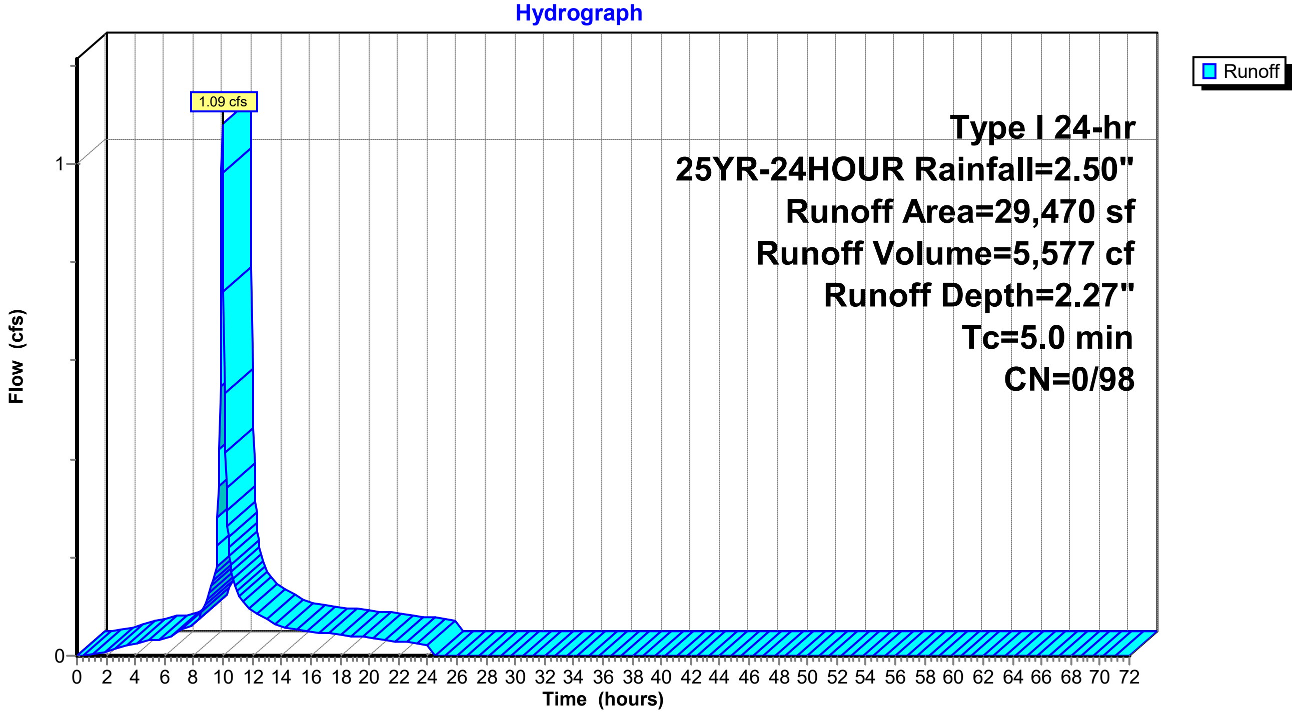
Runoff = 1.09 cfs @ 9.95 hrs, Volume= 5,577 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
29,470	98	Paved roads w/curbs & sewers, HSG A
29,470	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment F4: FRANKLIN 4



Summary for Subcatchment F5: FRANKLIN 5

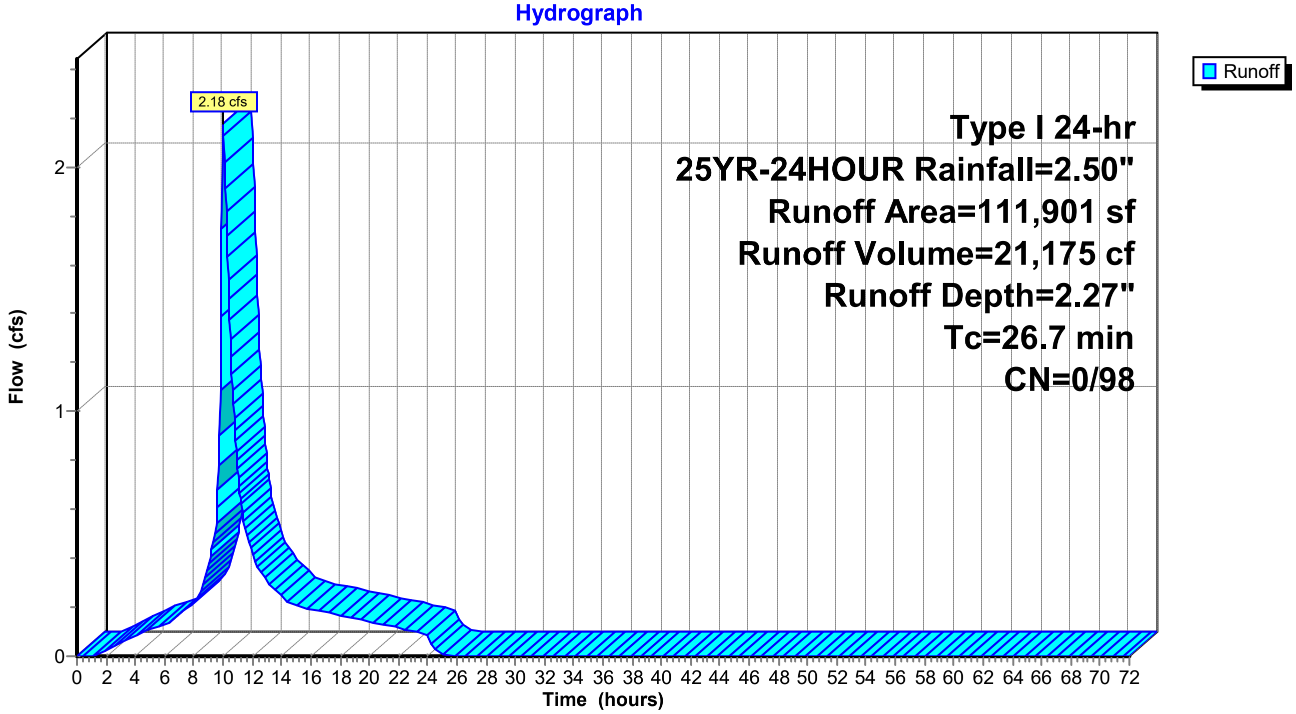
Runoff = 2.18 cfs @ 10.01 hrs, Volume= 21,175 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
111,901	98	Paved roads w/curbs & sewers, HSG A
111,901	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.7					**Direct Entry,**

Subcatchment F5: FRANKLIN 5



Summary for Subcatchment F6: FRANKLIN 6

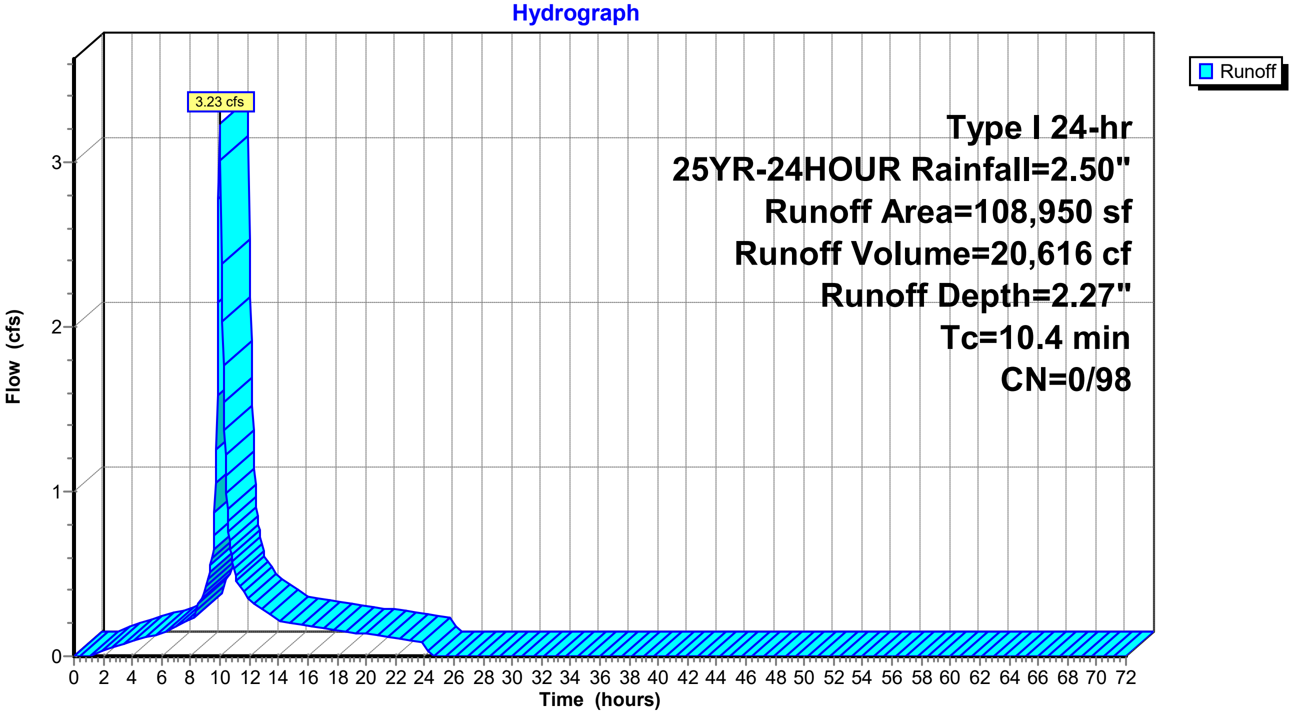
Runoff = 3.23 cfs @ 9.98 hrs, Volume= 20,616 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
108,950	98	Paved roads w/curbs & sewers, HSG A
108,950	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.4					**Direct Entry,**

Subcatchment F6: FRANKLIN 6



Summary for Subcatchment F7: FRANKLIN 7

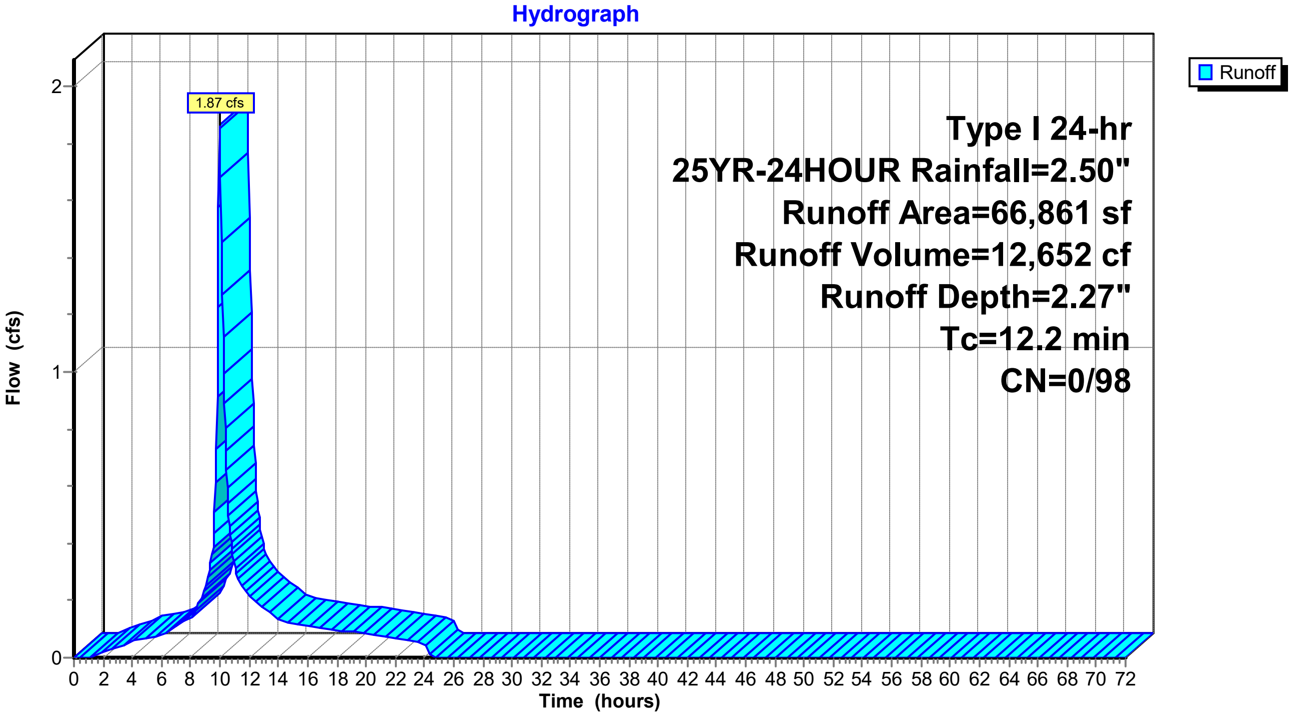
Runoff = 1.87 cfs @ 9.98 hrs, Volume= 12,652 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
66,861	98	Paved roads w/curbs & sewers, HSG A
66,861	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.2					**Direct Entry,**

Subcatchment F7: FRANKLIN 7



Summary for Subcatchment G1: GREENWOOD 1 (CONTRIBUTION)

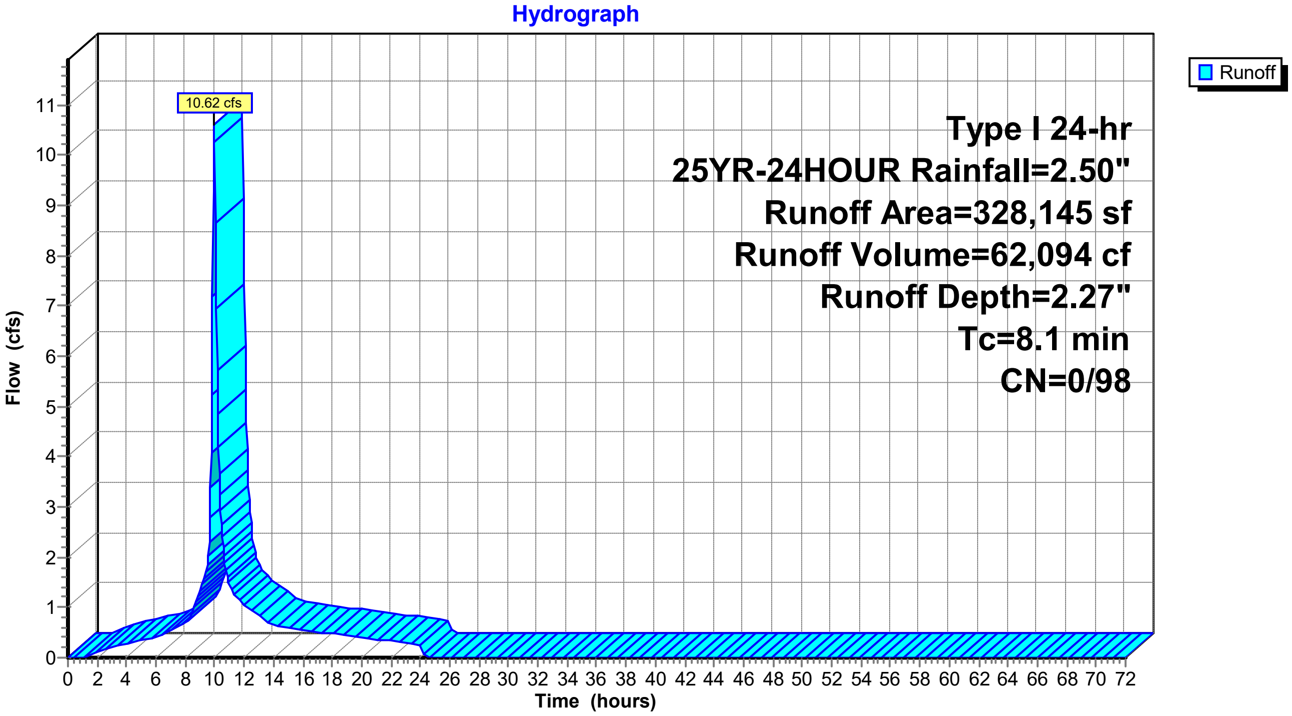
Runoff = 10.62 cfs @ 9.97 hrs, Volume= 62,094 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
328,145	98	Paved roads w/curbs & sewers, HSG A
328,145	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.1					**Direct Entry,**

Subcatchment G1: GREENWOOD 1 (CONTRIBUTION)



Summary for Subcatchment G10: GREENWOOD 10

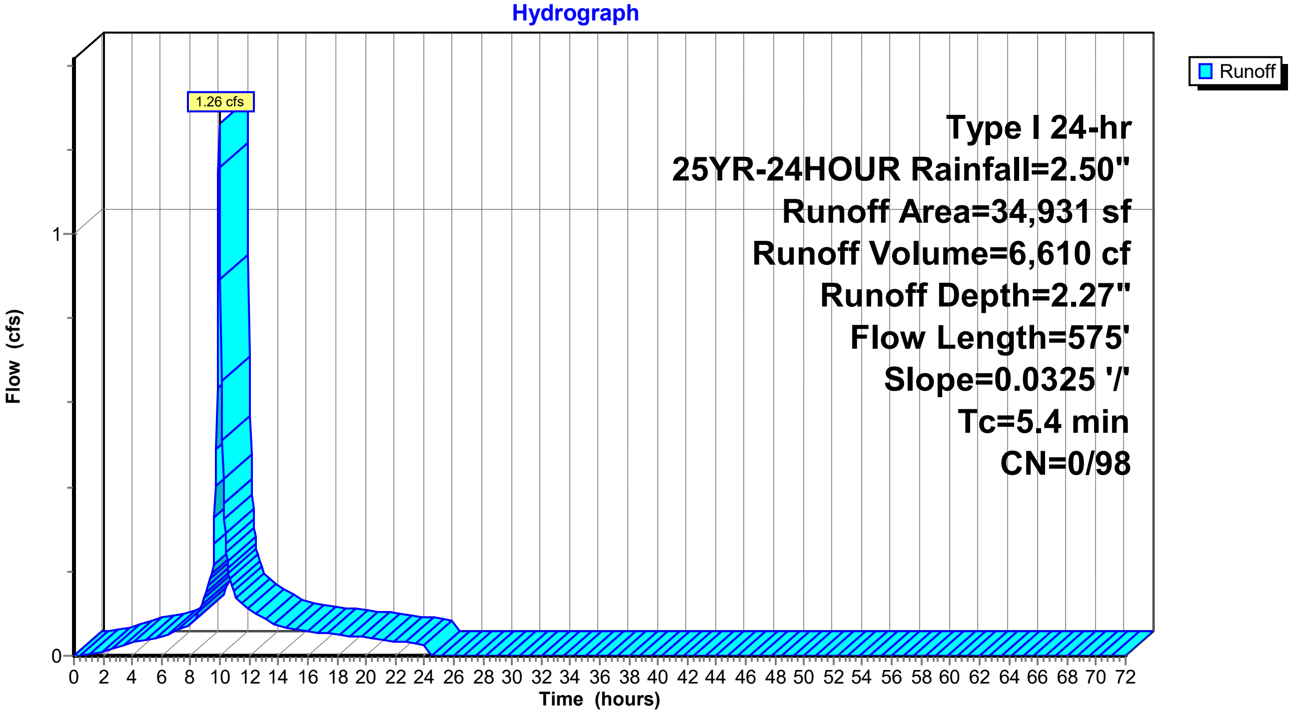
Runoff = 1.26 cfs @ 9.95 hrs, Volume= 6,610 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
34,931	98	Paved roads w/curbs & sewers, HSG A
34,931	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.4	575	0.0325	1.79		**Lag/CN Method,**

Subcatchment G10: GREENWOOD 10



Summary for Subcatchment G11: GREENWOOD 11

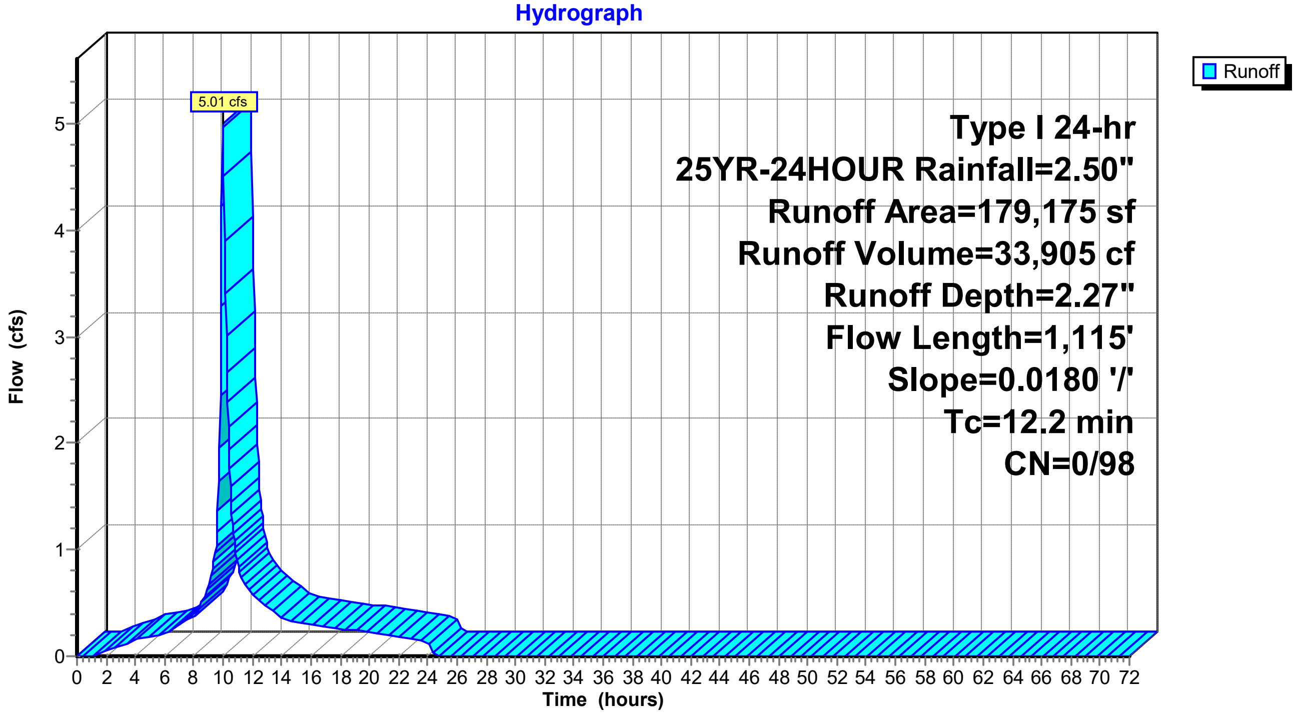
Runoff = 5.01 cfs @ 9.98 hrs, Volume= 33,905 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
179,175	98	Paved roads w/curbs & sewers, HSG A
179,175	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.2	1,115	0.0180	1.52		**Lag/CN Method,**

Subcatchment G11: GREENWOOD 11



Summary for Subcatchment G12: GREENWOOD 12

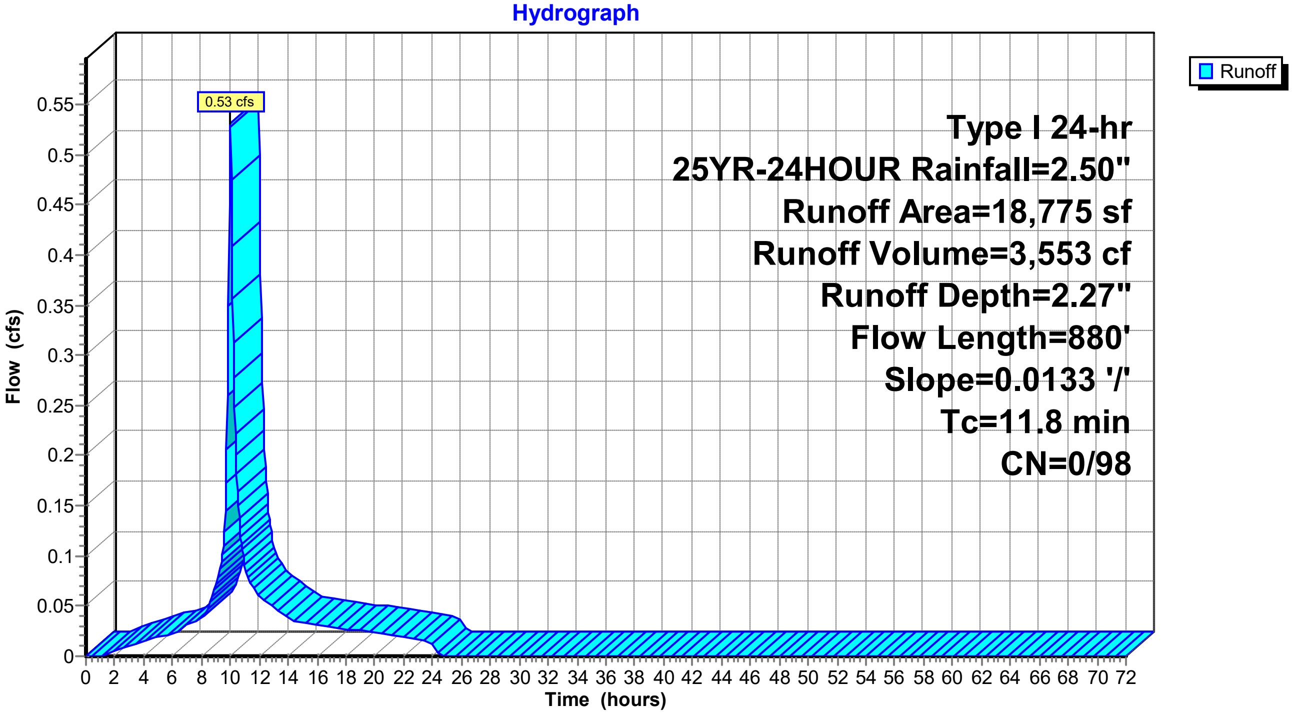
Runoff = 0.53 cfs @ 9.98 hrs, Volume= 3,553 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
18,775	98	Paved roads w/curbs & sewers, HSG A
18,775	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.8	880	0.0133	1.24		**Lag/CN Method,**

Subcatchment G12: GREENWOOD 12



Summary for Subcatchment G13: GREENWOOD 13

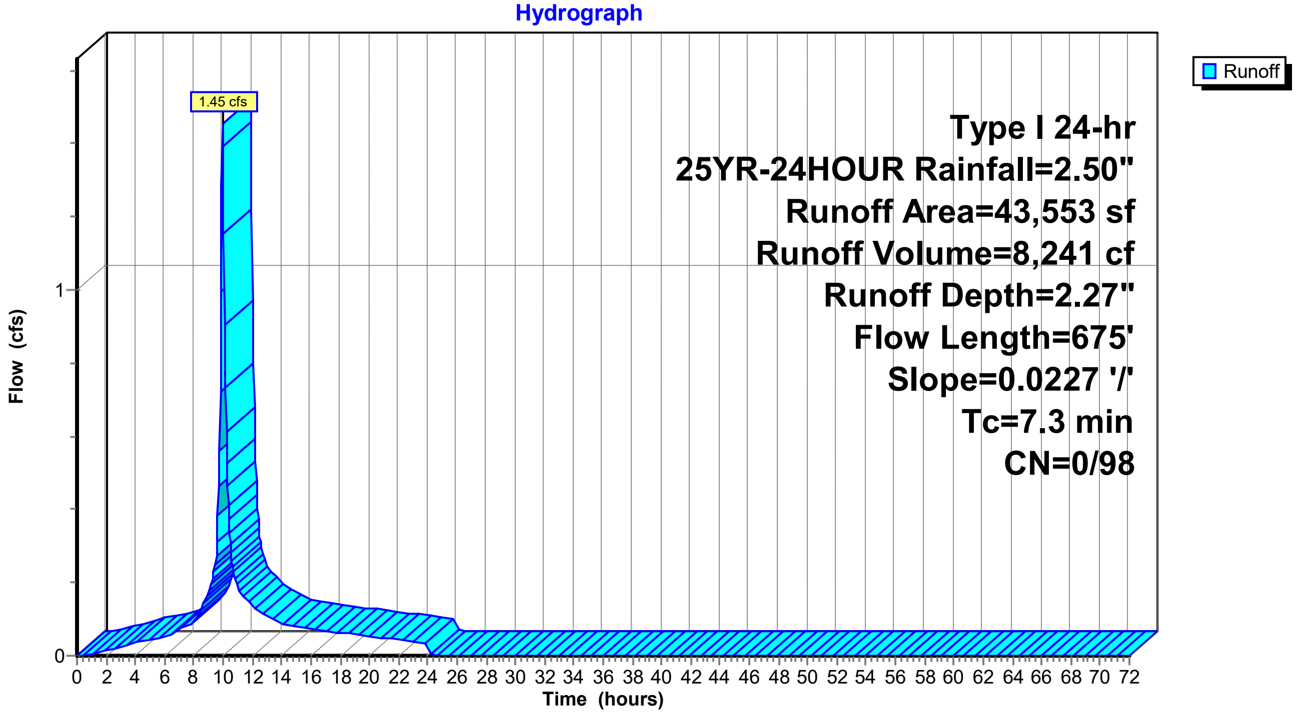
Runoff = 1.45 cfs @ 9.96 hrs, Volume= 8,241 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
43,553	98	Paved roads w/curbs & sewers, HSG A
43,553	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	675	0.0227	1.54		**Lag/CN Method,**

Subcatchment G13: GREENWOOD 13



Summary for Subcatchment G14: GREENWOOD 14

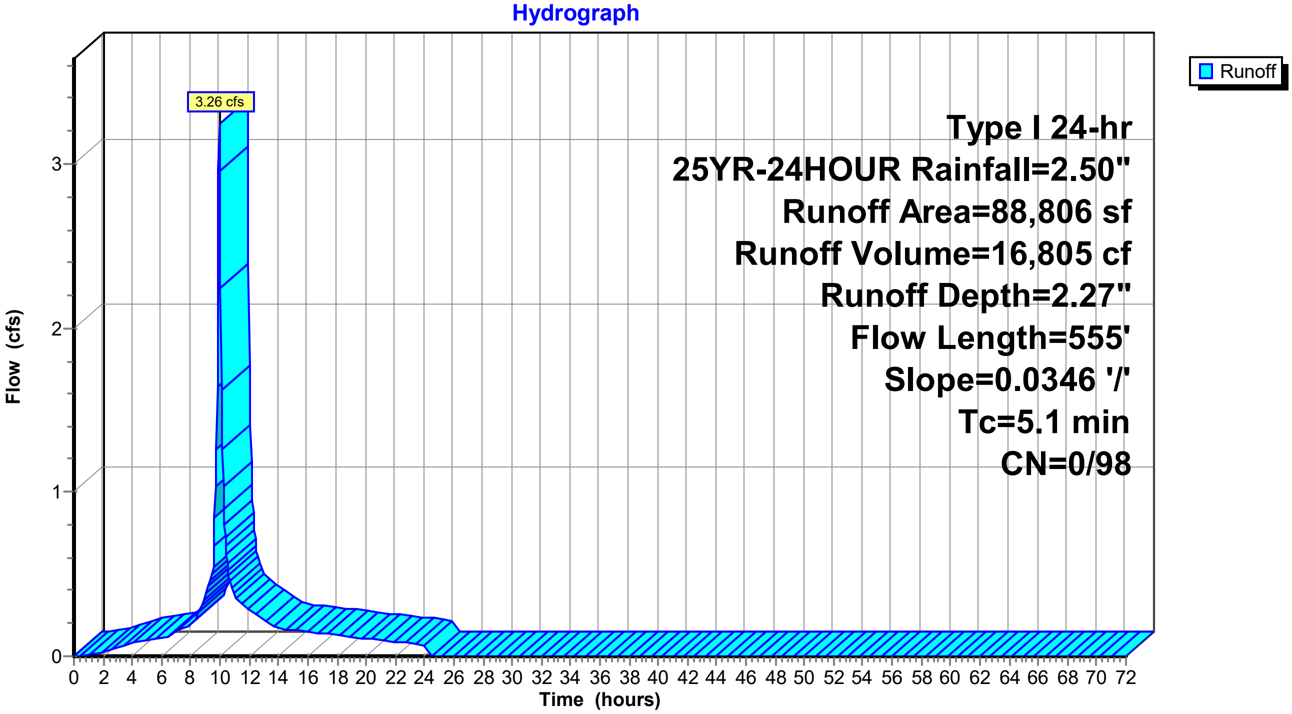
```
Runoff      =        3.26 cfs @    9.95 hrs,  Volume=           16,805 cf,  Depth=  2.27"
    Routed to nonexistent node DW-1A-B
```

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
88,806	98	Paved roads w/curbs & sewers, HSG A
88,806	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.1	555	0.0346	1.83		**Lag/CN Method,**

Subcatchment G14: GREENWOOD 14



Summary for Subcatchment G15: GREENWOOD 15

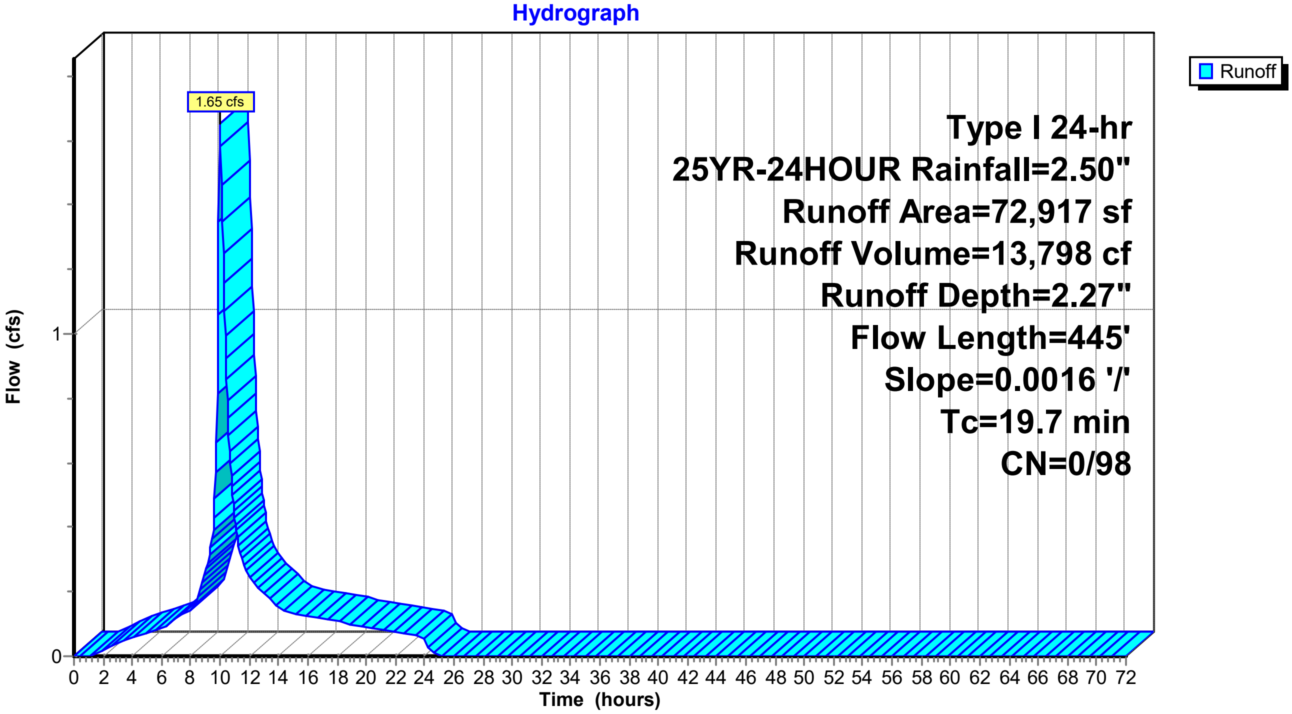
Runoff = 1.65 cfs @ 10.00 hrs, Volume= 13,798 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
72,917	98	Paved roads w/curbs & sewers, HSG A
72,917	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.7	445	0.0016	0.38		**Lag/CN Method,**

Subcatchment G15: GREENWOOD 15



Summary for Subcatchment G16: GREENWOOD 16

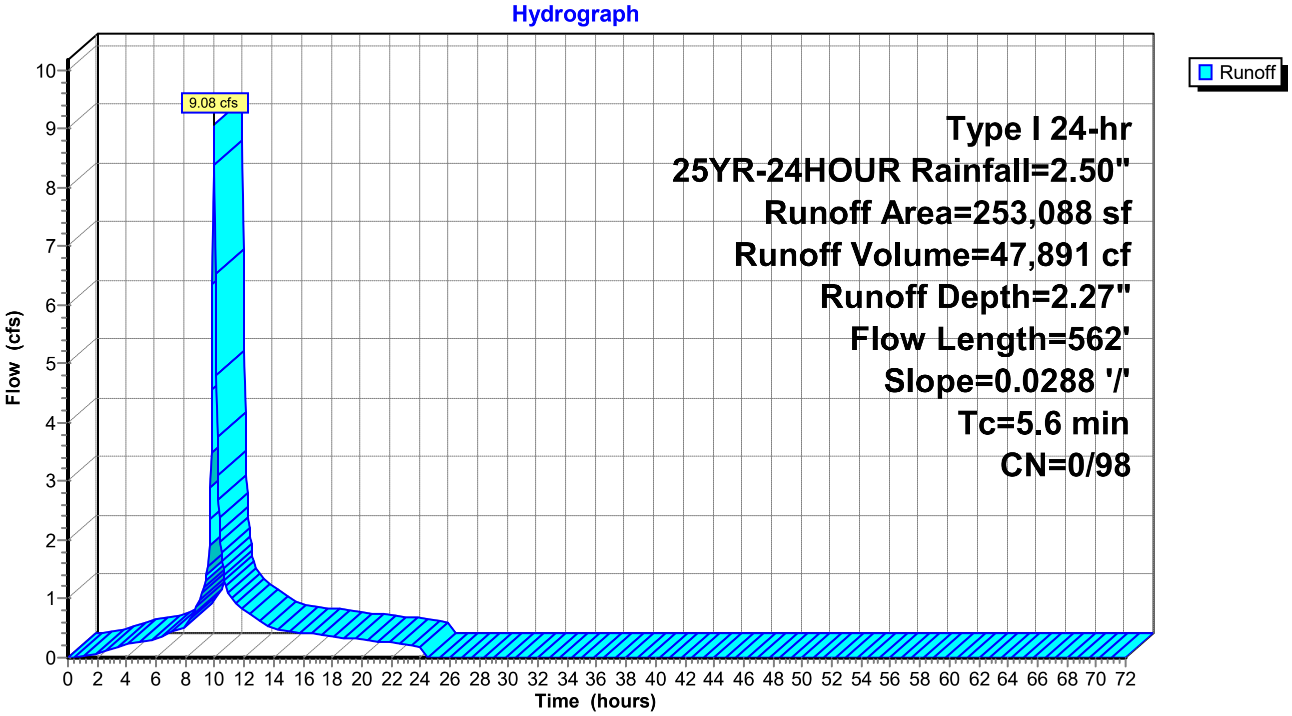
Runoff = 9.08 cfs @ 9.95 hrs, Volume= 47,891 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
253,088	98	Paved roads w/curbs & sewers, HSG A
253,088	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	562	0.0288	1.67		**Lag/CN Method,**

Subcatchment G16: GREENWOOD 16



Summary for Subcatchment G17: GREENWOOD 17

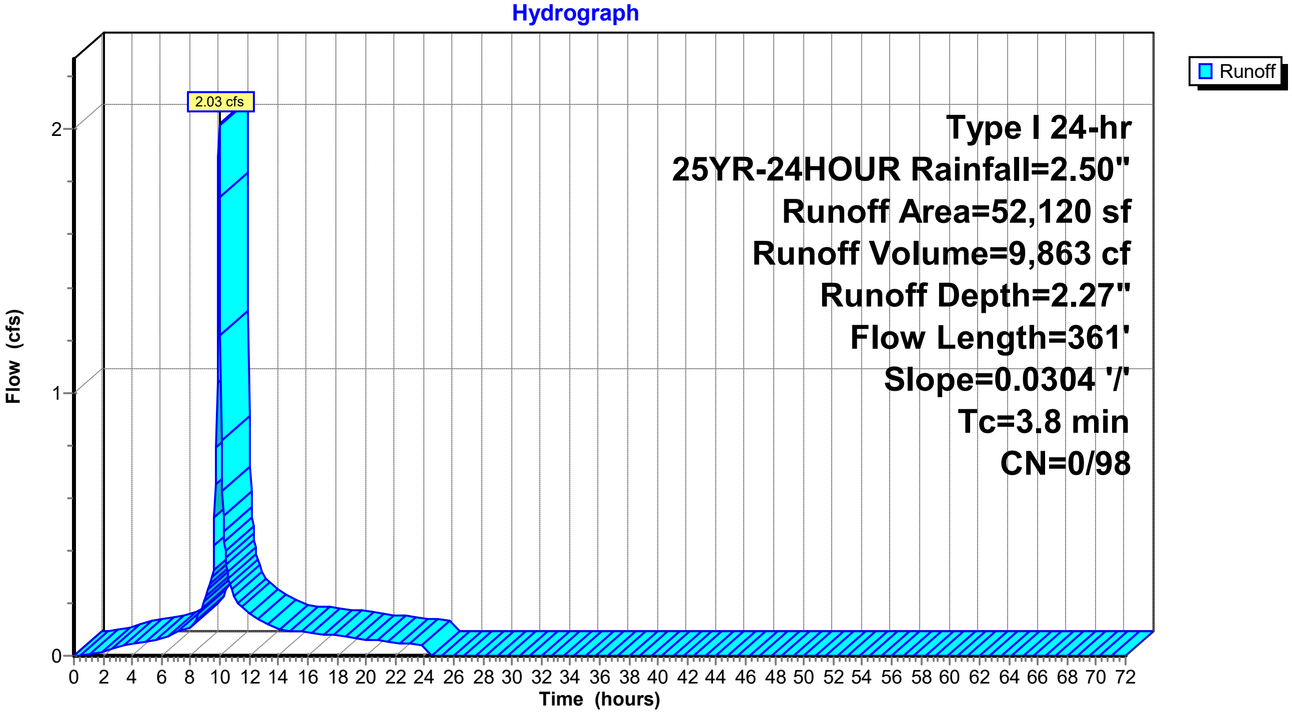
Runoff = 2.03 cfs @ 9.94 hrs, Volume= 9,863 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
52,120	98	Paved roads w/curbs & sewers, HSG A
52,120	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	361	0.0304	1.57		**Lag/CN Method,**

Subcatchment G17: GREENWOOD 17



Summary for Subcatchment G18: GREENWOOD 18

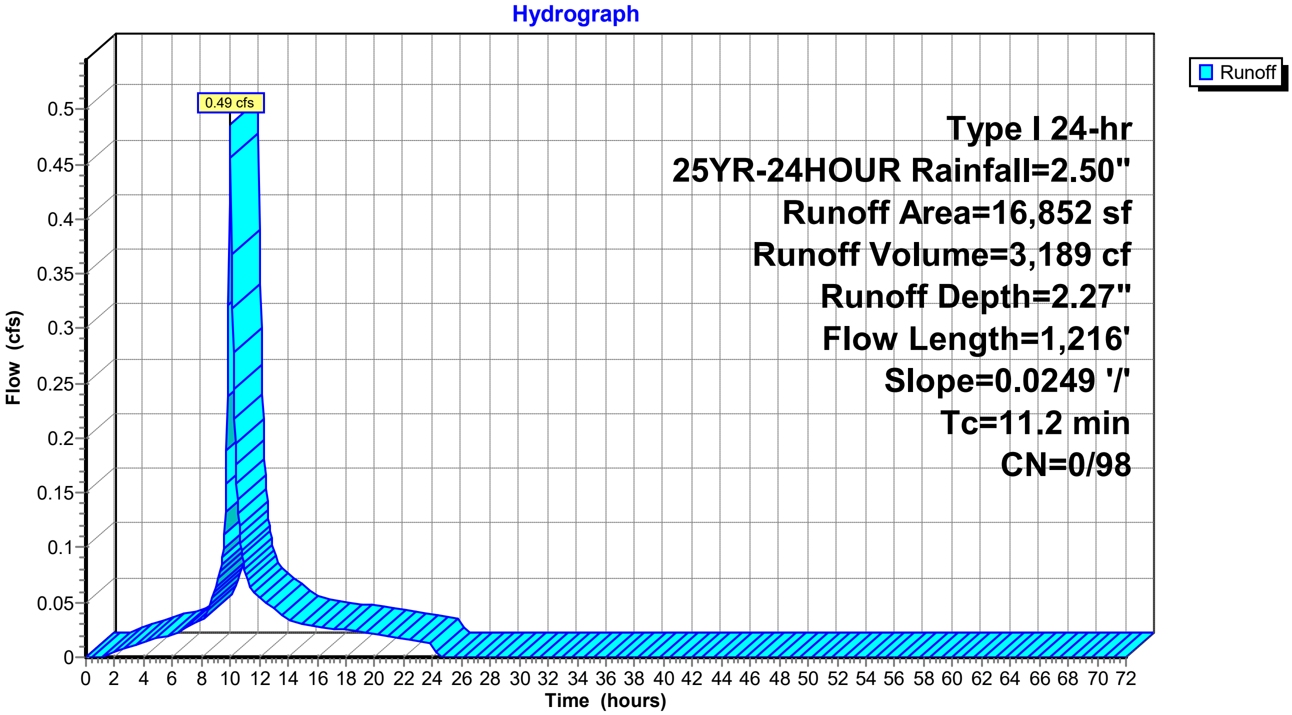
Runoff = 0.49 cfs @ 9.98 hrs, Volume= 3,189 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
16,852	98	Paved roads w/curbs & sewers, HSG A
16,852	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.2	1,216	0.0249	1.82		**Lag/CN Method,**

Subcatchment G18: GREENWOOD 18



Summary for Subcatchment G19: GREENWOOD 19

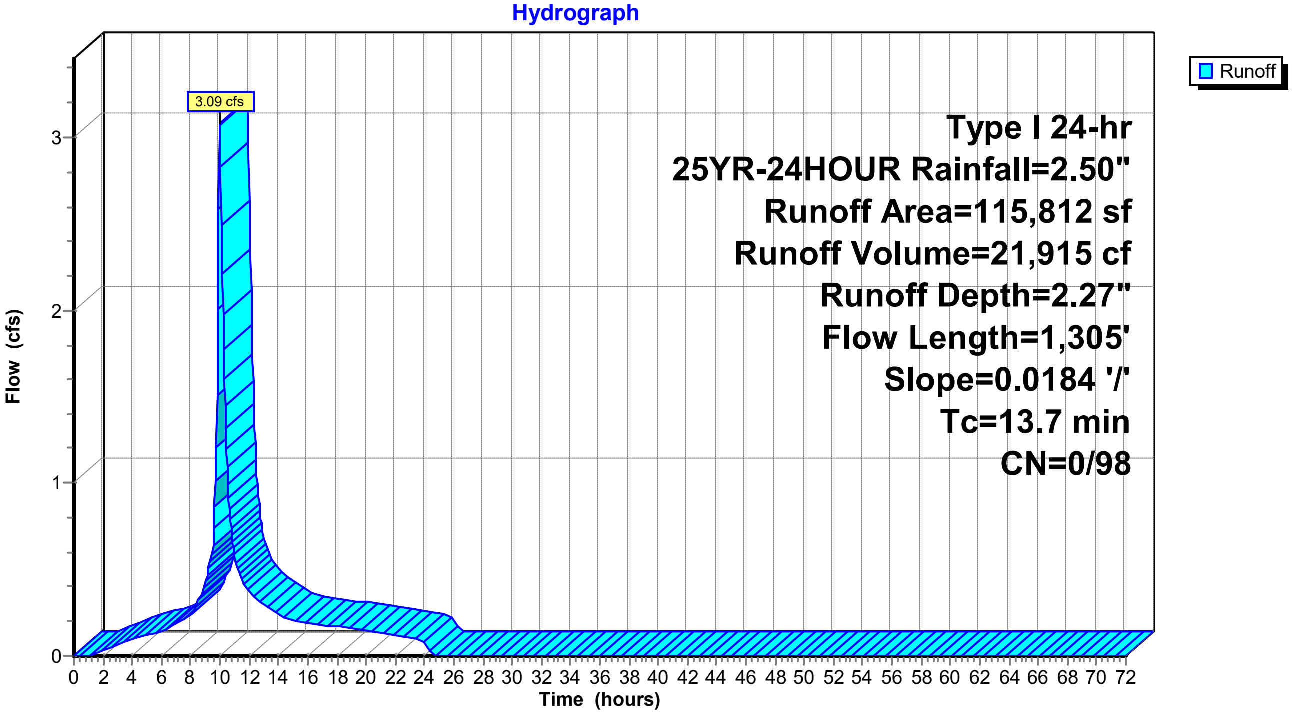
Runoff = 3.09 cfs @ 9.99 hrs, Volume= 21,915 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
115,812	98	Paved roads w/curbs & sewers, HSG A
115,812	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.7	1,305	0.0184	1.58		**Lag/CN Method,**

Subcatchment G19: GREENWOOD 19



Summary for Subcatchment G2: GREENWOOD 2

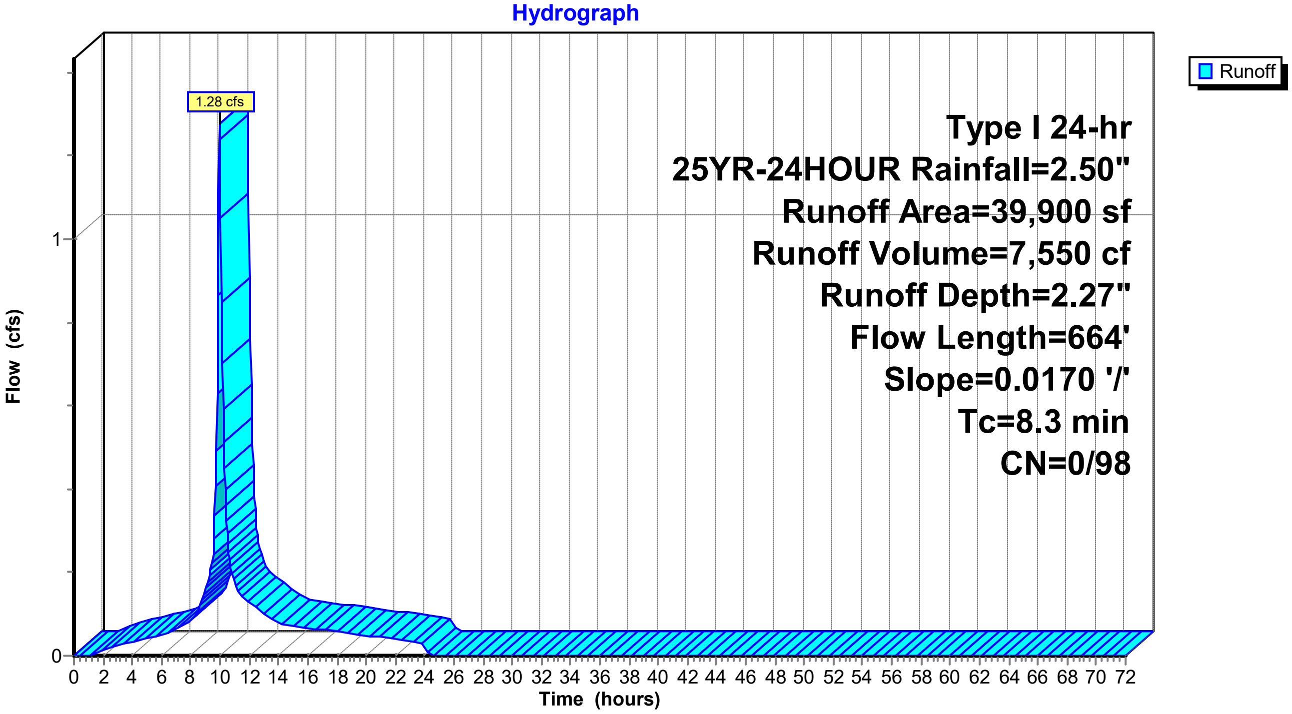
Runoff = 1.28 cfs @ 9.97 hrs, Volume= 7,550 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
39,900	98	Paved roads w/curbs & sewers, HSG A
39,900	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.3	664	0.0170	1.33		**Lag/CN Method,**

Subcatchment G2: GREENWOOD 2



Summary for Subcatchment G20: GREENWOOD 20

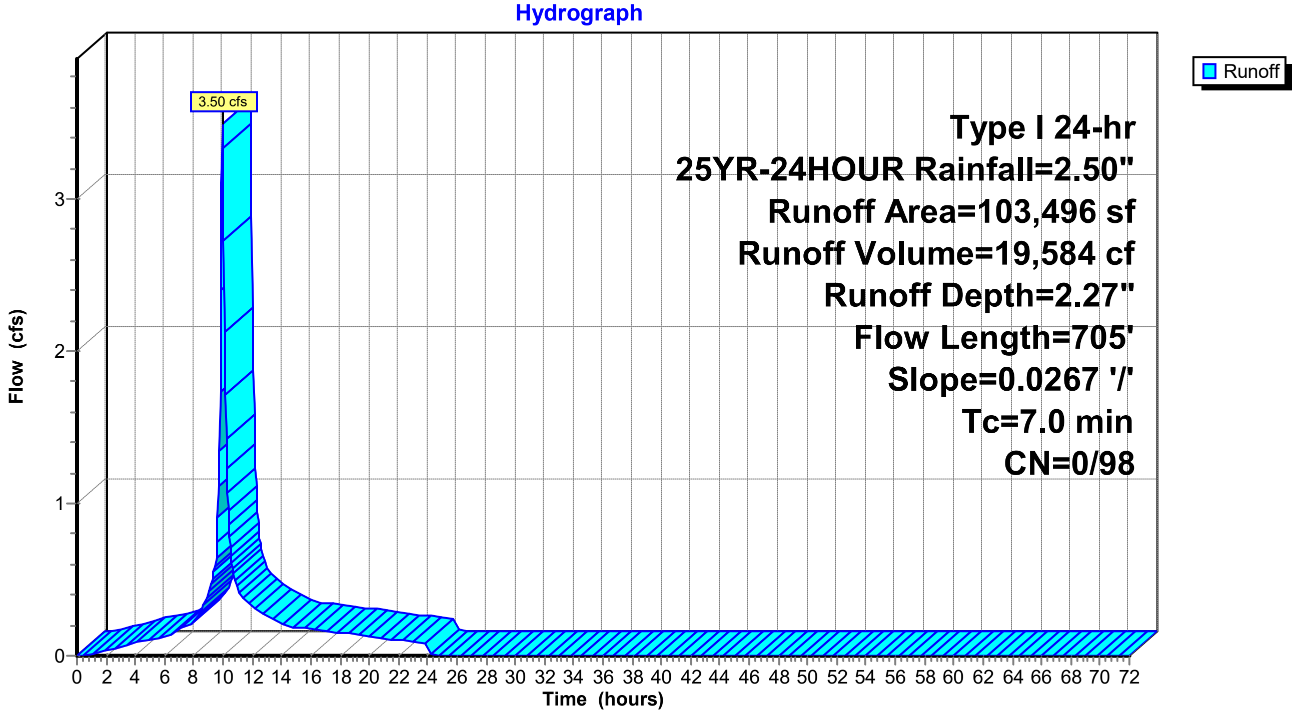
Runoff = 3.50 cfs @ 9.96 hrs, Volume= 19,584 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
103,496	98	Paved roads w/curbs & sewers, HSG A
103,496	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	705	0.0267	1.69		**Lag/CN Method,**

Subcatchment G20: GREENWOOD 20



Summary for Subcatchment G21: GREENWOOD 21

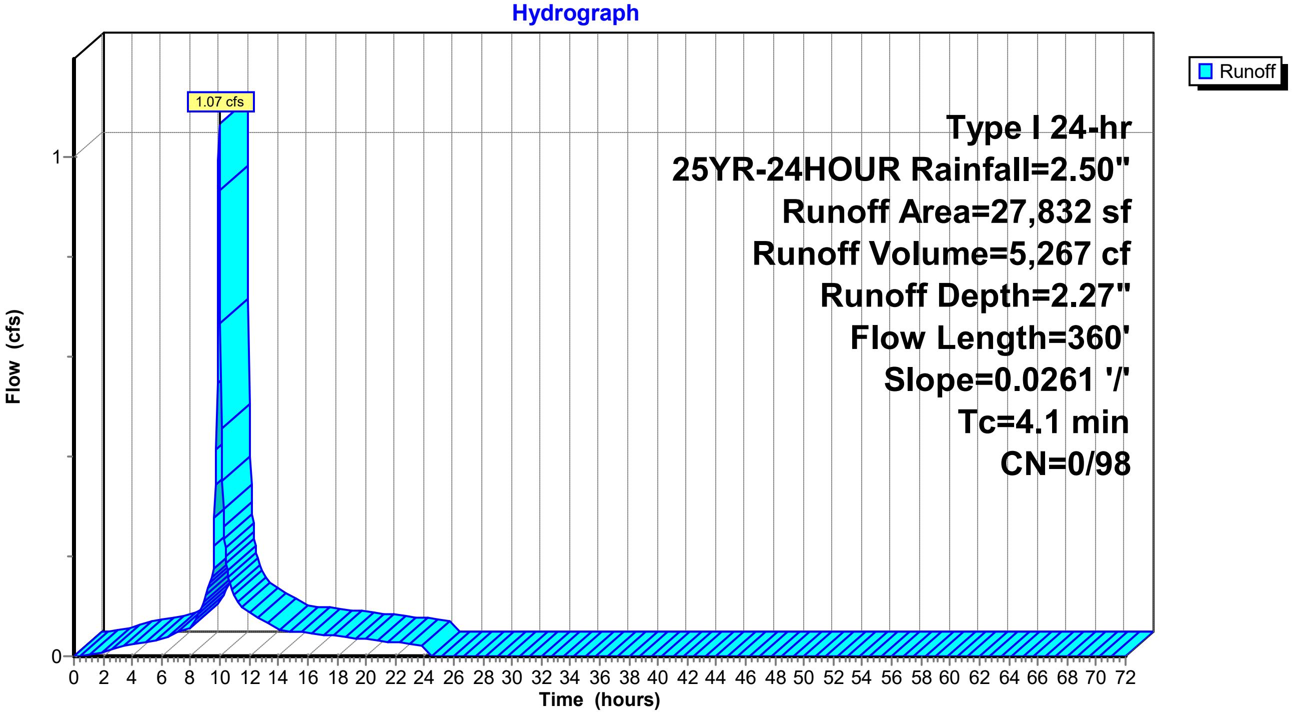
Runoff = 1.07 cfs @ 9.94 hrs, Volume= 5,267 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
27,832	98	Paved roads w/curbs & sewers, HSG A
27,832	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.1	360	0.0261	1.46		**Lag/CN Method,**

Subcatchment G21: GREENWOOD 21



Summary for Subcatchment G22: GREENWOOD 22

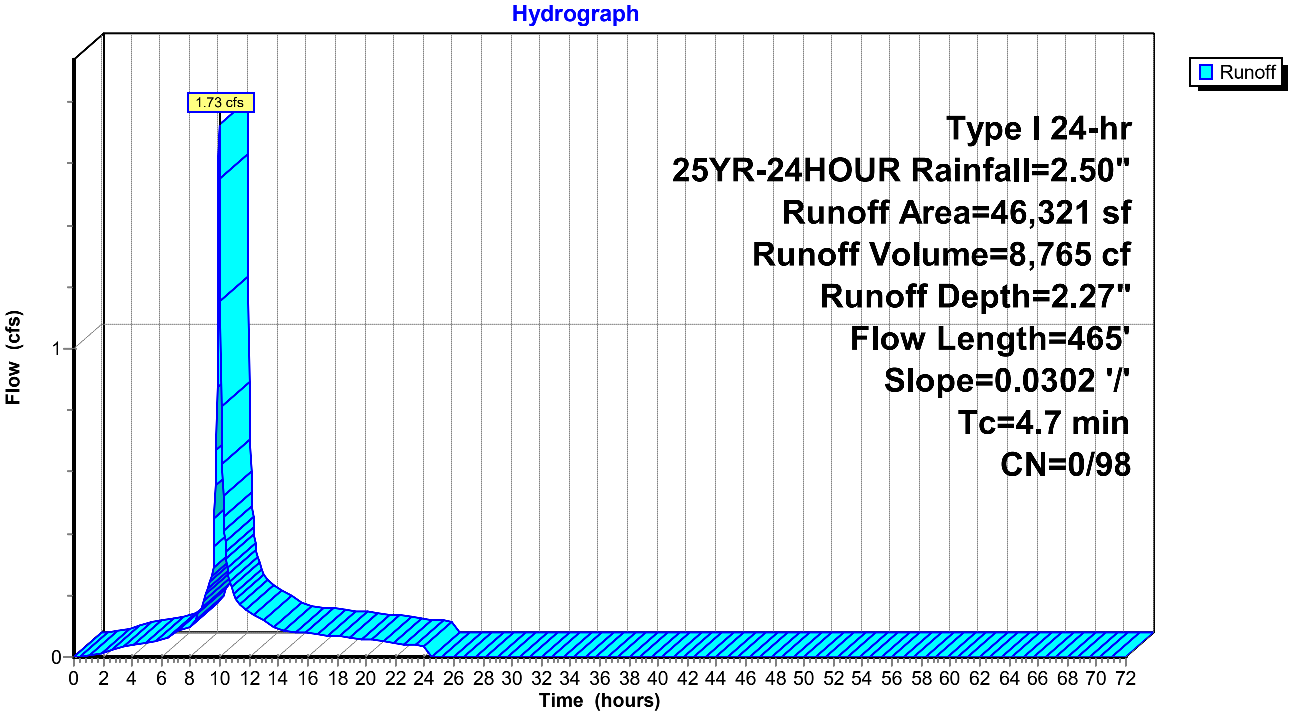
Runoff = 1.73 cfs @ 9.95 hrs, Volume= 8,765 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
46,321	98	Paved roads w/curbs & sewers, HSG A
46,321	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.7	465	0.0302	1.65		**Lag/CN Method,**

Subcatchment G22: GREENWOOD 22



Summary for Subcatchment G23: GREENWOOD 23

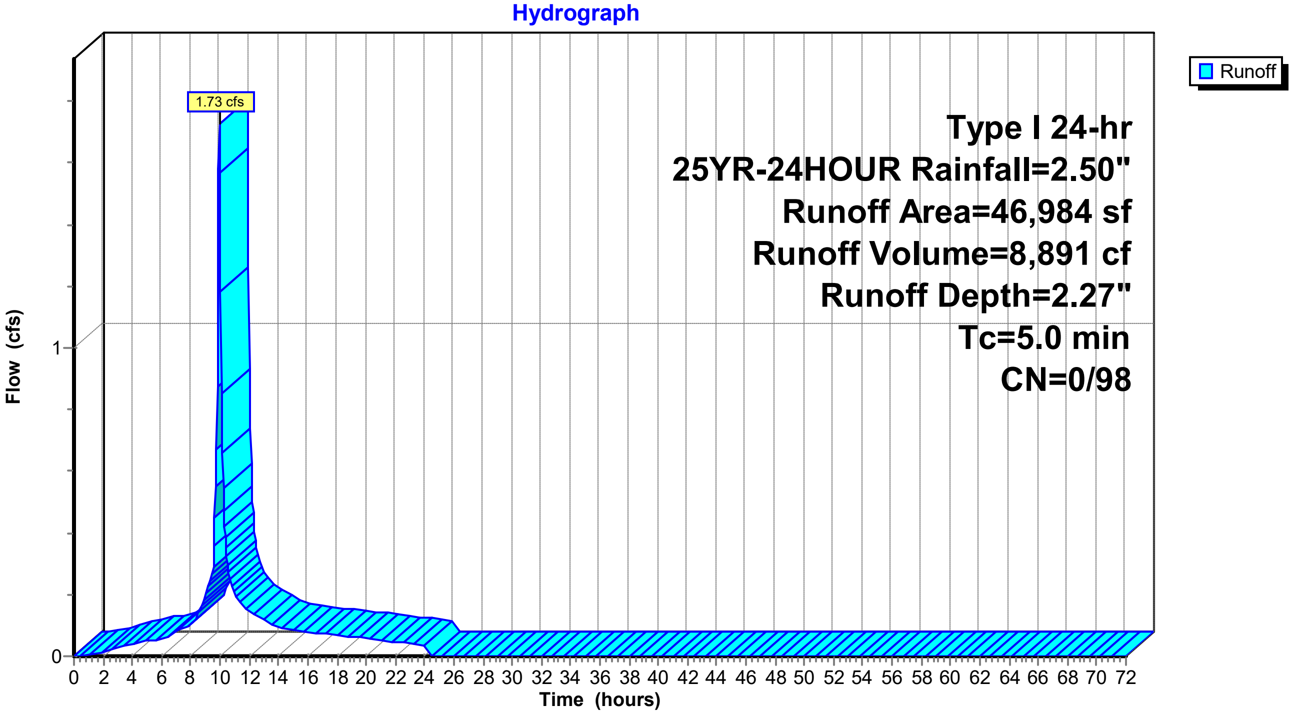
Runoff = 1.73 cfs @ 9.95 hrs, Volume= 8,891 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
46,984	98	Paved roads w/curbs & sewers, HSG A
46,984	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment G23: GREENWOOD 23



Summary for Subcatchment G24: GREENWOOD 24

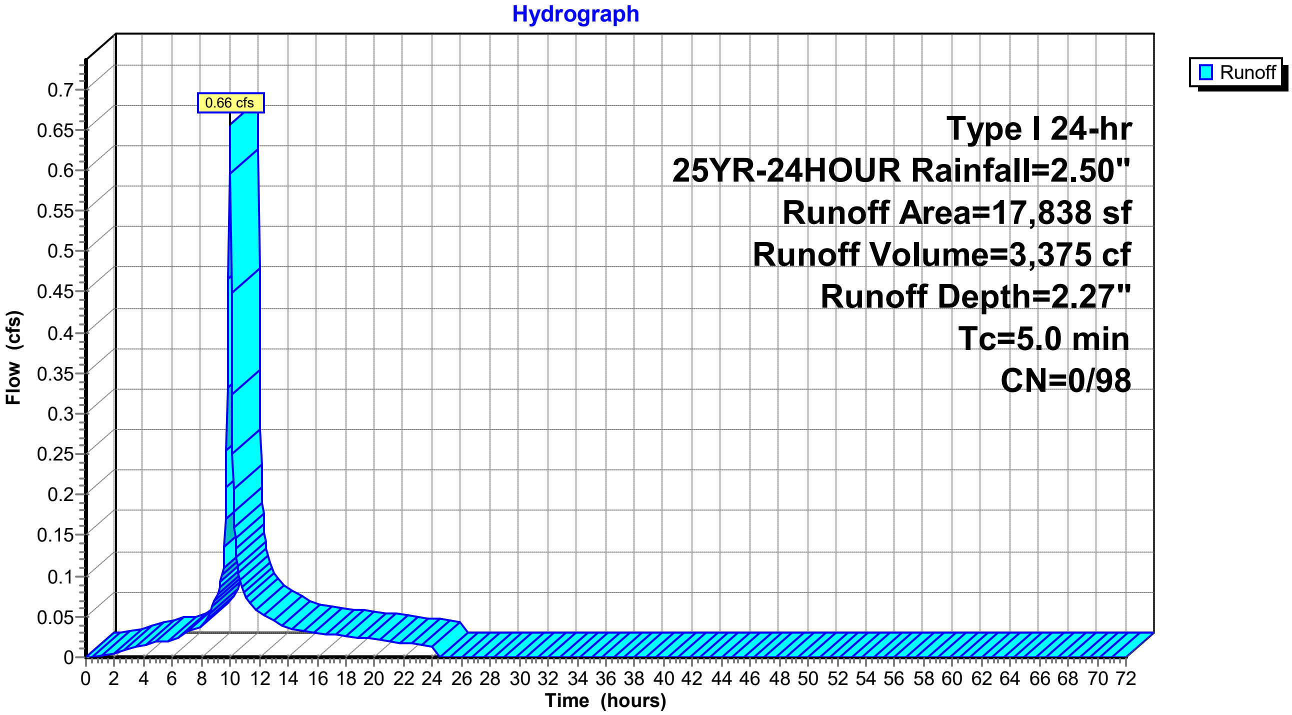
Runoff = 0.66 cfs @ 9.95 hrs, Volume= 3,375 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
17,838	98	Paved roads w/curbs & sewers, HSG A
17,838	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment G24: GREENWOOD 24



Summary for Subcatchment G25: GREENWOOD 25

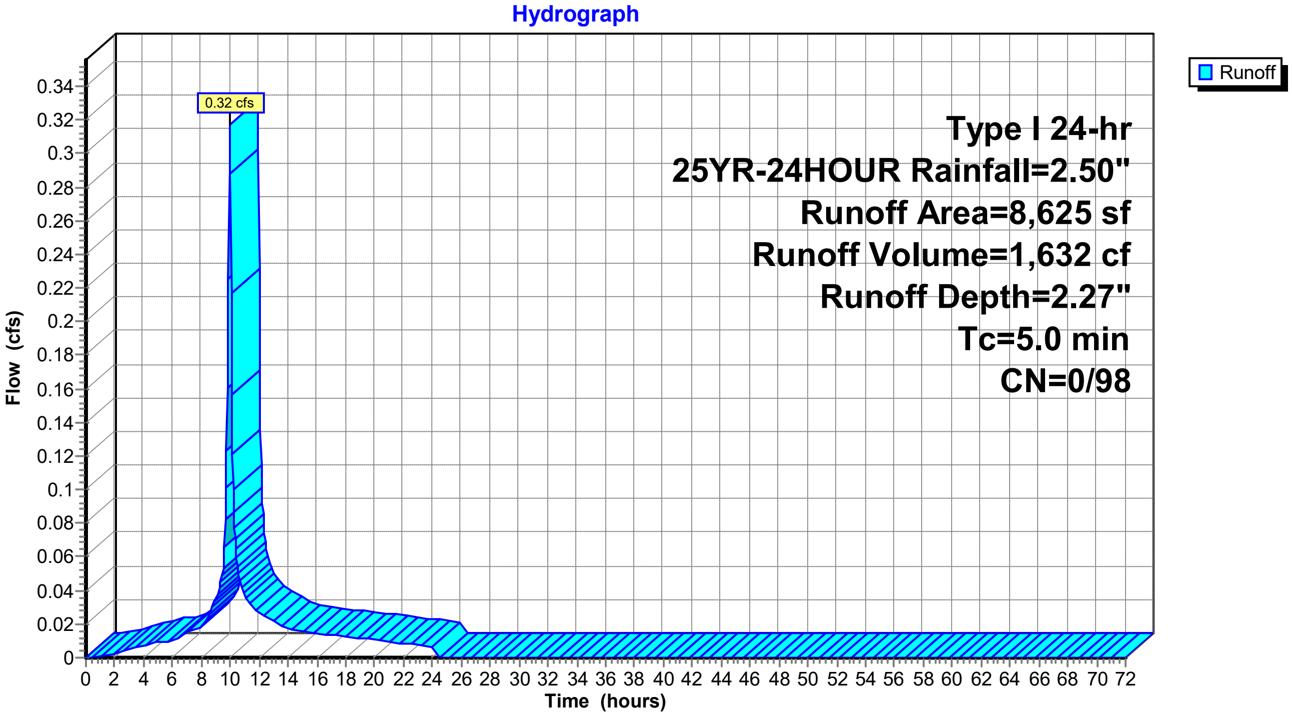
Runoff = 0.32 cfs @ 9.95 hrs, Volume= 1,632 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
8,625	98	Paved roads w/curbs & sewers, HSG A
8,625	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment G25: GREENWOOD 25



Summary for Subcatchment G26: GREENWOOD 26

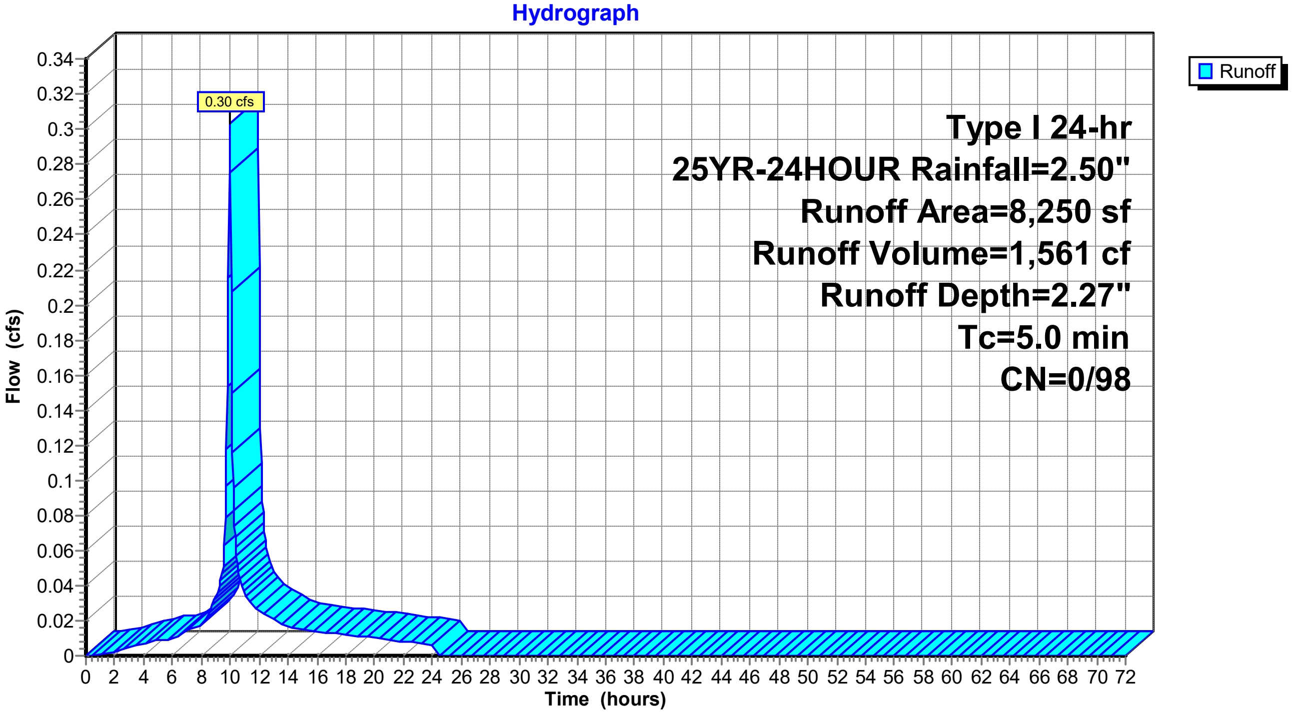
Runoff = 0.30 cfs @ 9.95 hrs, Volume= 1,561 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
8,250	98	Paved roads w/curbs & sewers, HSG A
8,250	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment G26: GREENWOOD 26



Summary for Subcatchment G27: GREENWOOD 27

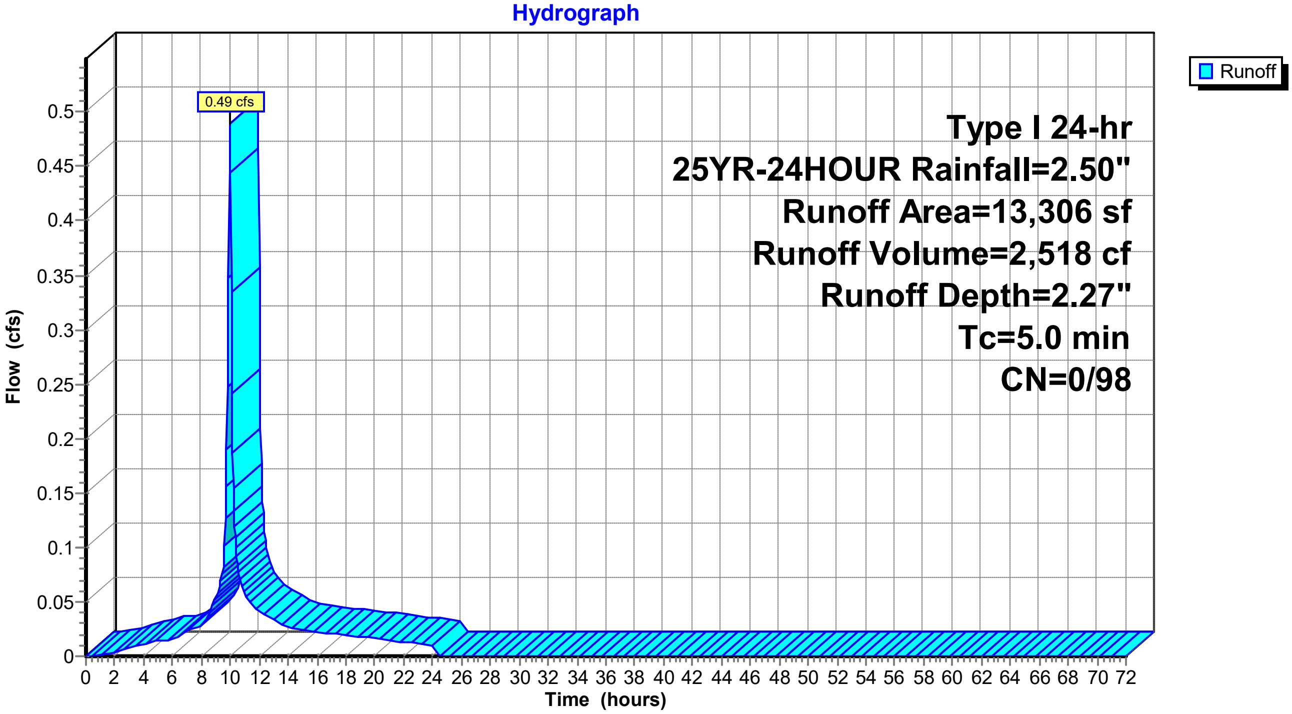
Runoff = 0.49 cfs @ 9.95 hrs, Volume= 2,518 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
13,306	98	Paved roads w/curbs & sewers, HSG A
13,306	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment G27: GREENWOOD 27



Summary for Subcatchment G28: GREENWOOD 28

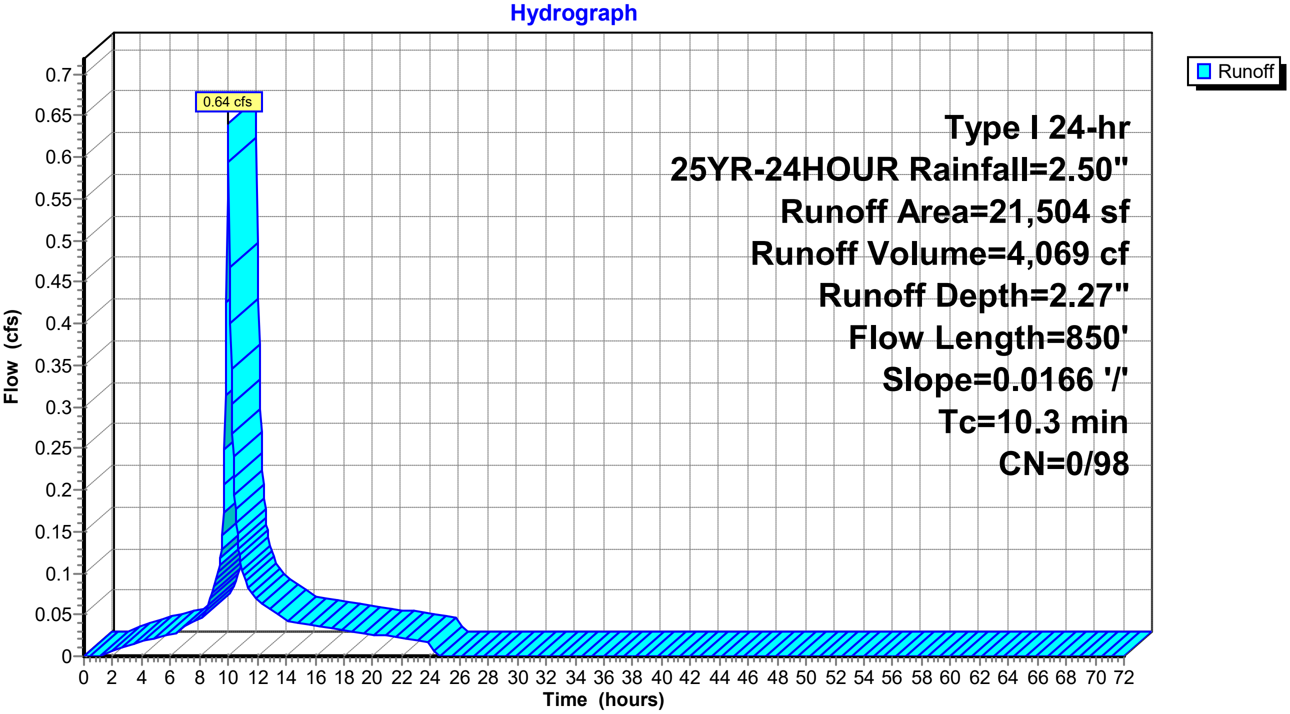
```
Runoff      =       0.64 cfs @    9.97 hrs,  Volume=            4,069 cf,  Depth=  2.27"
    Routed to nonexistent node DW-1A-B
```

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
21,504	98	Paved roads w/curbs & sewers, HSG A
21,504	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.3	850	0.0166	1.38		**Lag/CN Method,**

Subcatchment G28: GREENWOOD 28



Summary for Subcatchment G29: GREENWOOD 29

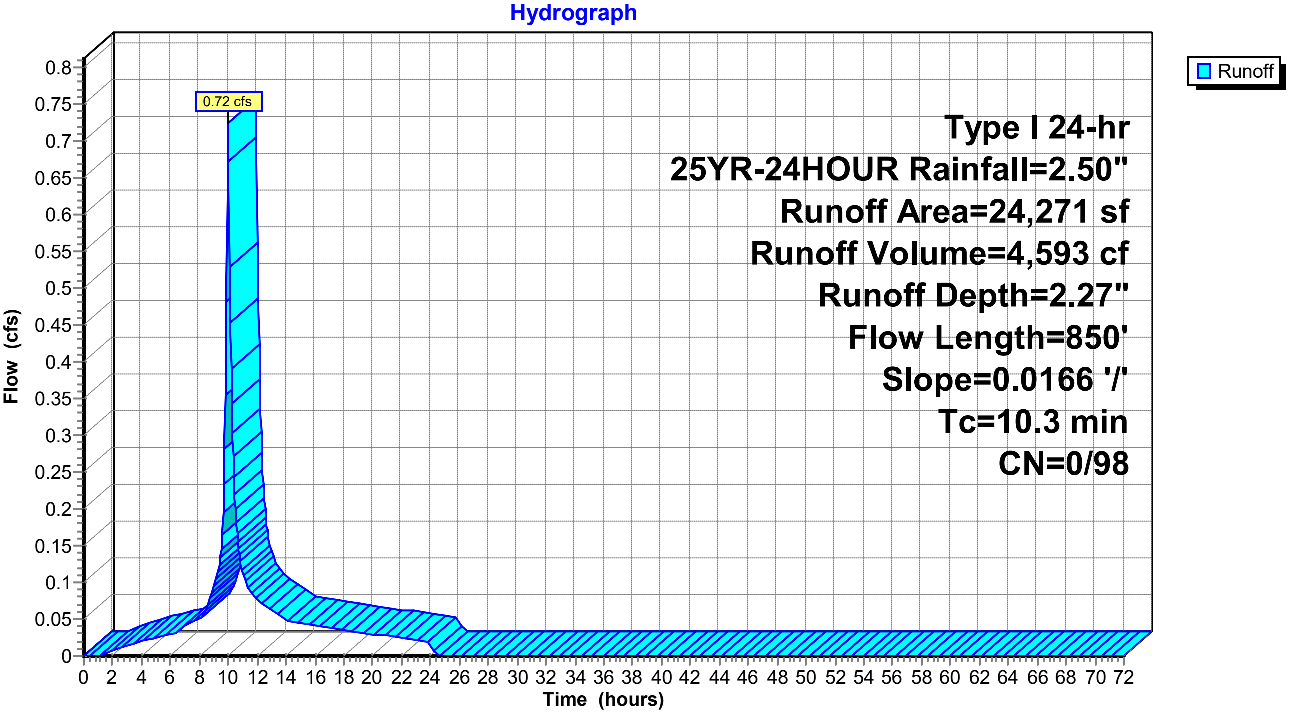
```
Runoff      =      0.72 cfs @   9.97 hrs,  Volume=        4,593 cf,  Depth=  2.27"
    Routed to nonexistent node DW-1A-B
```

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
24,271	98	Paved roads w/curbs & sewers, HSG A
24,271	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.3	850	0.0166	1.38		**Lag/CN Method,**

Subcatchment G29: GREENWOOD 29



Summary for Subcatchment G3: GREENWOOD 3

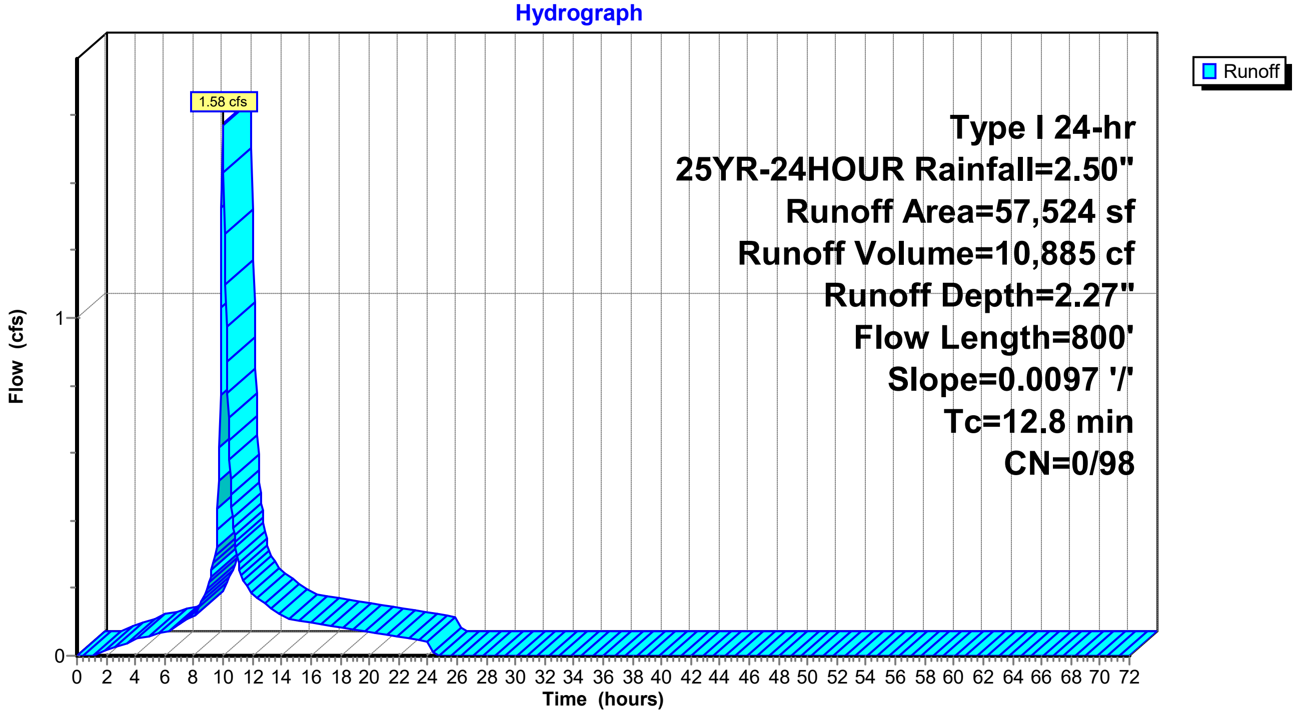
Runoff = 1.58 cfs @ 9.98 hrs, Volume= 10,885 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
57,524	98	Paved roads w/curbs & sewers, HSG A
57,524	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.8	800	0.0097	1.04		**Lag/CN Method,**

Subcatchment G3: GREENWOOD 3



Summary for Subcatchment G30: GREENWOOD 30

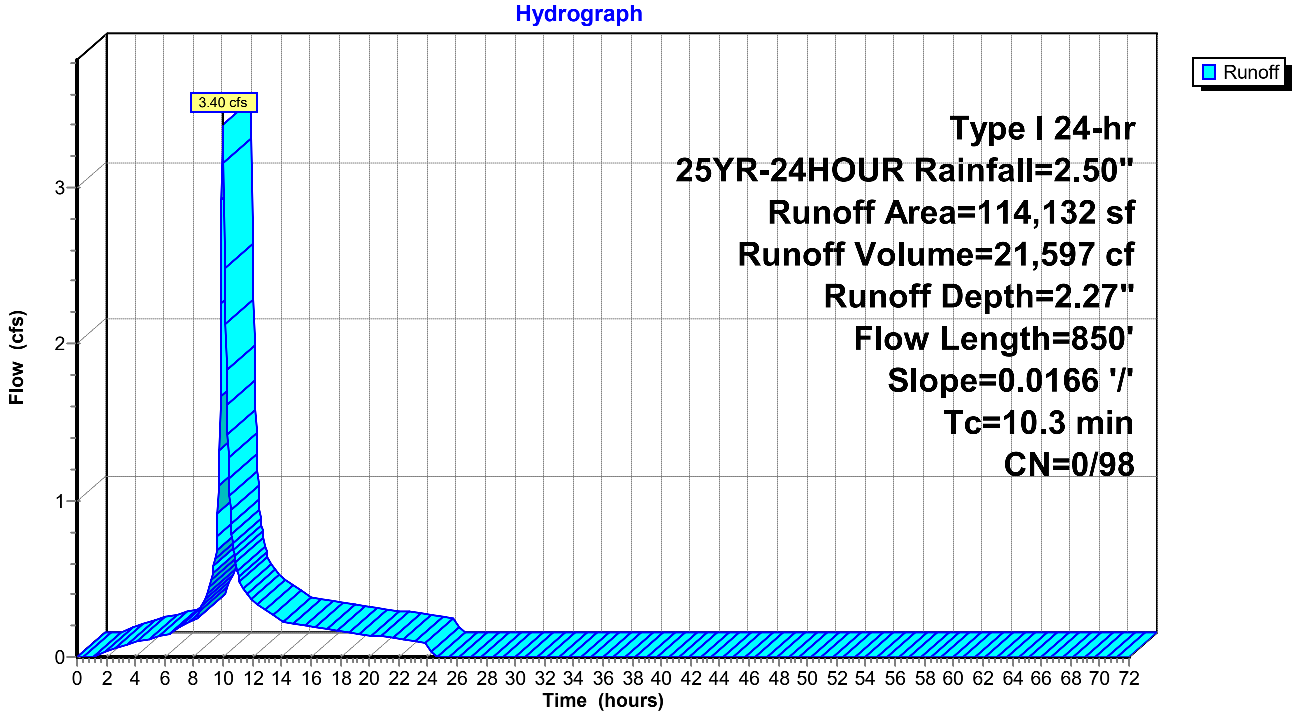
Runoff = 3.40 cfs @ 9.97 hrs, Volume= 21,597 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
114,132	98	Paved roads w/curbs & sewers, HSG A
114,132	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.3	850	0.0166	1.38		**Lag/CN Method,**

Subcatchment G30: GREENWOOD 30



Summary for Subcatchment G4: GREENWOOD 4

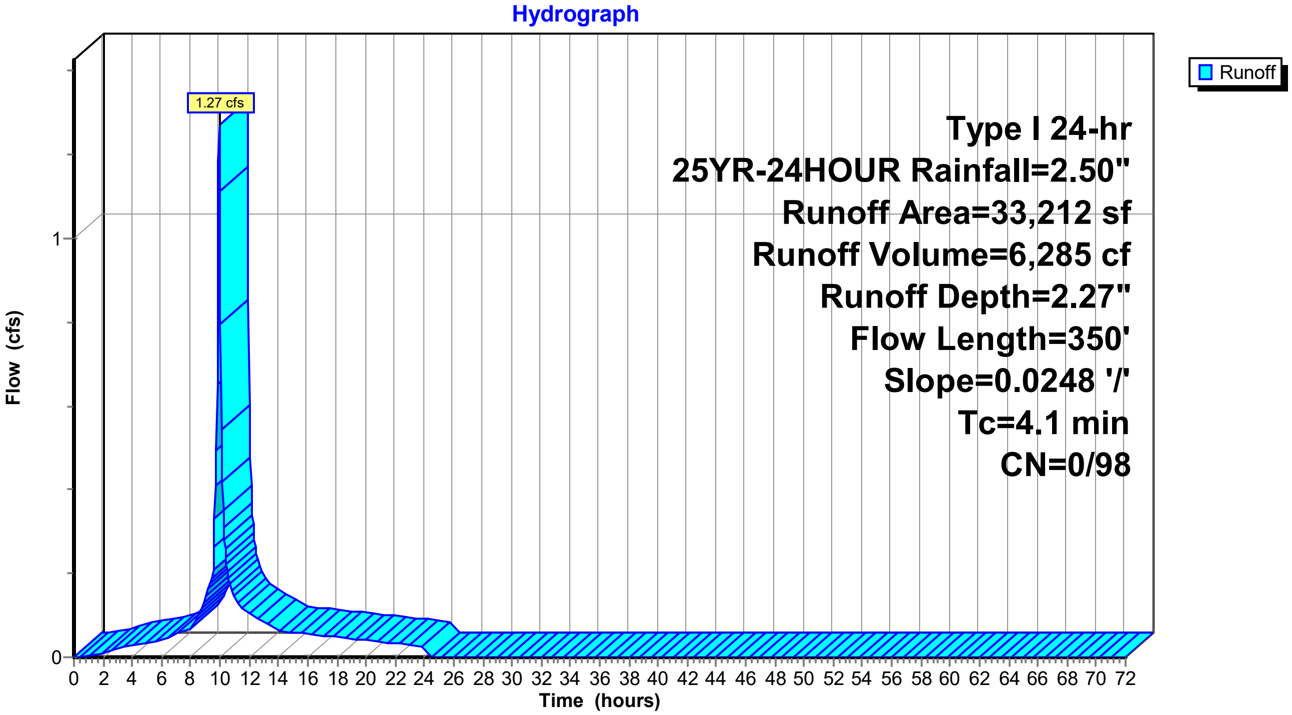
Runoff = 1.27 cfs @ 9.94 hrs, Volume= 6,285 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
33,212	98	Paved roads w/curbs & sewers, HSG A
33,212	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.1	350	0.0248	1.41		**Lag/CN Method,**

Subcatchment G4: GREENWOOD 4



Summary for Subcatchment G5: GREENWOOD 5

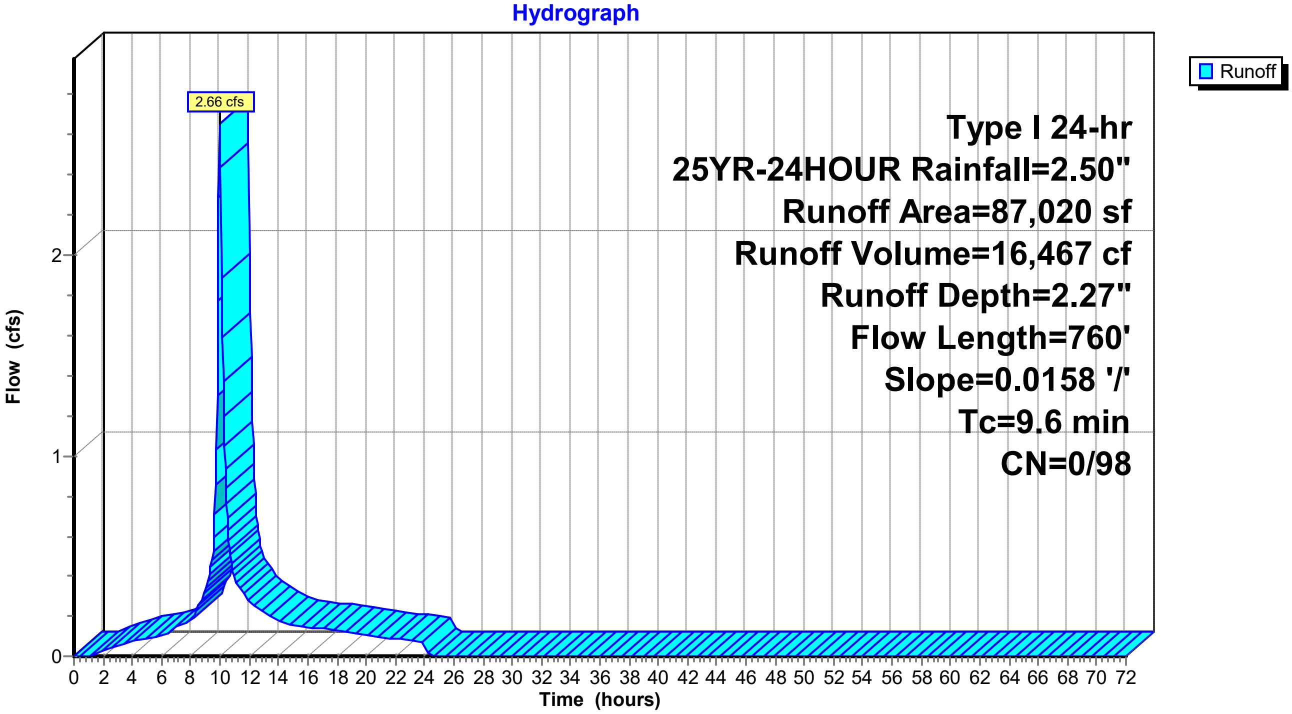
Runoff = 2.66 cfs @ 9.97 hrs, Volume= 16,467 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
87,020	98	Paved roads w/curbs & sewers, HSG A
87,020	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.6	760	0.0158	1.32		**Lag/CN Method,**

Subcatchment G5: GREENWOOD 5



Summary for Subcatchment G6: GREENWOOD 6

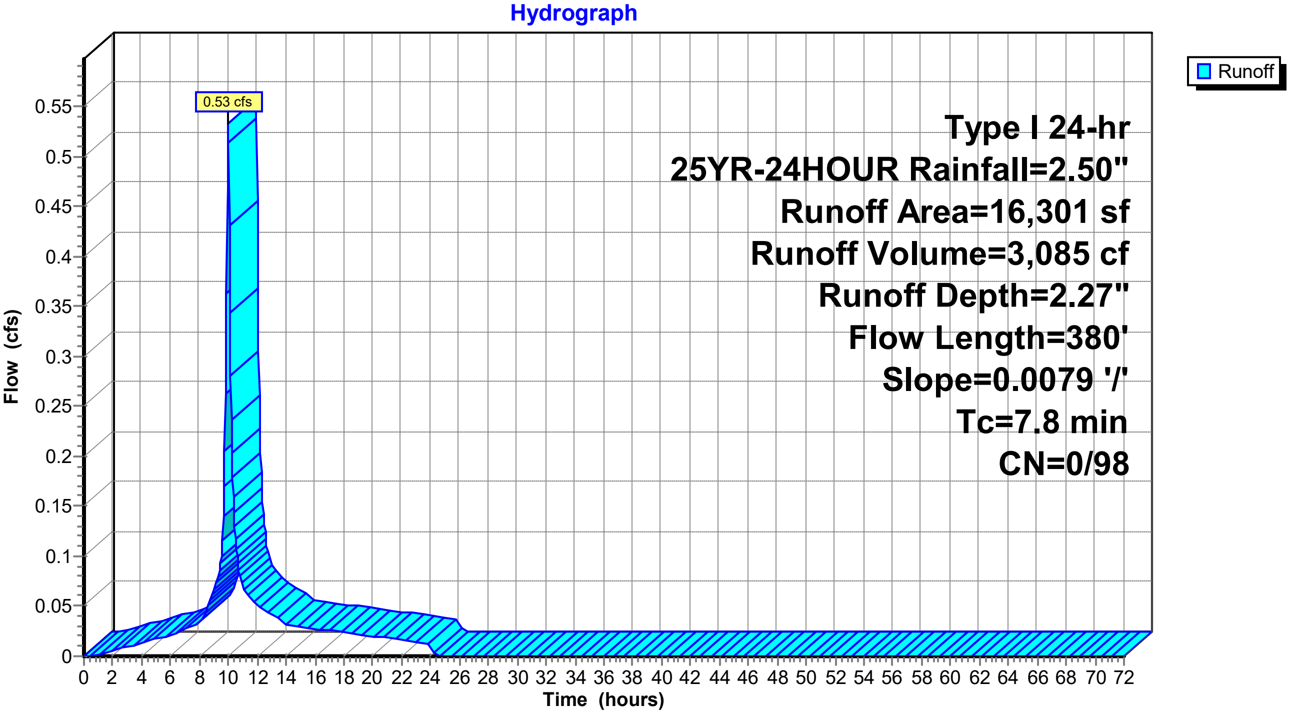
Runoff = 0.53 cfs @ 9.96 hrs, Volume= 3,085 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
16,301	98	Paved roads w/curbs & sewers, HSG A
16,301	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.8	380	0.0079	0.81		**Lag/CN Method,**

Subcatchment G6: GREENWOOD 6



Summary for Subcatchment G7: GREENWOOD 7

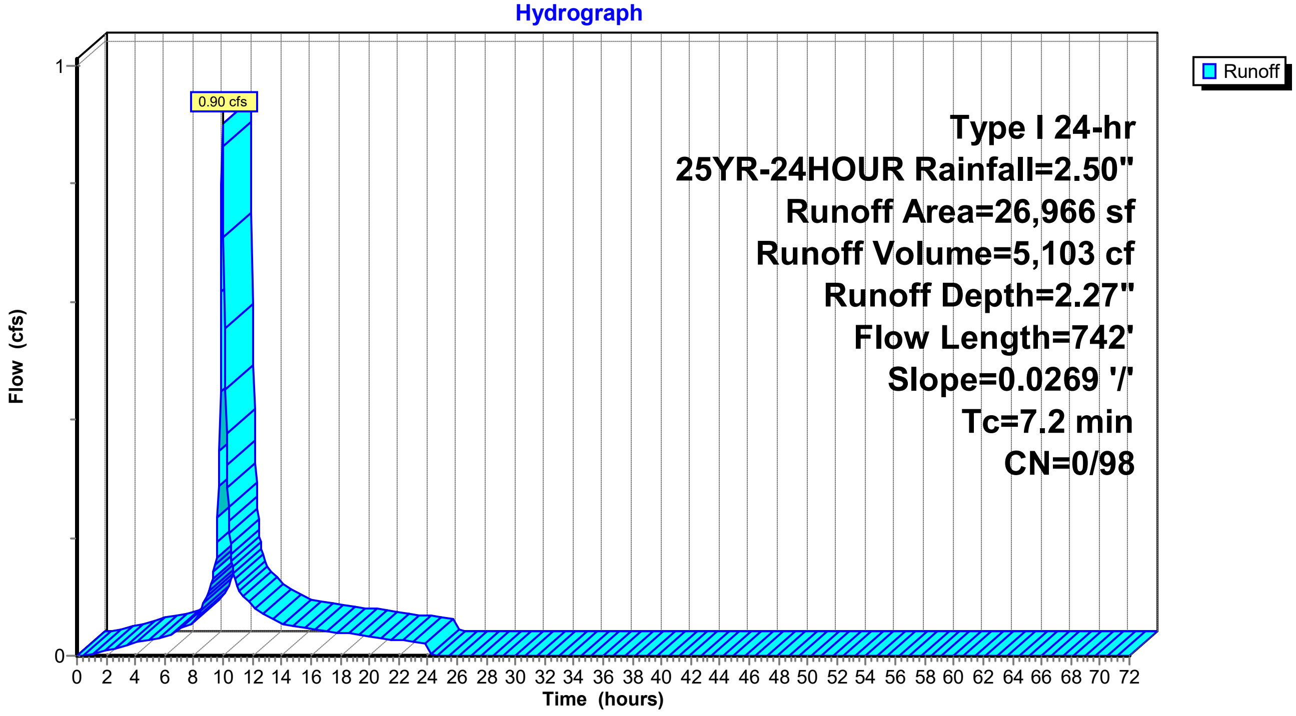
Runoff = 0.90 cfs @ 9.96 hrs, Volume= 5,103 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
26,966	98	Paved roads w/curbs & sewers, HSG A
26,966	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.2	742	0.0269	1.71		**Lag/CN Method,**

Subcatchment G7: GREENWOOD 7



Summary for Subcatchment G8: GREENWOOD 8

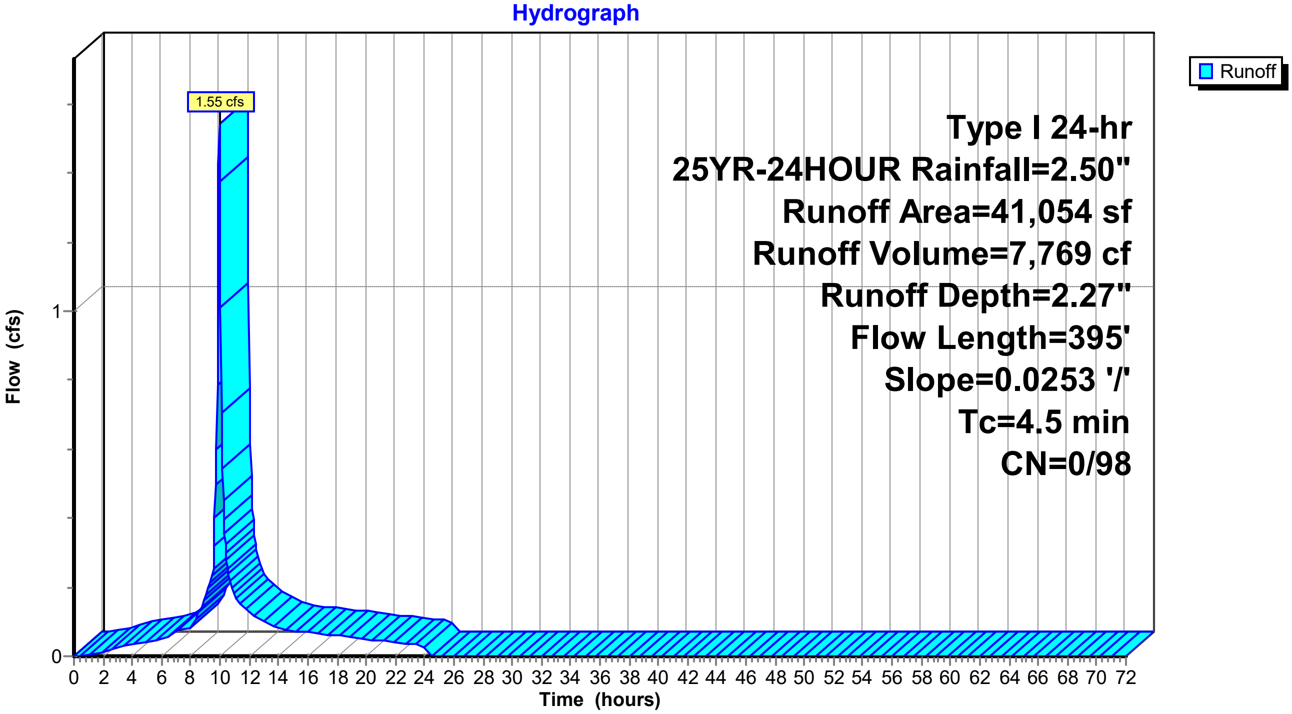
Runoff = 1.55 cfs @ 9.95 hrs, Volume= 7,769 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
41,054	98	Paved roads w/curbs & sewers, HSG A
41,054	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.5	395	0.0253	1.46		**Lag/CN Method,**

Subcatchment G8: GREENWOOD 8



Summary for Subcatchment G9: GREENWOOD 9

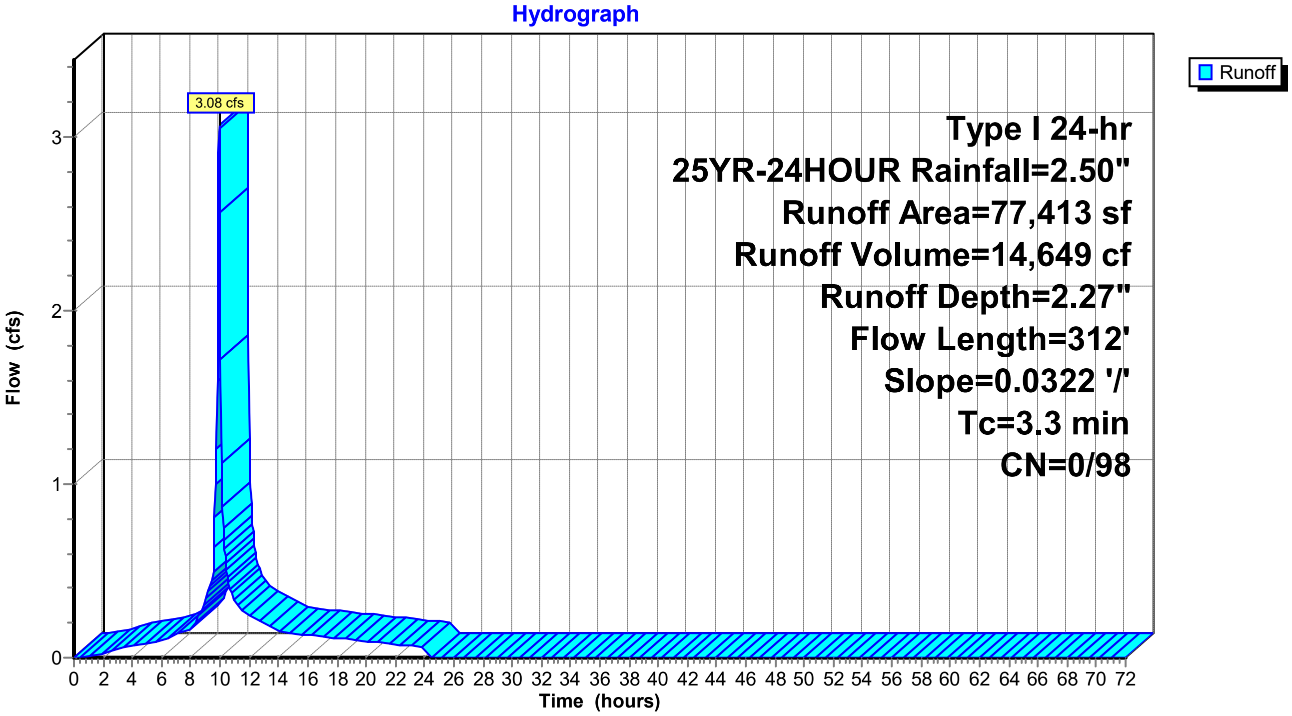
Runoff = 3.08 cfs @ 9.94 hrs, Volume= 14,649 cf, Depth= 2.27"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

Area (sf)	CN	Description
77,413	98	Paved roads w/curbs & sewers, HSG A
77,413	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.3	312	0.0322	1.57		**Lag/CN Method,**

Subcatchment G9: GREENWOOD 9



Summary for Subcatchment F1: FRANKLIN 1

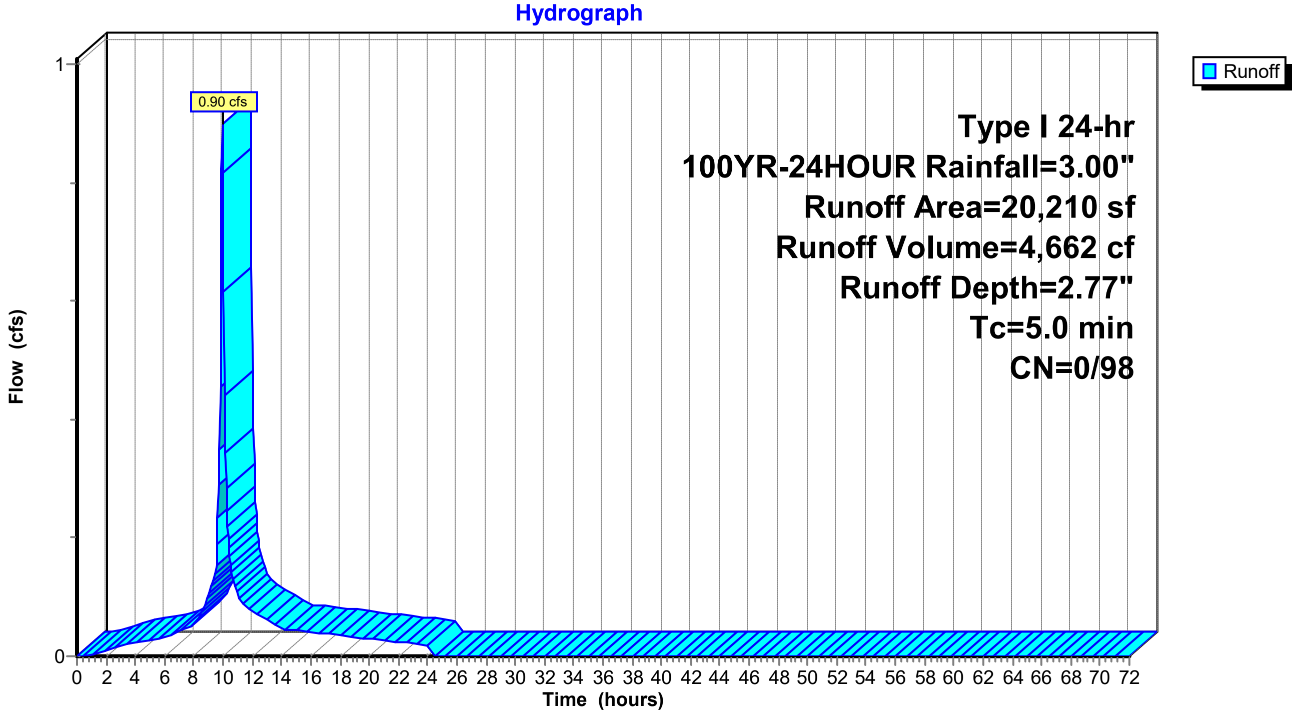
Runoff = 0.90 cfs @ 9.95 hrs, Volume= 4,662 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
20,210	98	Paved roads w/curbs & sewers, HSG A
20,210	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment F1: FRANKLIN 1



Summary for Subcatchment F2: FRANKLIN 2

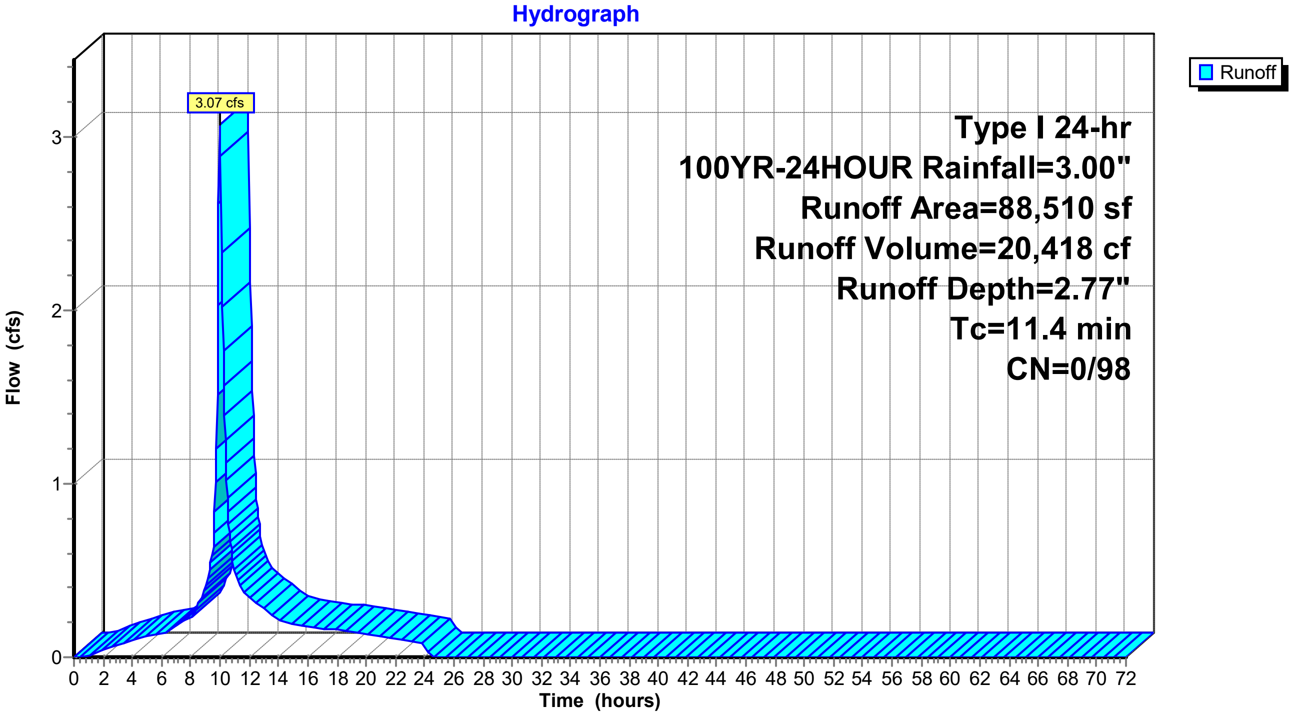
Runoff = 3.07 cfs @ 9.98 hrs, Volume= 20,418 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
88,510	98	Paved roads w/curbs & sewers, HSG A
88,510	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.4					**Direct Entry,**

Subcatchment F2: FRANKLIN 2



Summary for Subcatchment F3: FRANKLIN 3

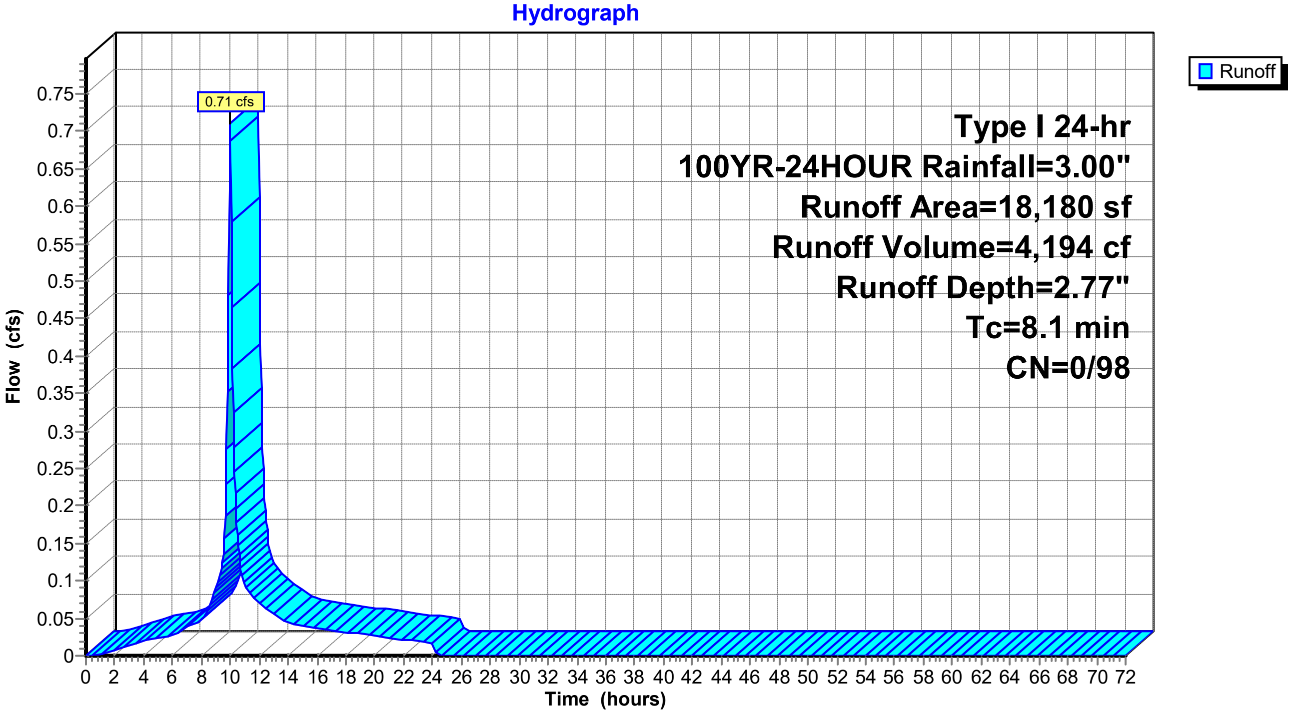
Runoff = 0.71 cfs @ 9.97 hrs, Volume= 4,194 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
18,180	98	Paved roads w/curbs & sewers, HSG A
18,180	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.1					**Direct Entry,**

Subcatchment F3: FRANKLIN 3



Summary for Subcatchment F4: FRANKLIN 4

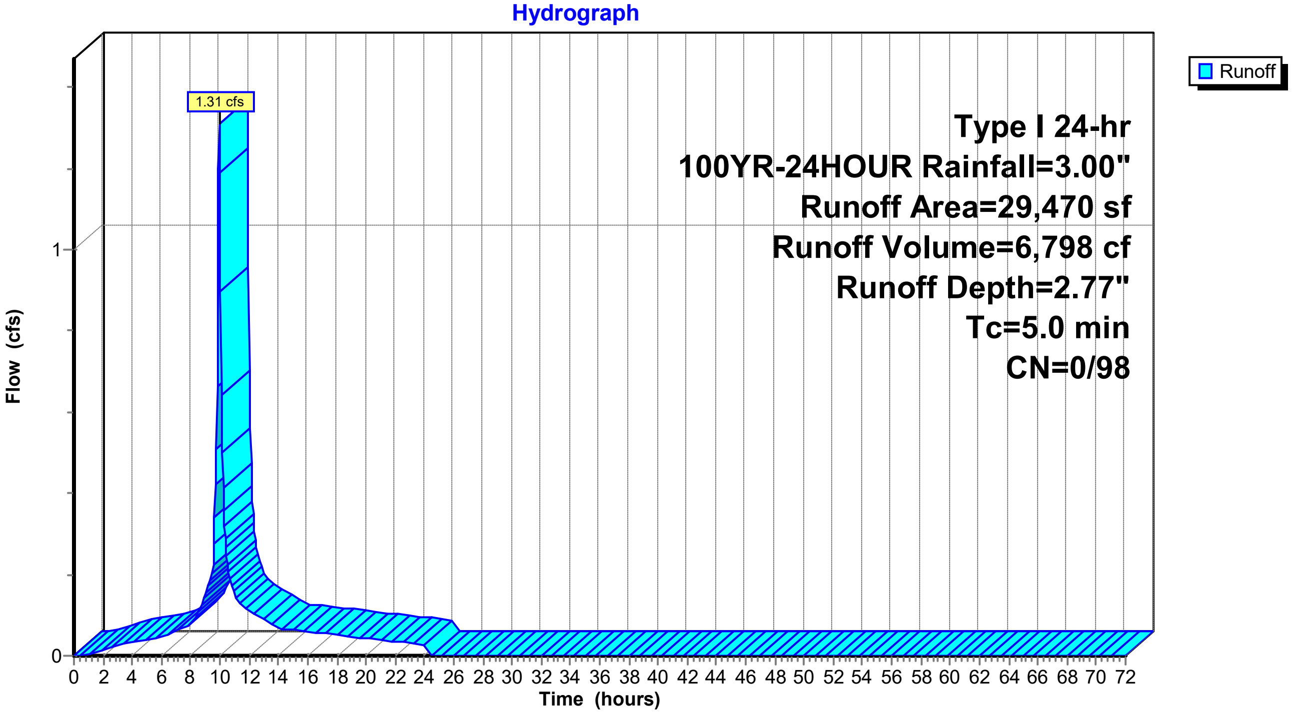
Runoff = 1.31 cfs @ 9.95 hrs, Volume= 6,798 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
29,470	98	Paved roads w/curbs & sewers, HSG A
29,470	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment F4: FRANKLIN 4



Summary for Subcatchment F5: FRANKLIN 5

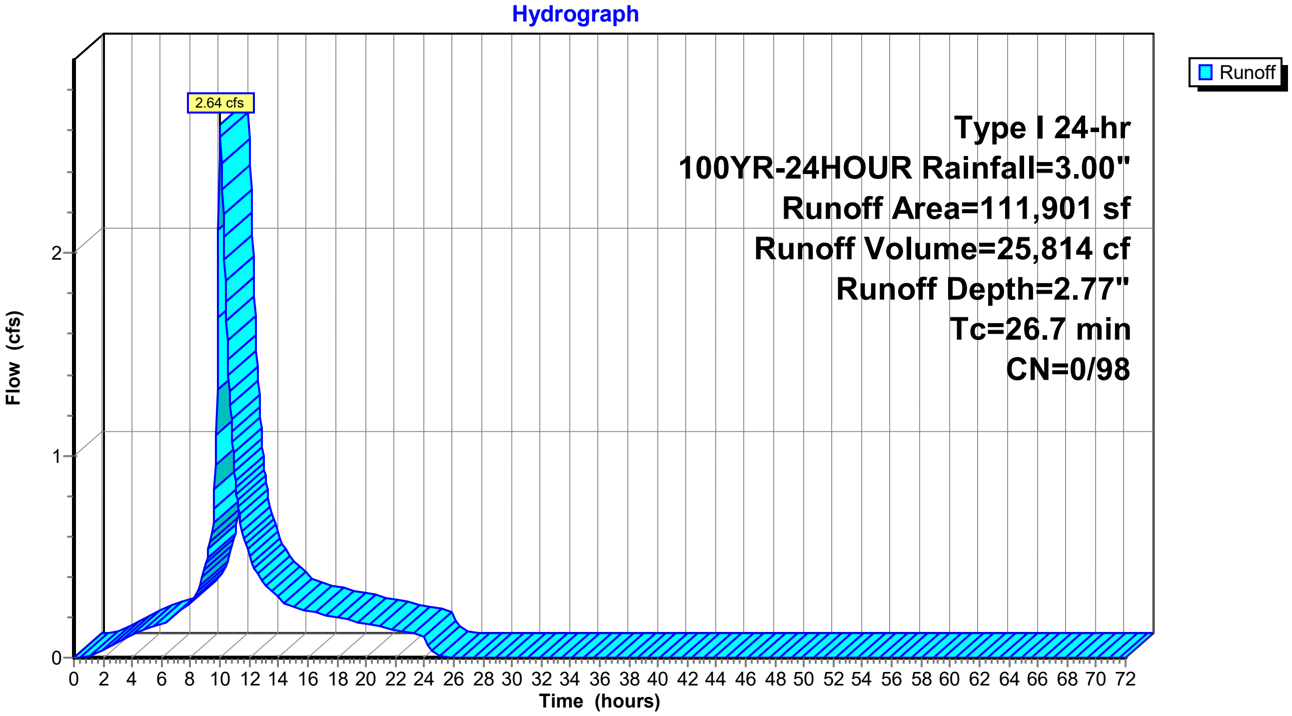
Runoff = 2.64 cfs @ 10.01 hrs, Volume= 25,814 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
111,901	98	Paved roads w/curbs & sewers, HSG A
111,901	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.7					**Direct Entry,**

Subcatchment F5: FRANKLIN 5



Summary for Subcatchment F6: FRANKLIN 6

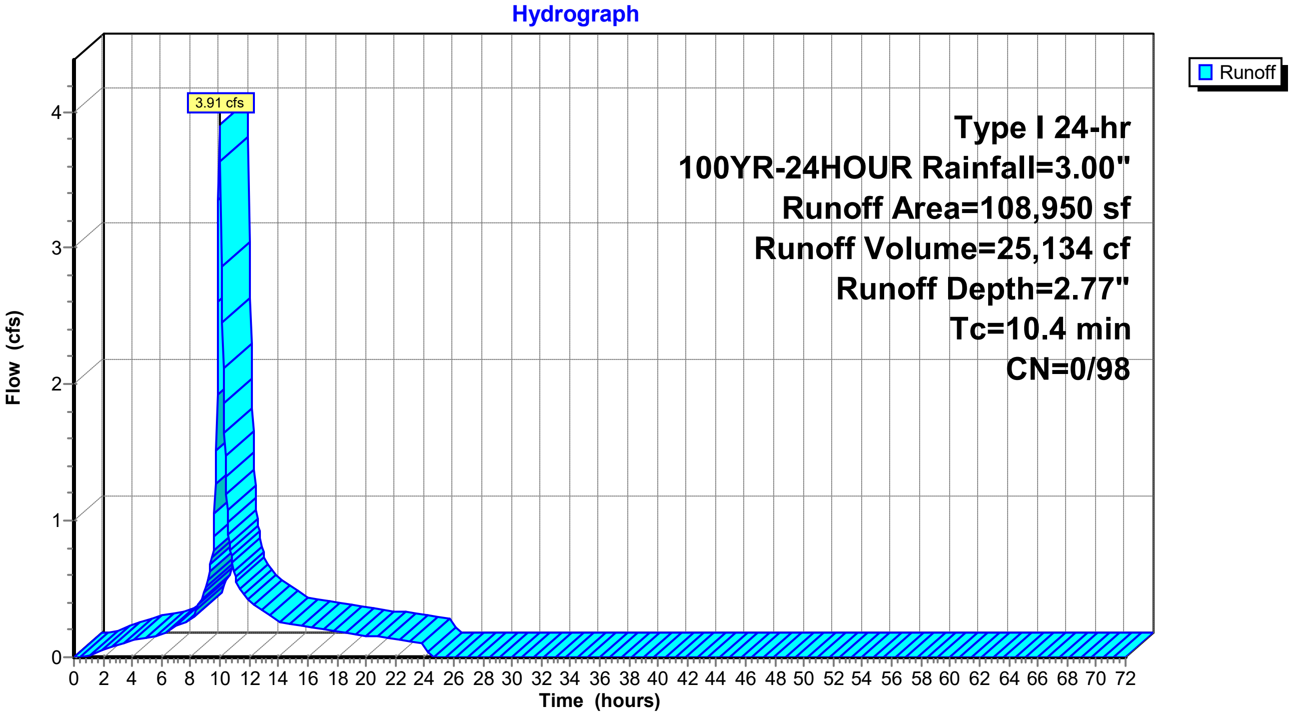
Runoff = 3.91 cfs @ 9.98 hrs, Volume= 25,134 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
108,950	98	Paved roads w/curbs & sewers, HSG A
108,950	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.4					**Direct Entry,**

Subcatchment F6: FRANKLIN 6



Summary for Subcatchment F7: FRANKLIN 7

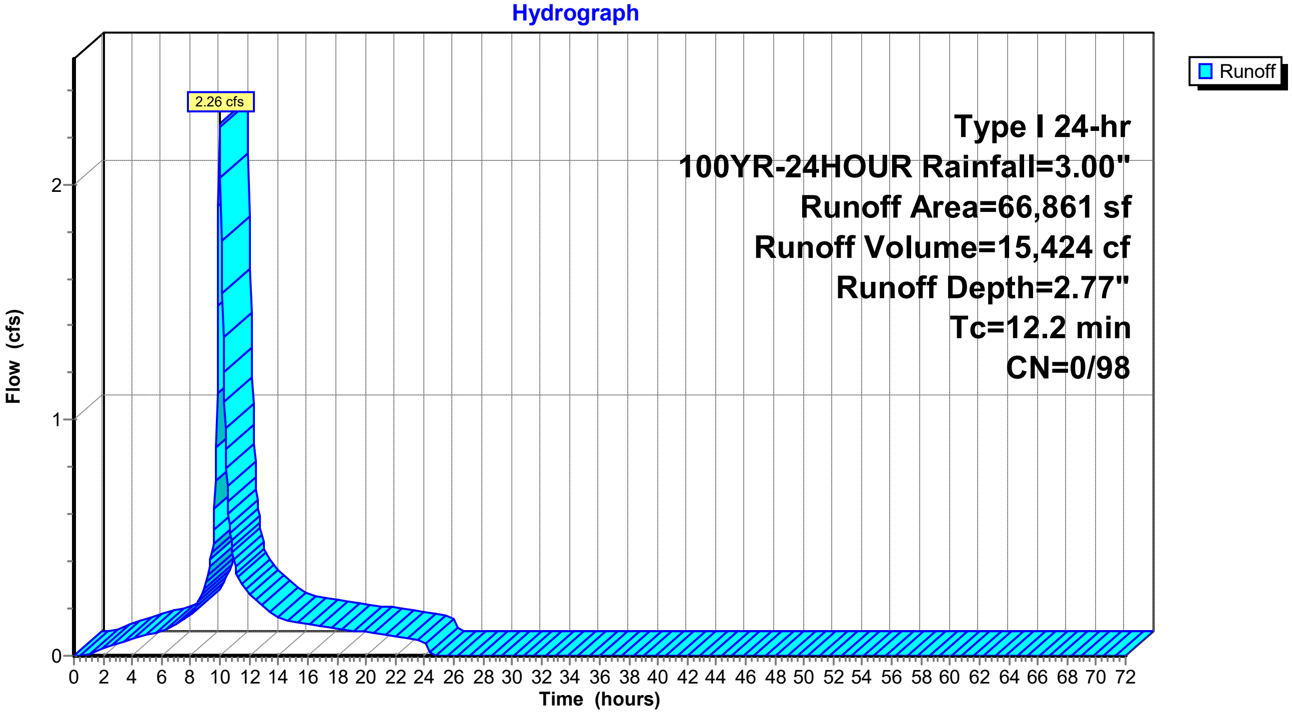
Runoff = 2.26 cfs @ 9.98 hrs, Volume= 15,424 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
66,861	98	Paved roads w/curbs & sewers, HSG A
66,861	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.2					**Direct Entry,**

Subcatchment F7: FRANKLIN 7



Summary for Subcatchment G1: GREENWOOD 1 (CONTRIBUTION)

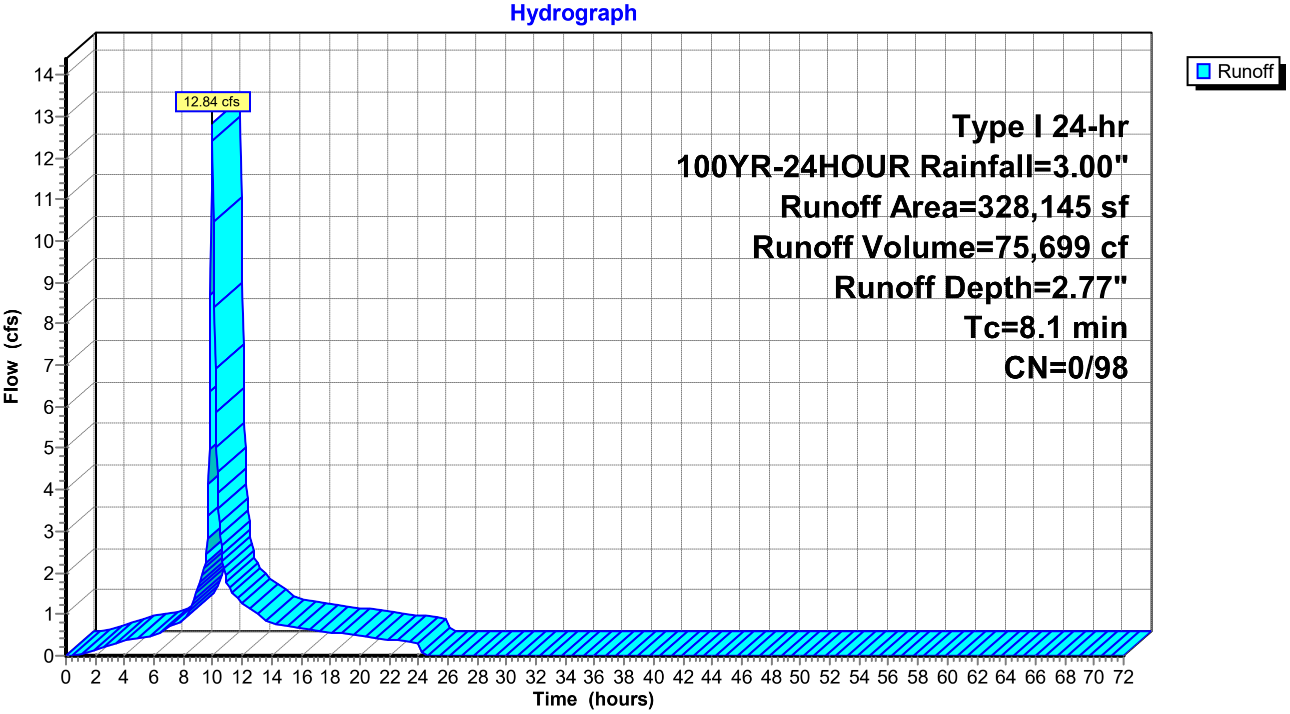
Runoff = 12.84 cfs @ 9.97 hrs, Volume= 75,699 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
328,145	98	Paved roads w/curbs & sewers, HSG A
328,145	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.1					**Direct Entry,**

Subcatchment G1: GREENWOOD 1 (CONTRIBUTION)



Summary for Subcatchment G10: GREENWOOD 10

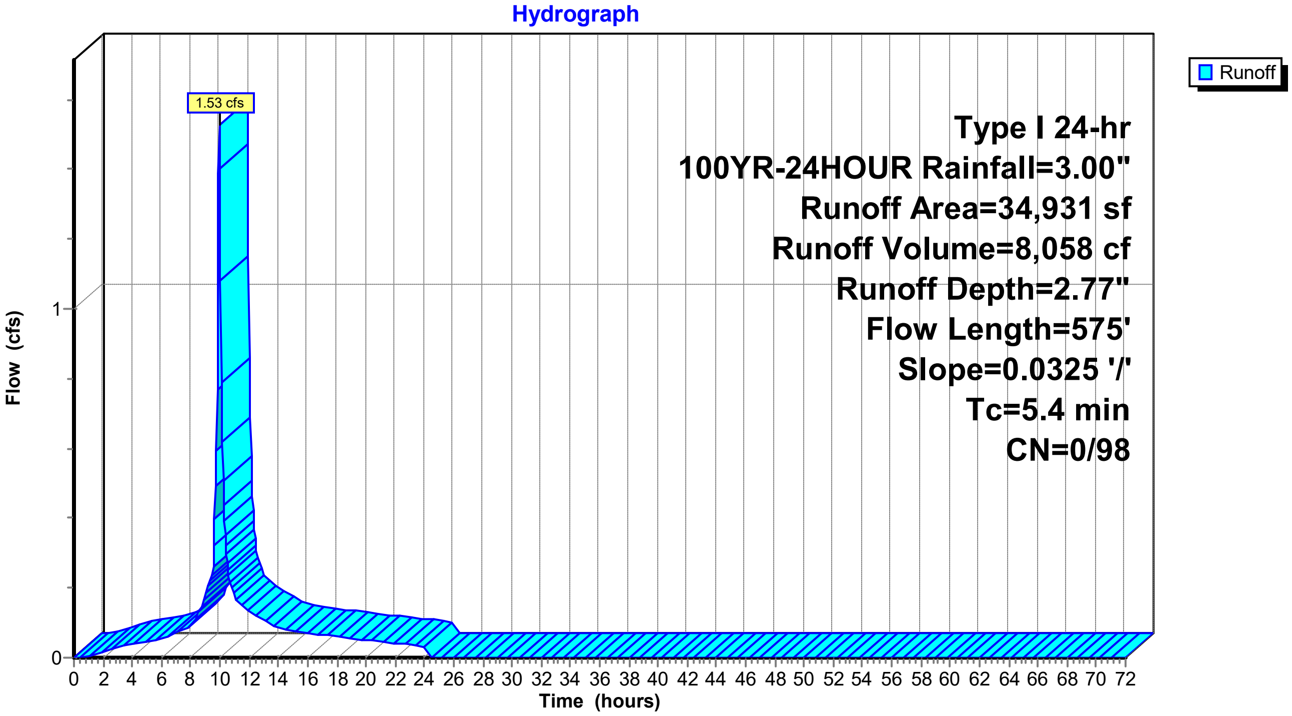
```
Runoff      =      1.53 cfs @   9.95 hrs,  Volume=          8,058 cf,  Depth=  2.77"
    Routed to nonexistent node DW-1A-B
```

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
34,931	98	Paved roads w/curbs & sewers, HSG A
34,931	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.4	575	0.0325	1.79		**Lag/CN Method,**

Subcatchment G10: GREENWOOD 10



Summary for Subcatchment G11: GREENWOOD 11

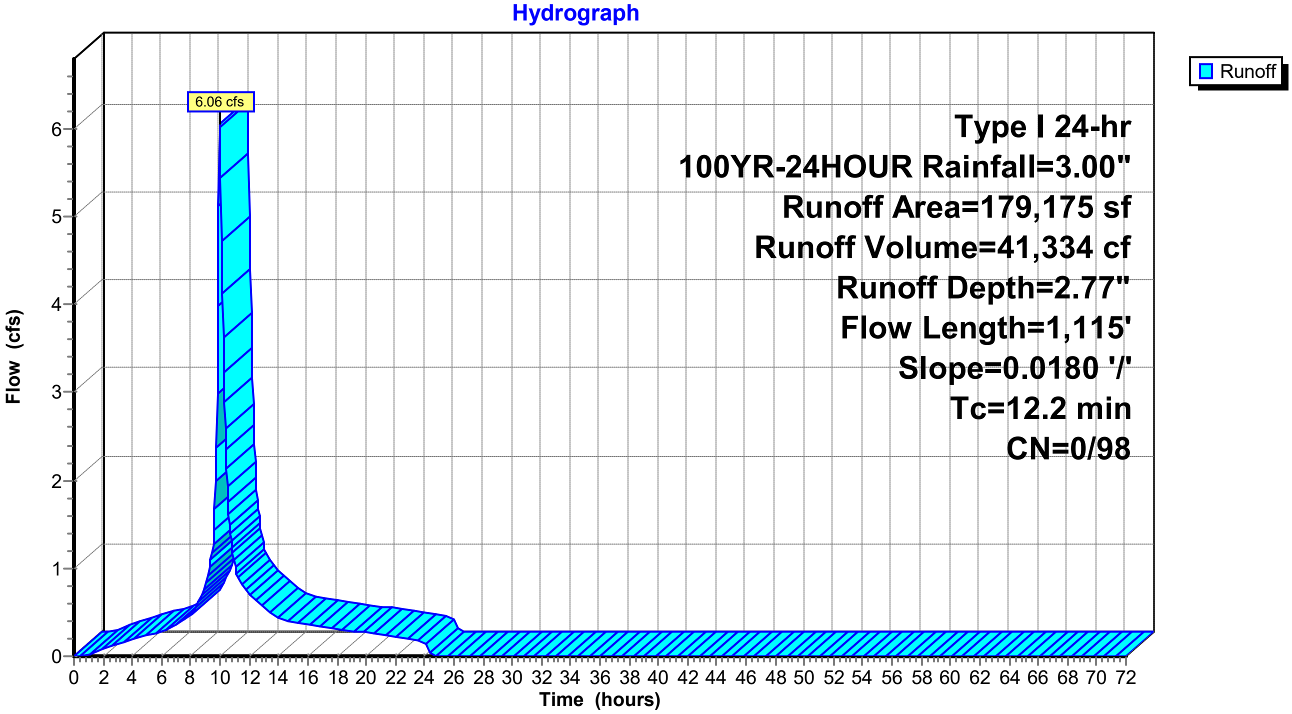
Runoff = 6.06 cfs @ 9.98 hrs, Volume= 41,334 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
179,175	98	Paved roads w/curbs & sewers, HSG A
179,175	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.2	1,115	0.0180	1.52		**Lag/CN Method,**

Subcatchment G11: GREENWOOD 11



Summary for Subcatchment G12: GREENWOOD 12

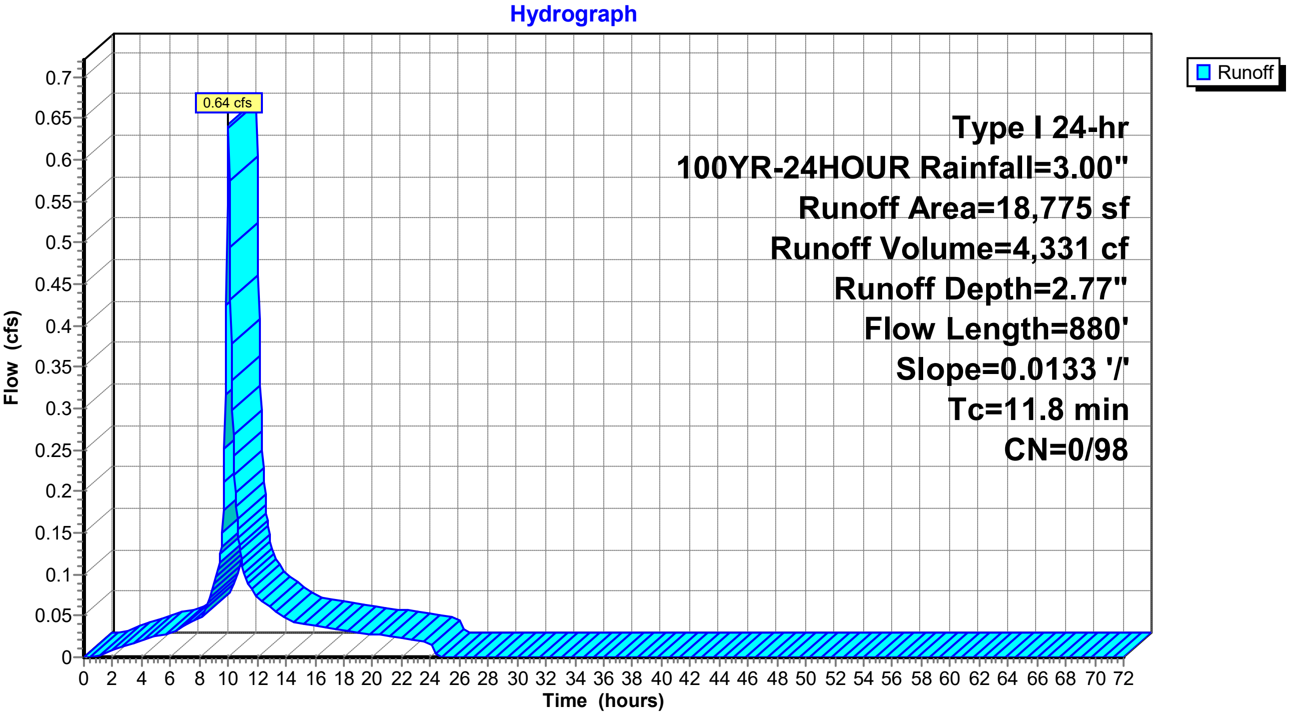
Runoff = 0.64 cfs @ 9.98 hrs, Volume= 4,331 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
18,775	98	Paved roads w/curbs & sewers, HSG A
18,775	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.8	880	0.0133	1.24		**Lag/CN Method,**

Subcatchment G12: GREENWOOD 12



Summary for Subcatchment G13: GREENWOOD 13

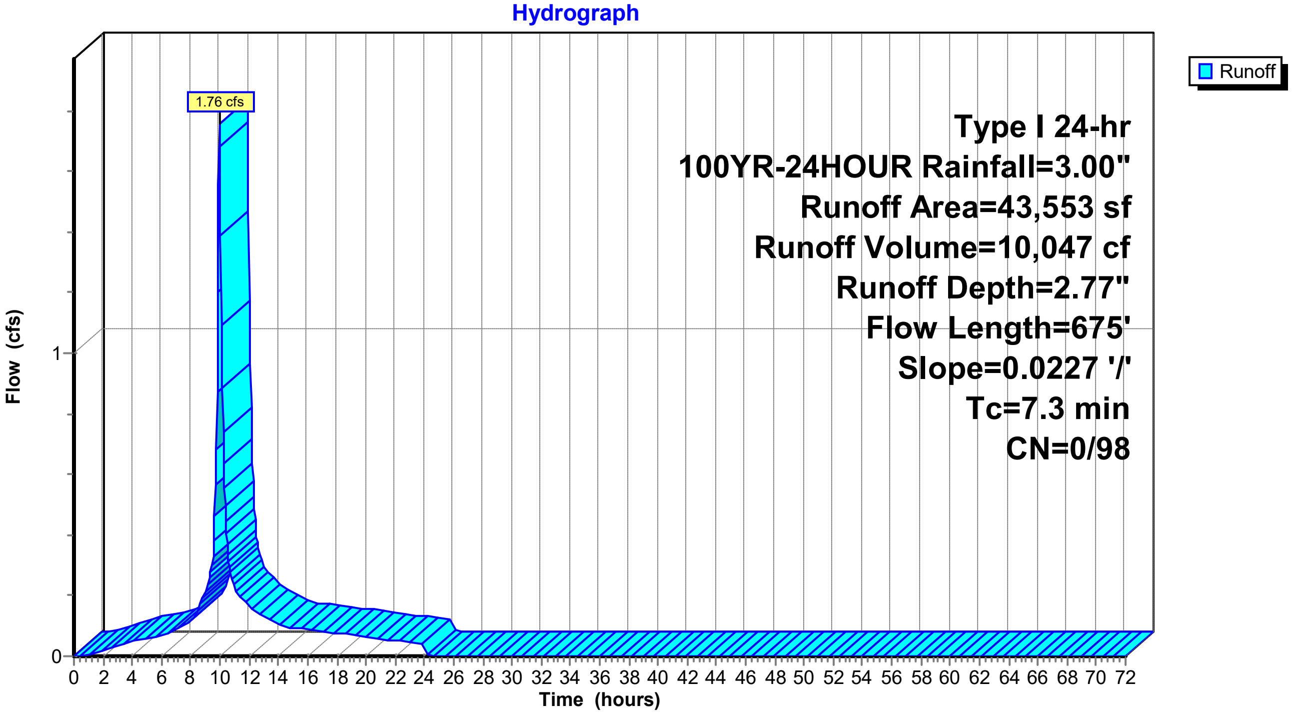
Runoff = 1.76 cfs @ 9.96 hrs, Volume= 10,047 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
43,553	98	Paved roads w/curbs & sewers, HSG A
43,553	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	675	0.0227	1.54		**Lag/CN Method,**

Subcatchment G13: GREENWOOD 13



Summary for Subcatchment G14: GREENWOOD 14

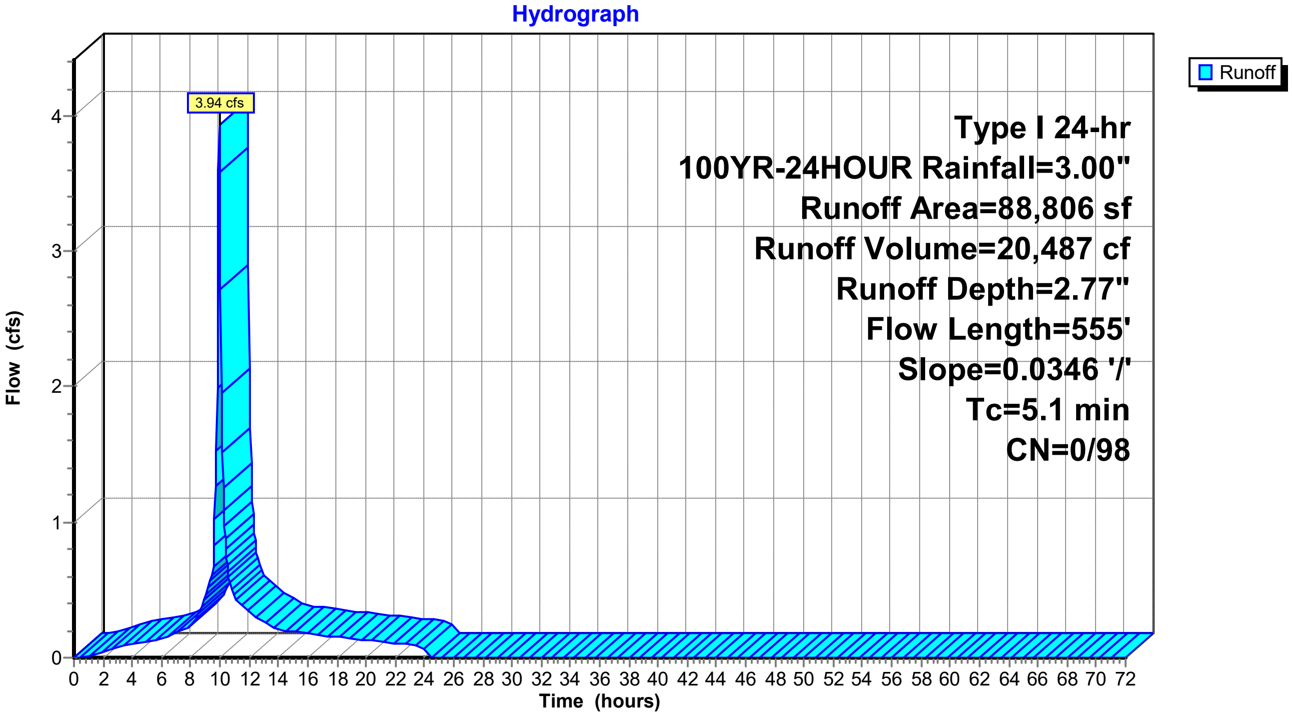
```
Runoff       =         3.94 cfs @      9.95 hrs,  Volume=            20,487 cf,  Depth=  2.77"
     Routed to nonexistent node DW-1A-B
```

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
88,806	98	Paved roads w/curbs & sewers, HSG A
88,806	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.1	555	0.0346	1.83		**Lag/CN Method,**

Subcatchment G14: GREENWOOD 14



Summary for Subcatchment G15: GREENWOOD 15

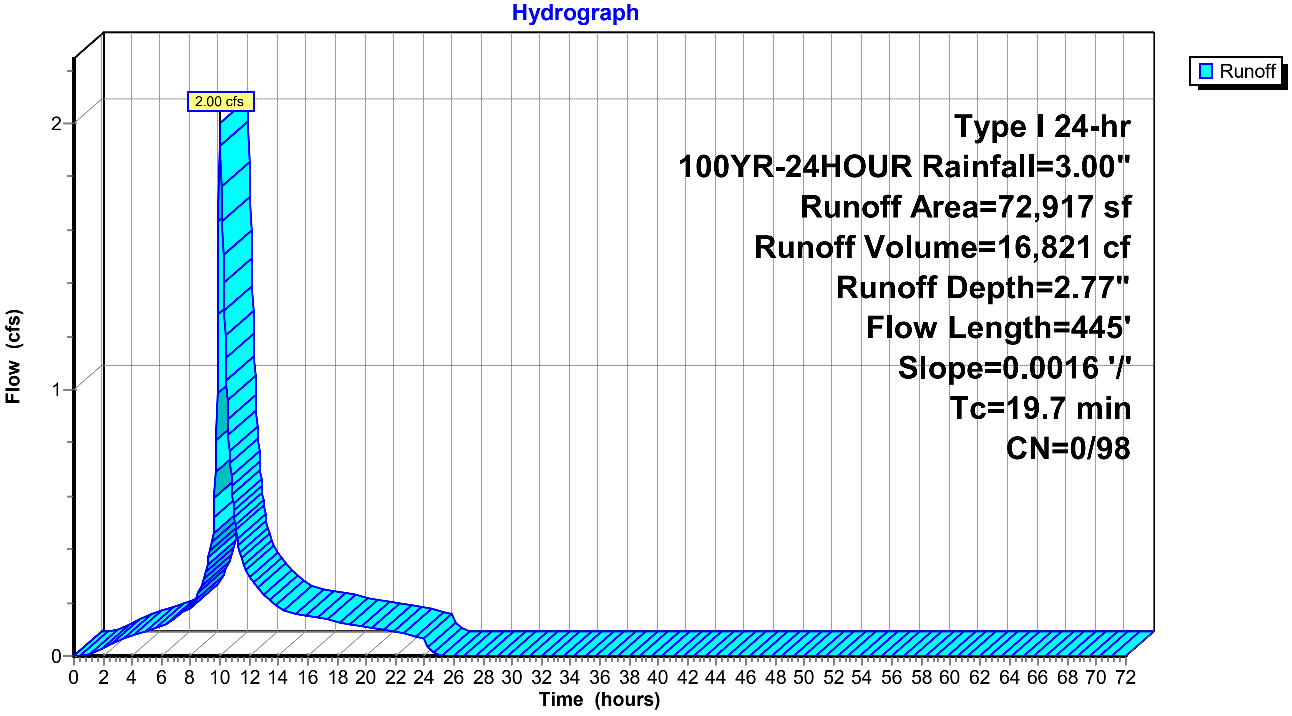
Runoff = 2.00 cfs @ 10.00 hrs, Volume= 16,821 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
72,917	98	Paved roads w/curbs & sewers, HSG A
72,917	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.7	445	0.0016	0.38		**Lag/CN Method,**

Subcatchment G15: GREENWOOD 15



Summary for Subcatchment G16: GREENWOOD 16

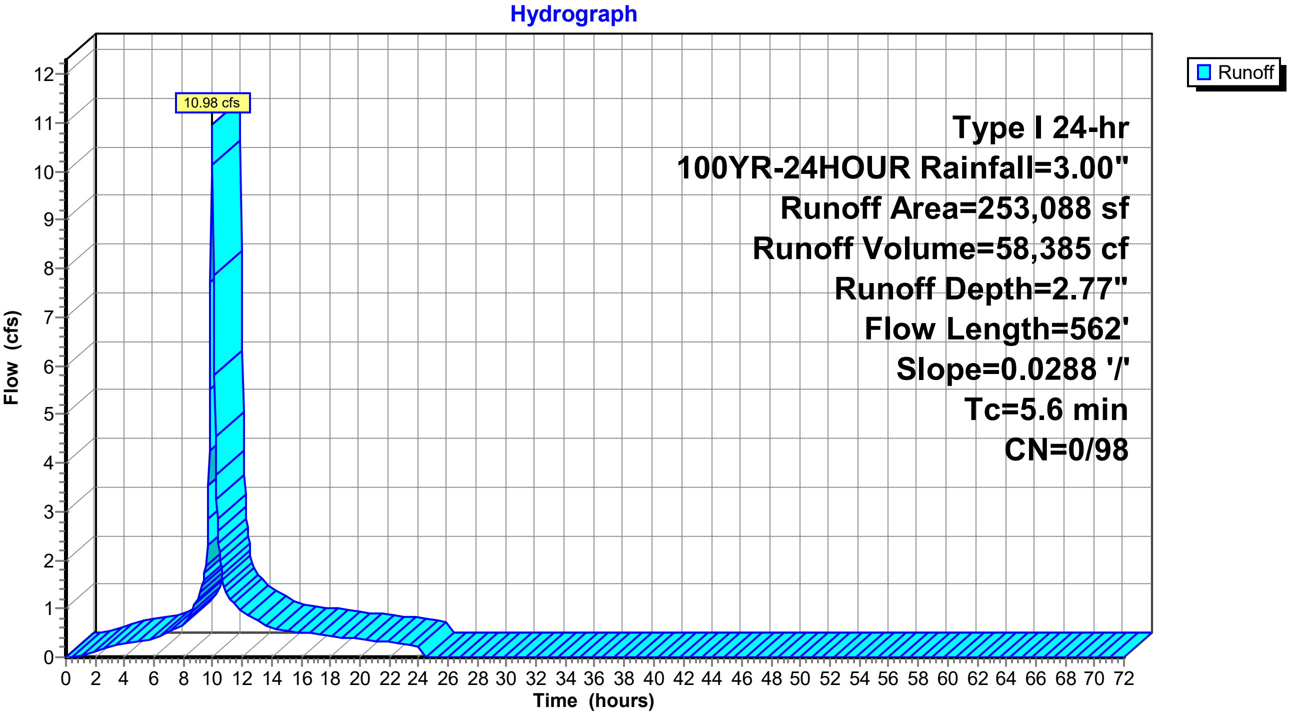
Runoff = 10.98 cfs @ 9.95 hrs, Volume= 58,385 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
253,088	98	Paved roads w/curbs & sewers, HSG A
253,088	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	562	0.0288	1.67		**Lag/CN Method,**

Subcatchment G16: GREENWOOD 16



Summary for Subcatchment G17: GREENWOOD 17

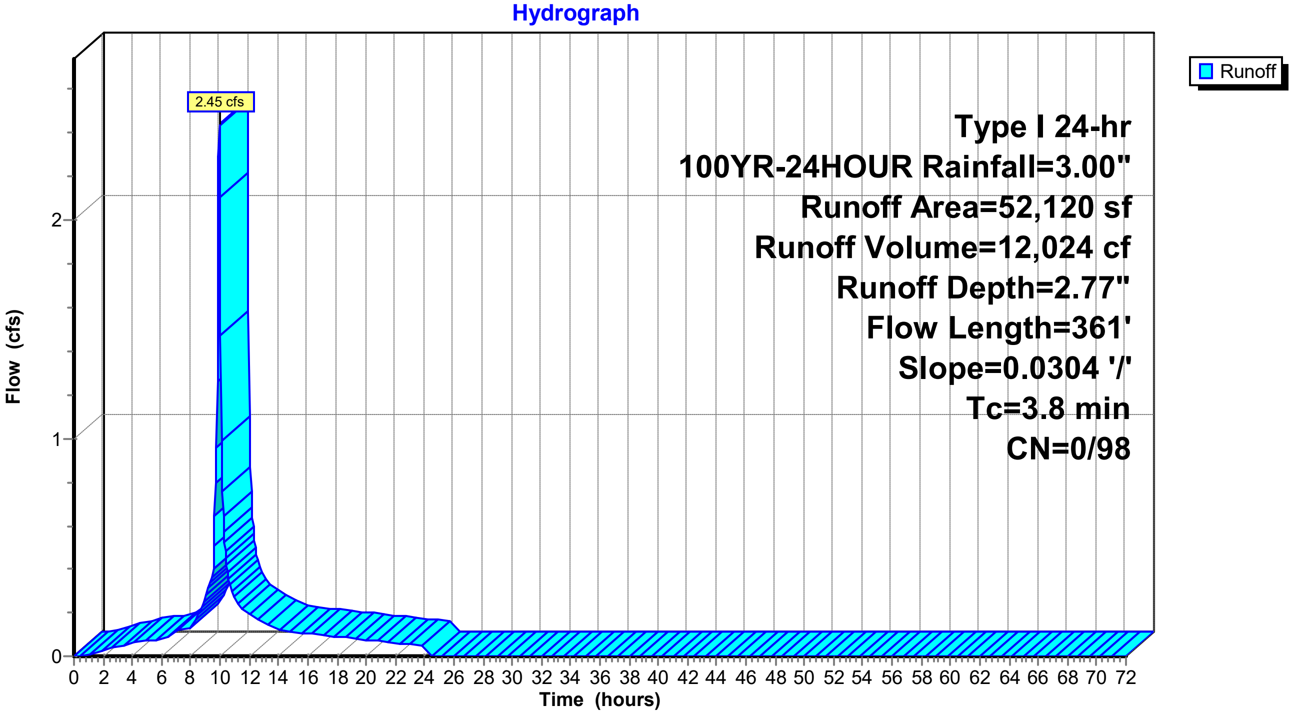
Runoff = 2.45 cfs @ 9.94 hrs, Volume= 12,024 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
52,120	98	Paved roads w/curbs & sewers, HSG A
52,120	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	361	0.0304	1.57		**Lag/CN Method,**

Subcatchment G17: GREENWOOD 17



Summary for Subcatchment G18: GREENWOOD 18

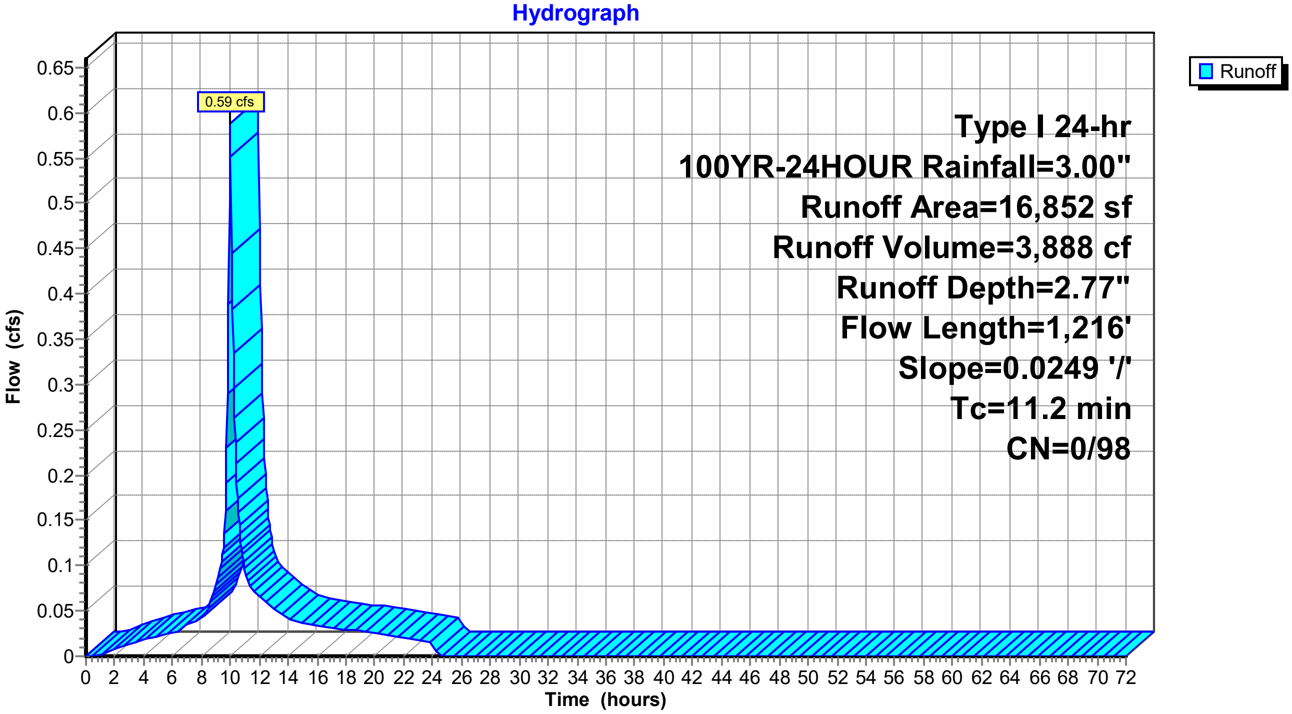
```
Runoff      =      0.59 cfs @   9.98 hrs,  Volume=         3,888 cf,  Depth=  2.77"
    Routed to nonexistent node DW-1A-B
```

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
16,852	98	Paved roads w/curbs & sewers, HSG A
16,852	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.2	1,216	0.0249	1.82		**Lag/CN Method,**

Subcatchment G18: GREENWOOD 18



Summary for Subcatchment G19: GREENWOOD 19

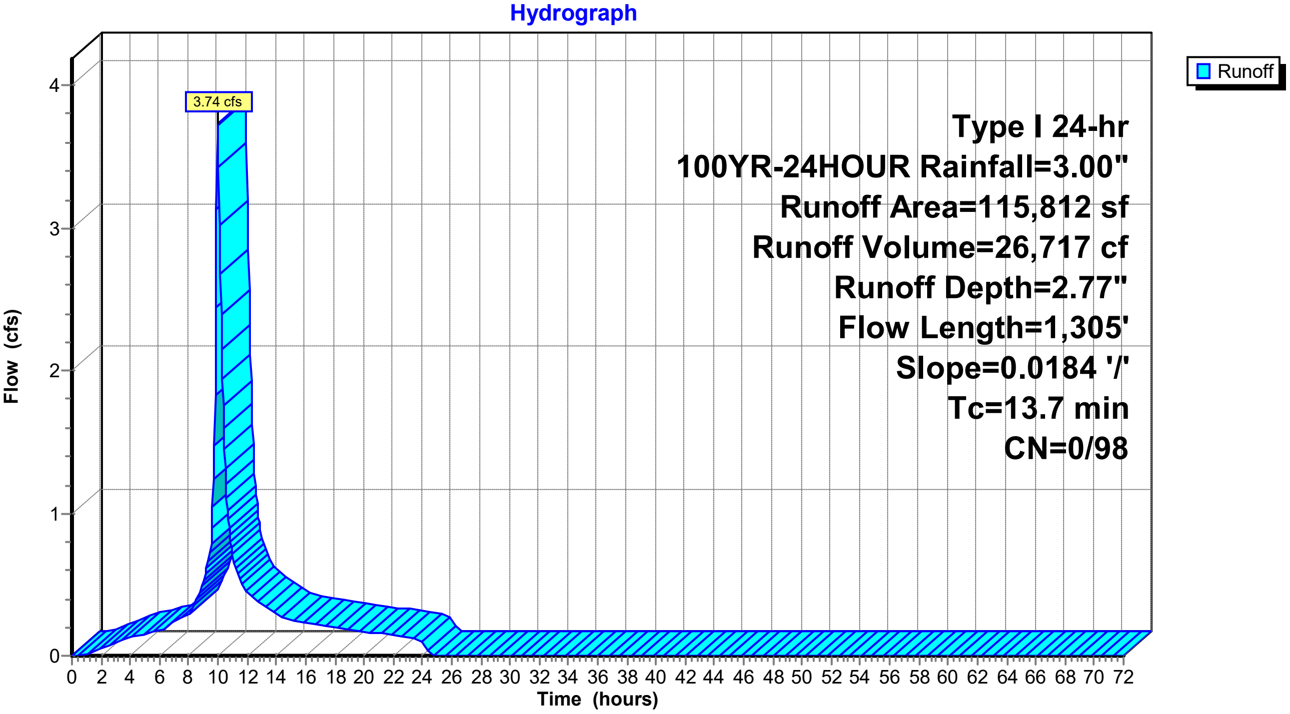
Runoff = 3.74 cfs @ 9.99 hrs, Volume= 26,717 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
115,812	98	Paved roads w/curbs & sewers, HSG A
115,812	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.7	1,305	0.0184	1.58		**Lag/CN Method,**

Subcatchment G19: GREENWOOD 19



Summary for Subcatchment G2: GREENWOOD 2

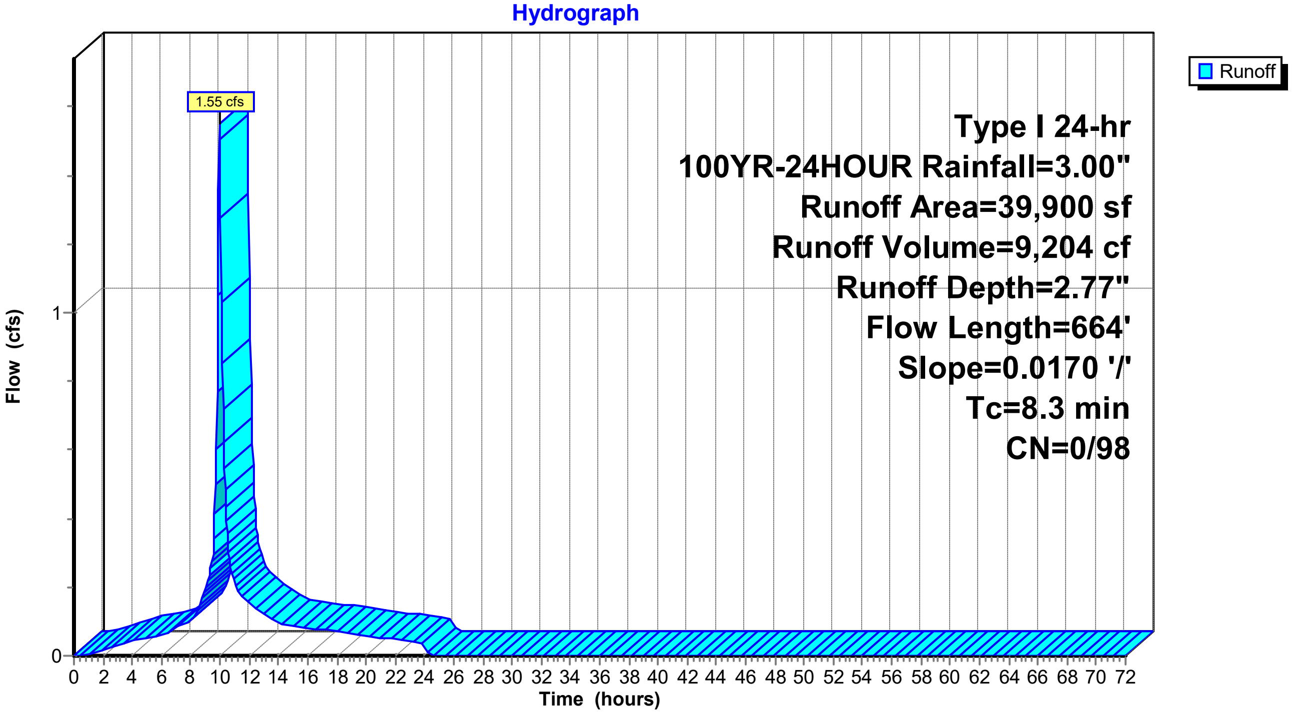
Runoff = 1.55 cfs @ 9.97 hrs, Volume= 9,204 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
39,900	98	Paved roads w/curbs & sewers, HSG A
39,900	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.3	664	0.0170	1.33		**Lag/CN Method,**

Subcatchment G2: GREENWOOD 2



Summary for Subcatchment G20: GREENWOOD 20

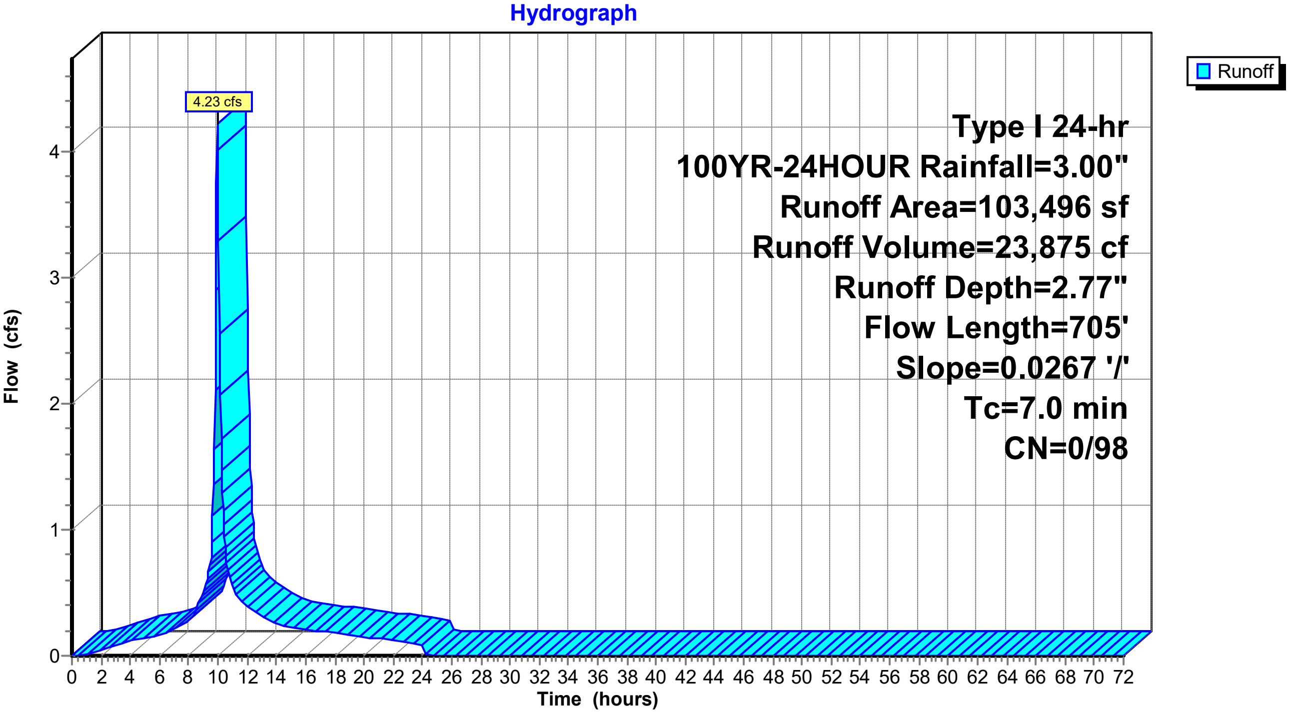
Runoff = 4.23 cfs @ 9.96 hrs, Volume= 23,875 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
103,496	98	Paved roads w/curbs & sewers, HSG A
103,496	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	705	0.0267	1.69		**Lag/CN Method,**

Subcatchment G20: GREENWOOD 20



Summary for Subcatchment G21: GREENWOOD 21

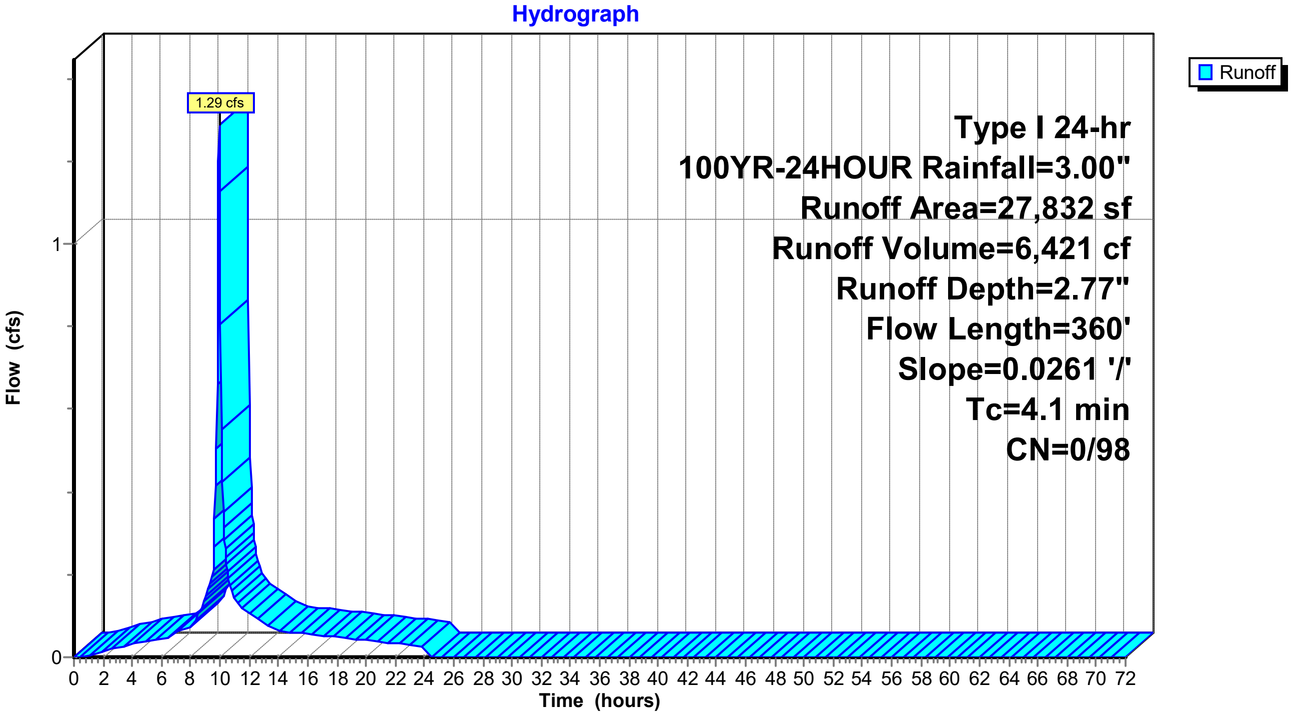
Runoff = 1.29 cfs @ 9.94 hrs, Volume= 6,421 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
27,832	98	Paved roads w/curbs & sewers, HSG A
27,832	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.1	360	0.0261	1.46		**Lag/CN Method,**

Subcatchment G21: GREENWOOD 21



Summary for Subcatchment G22: GREENWOOD 22

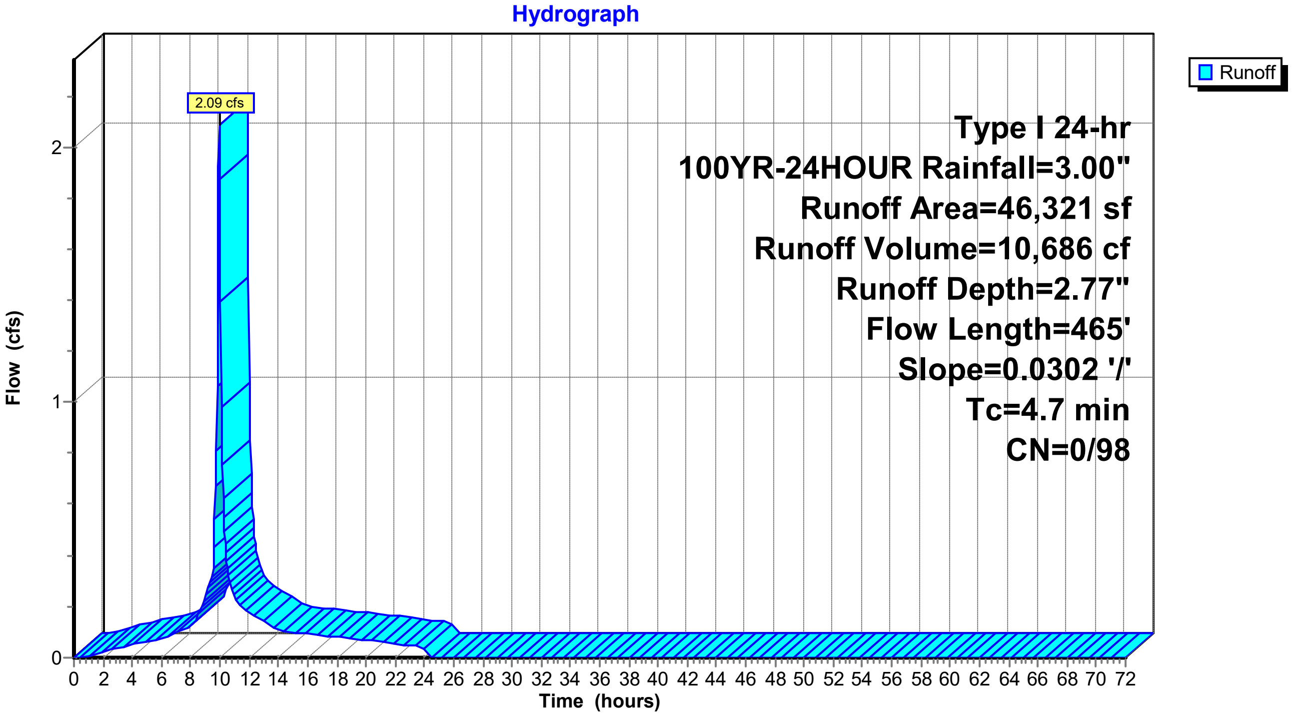
Runoff = 2.09 cfs @ 9.95 hrs, Volume= 10,686 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
46,321	98	Paved roads w/curbs & sewers, HSG A
46,321	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.7	465	0.0302	1.65		**Lag/CN Method,**

Subcatchment G22: GREENWOOD 22



Summary for Subcatchment G23: GREENWOOD 23

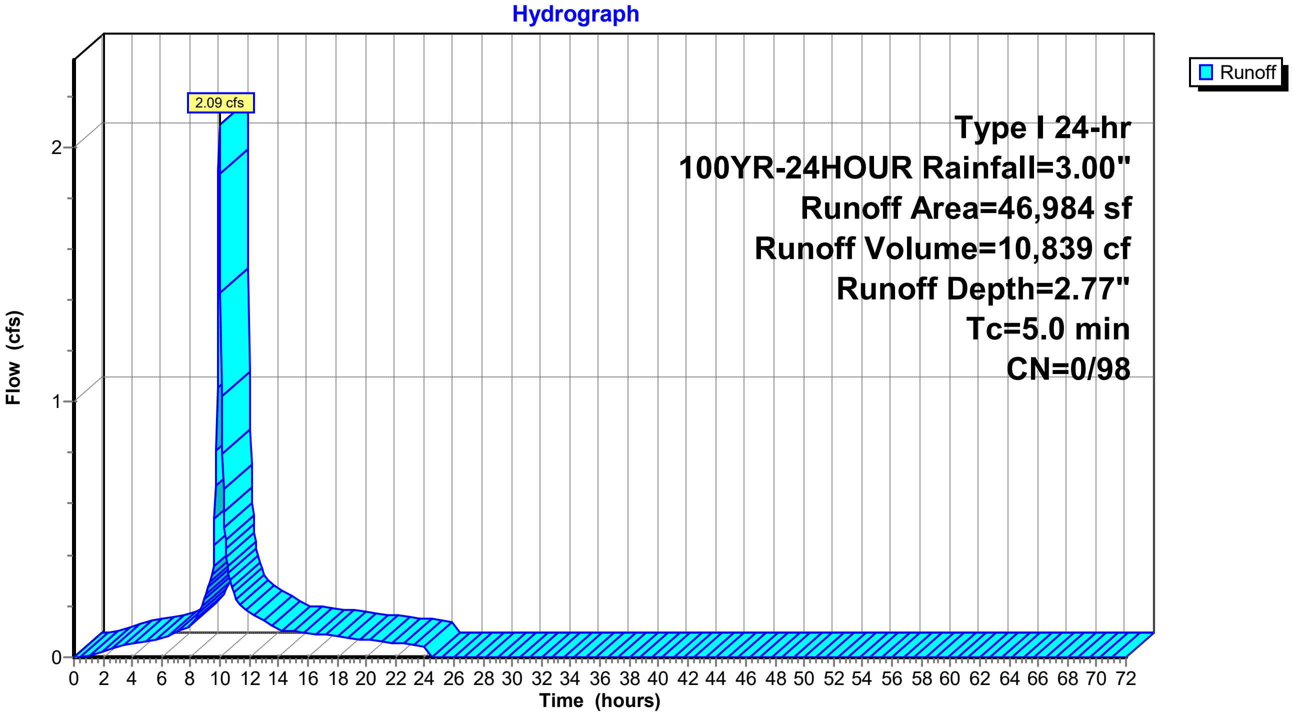
Runoff = 2.09 cfs @ 9.95 hrs, Volume= 10,839 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
46,984	98	Paved roads w/curbs & sewers, HSG A
46,984	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment G23: GREENWOOD 23



Summary for Subcatchment G24: GREENWOOD 24

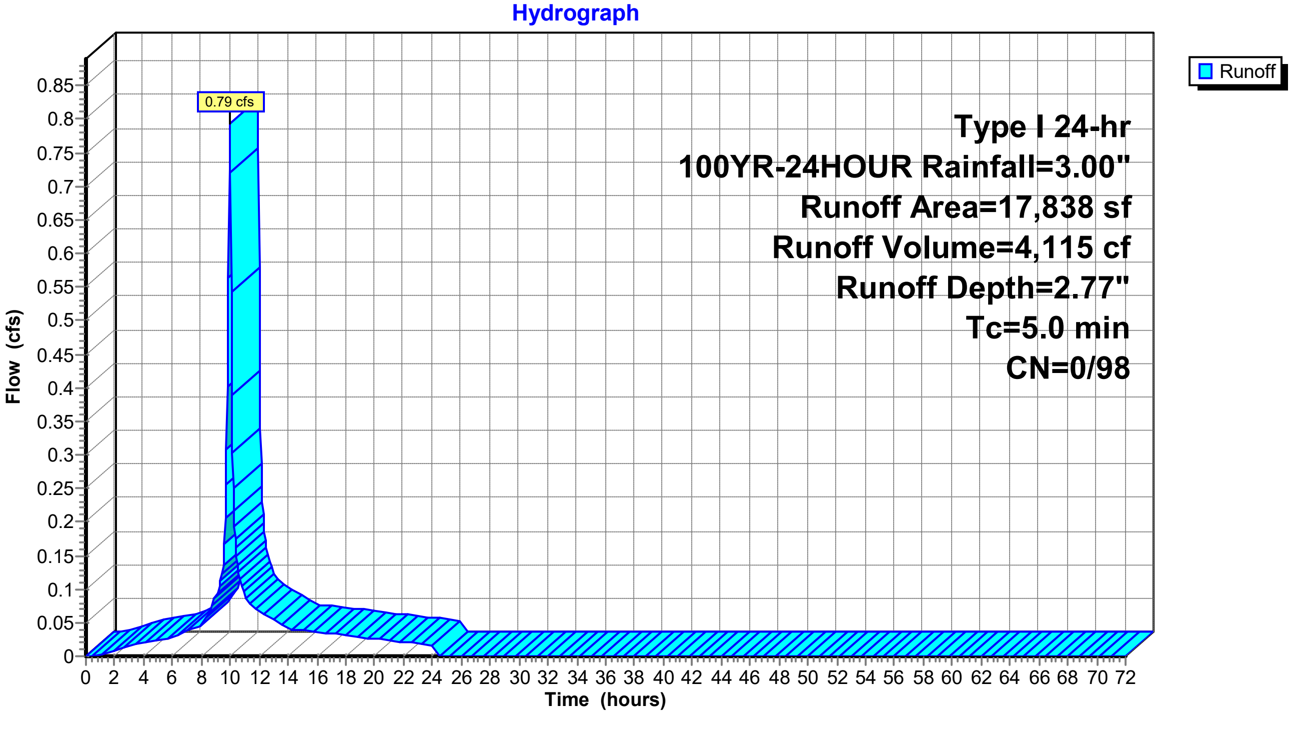
Runoff = 0.79 cfs @ 9.95 hrs, Volume= 4,115 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
17,838	98	Paved roads w/curbs & sewers, HSG A
17,838	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment G24: GREENWOOD 24



Summary for Subcatchment G25: GREENWOOD 25

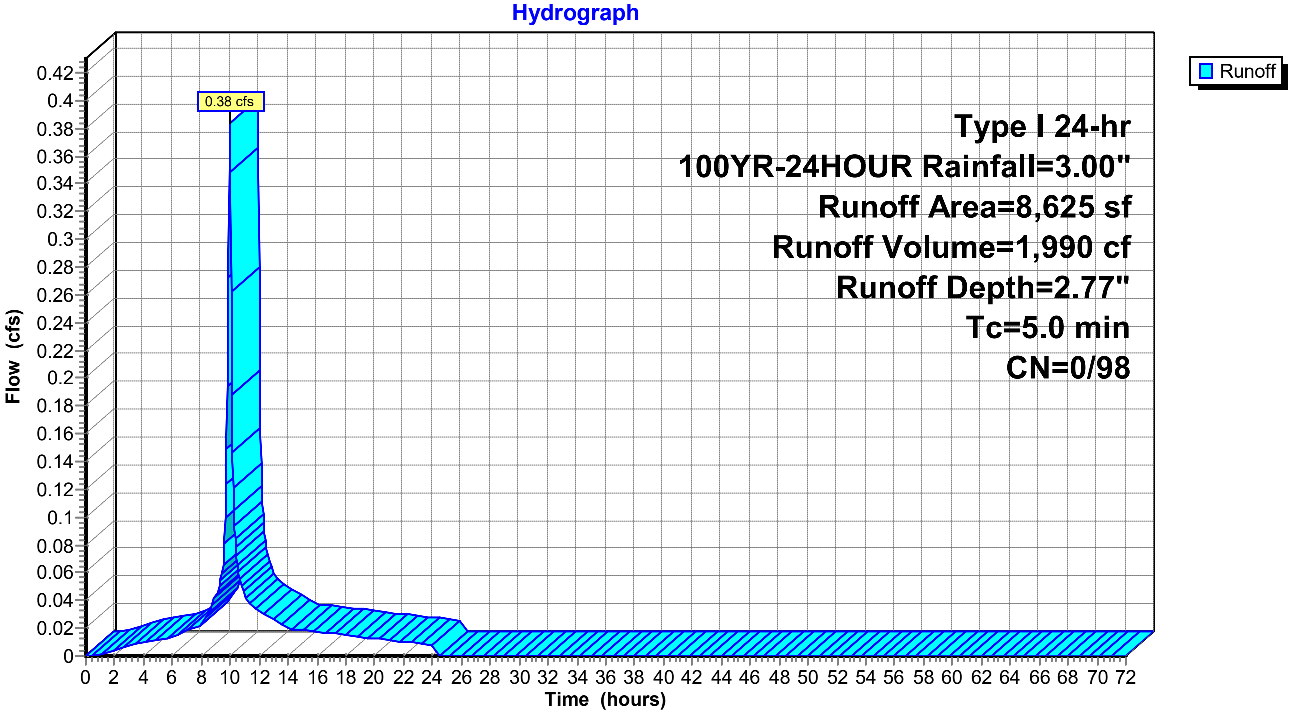
Runoff = 0.38 cfs @ 9.95 hrs, Volume= 1,990 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
8,625	98	Paved roads w/curbs & sewers, HSG A
8,625	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment G25: GREENWOOD 25



Summary for Subcatchment G26: GREENWOOD 26

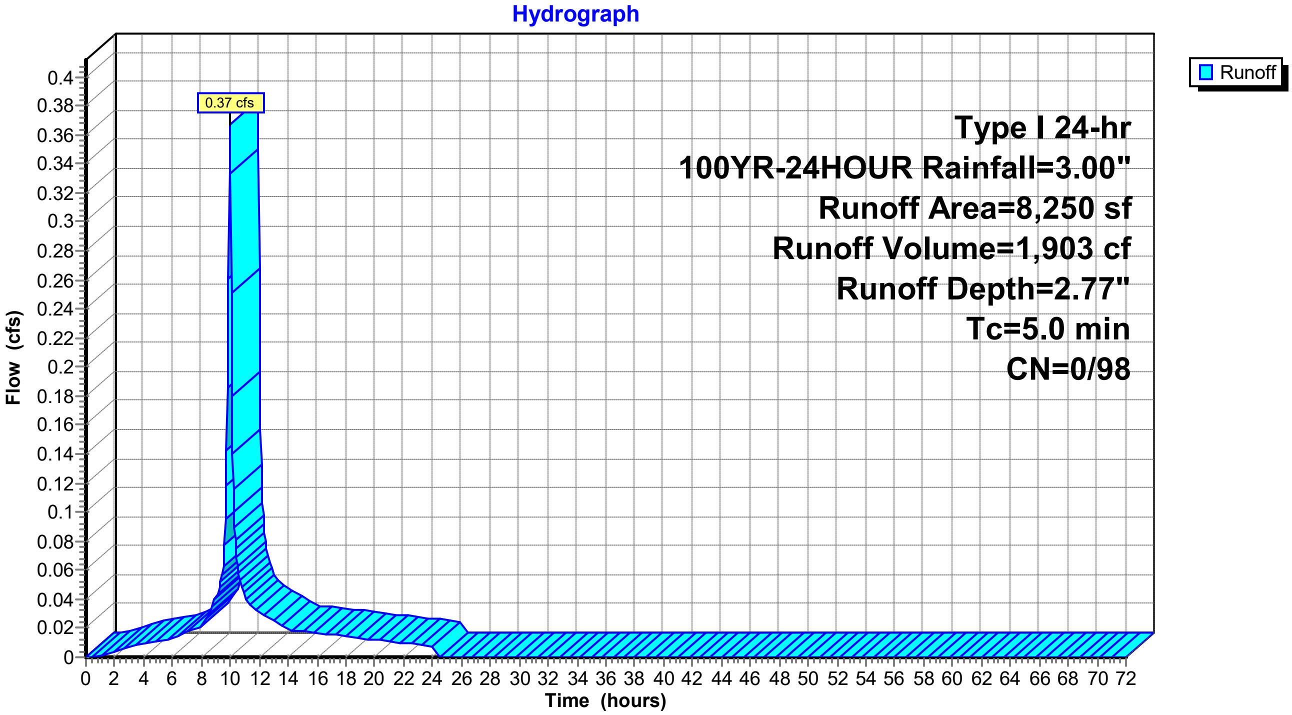
Runoff = 0.37 cfs @ 9.95 hrs, Volume= 1,903 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
8,250	98	Paved roads w/curbs & sewers, HSG A
8,250	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment G26: GREENWOOD 26



Summary for Subcatchment G27: GREENWOOD 27

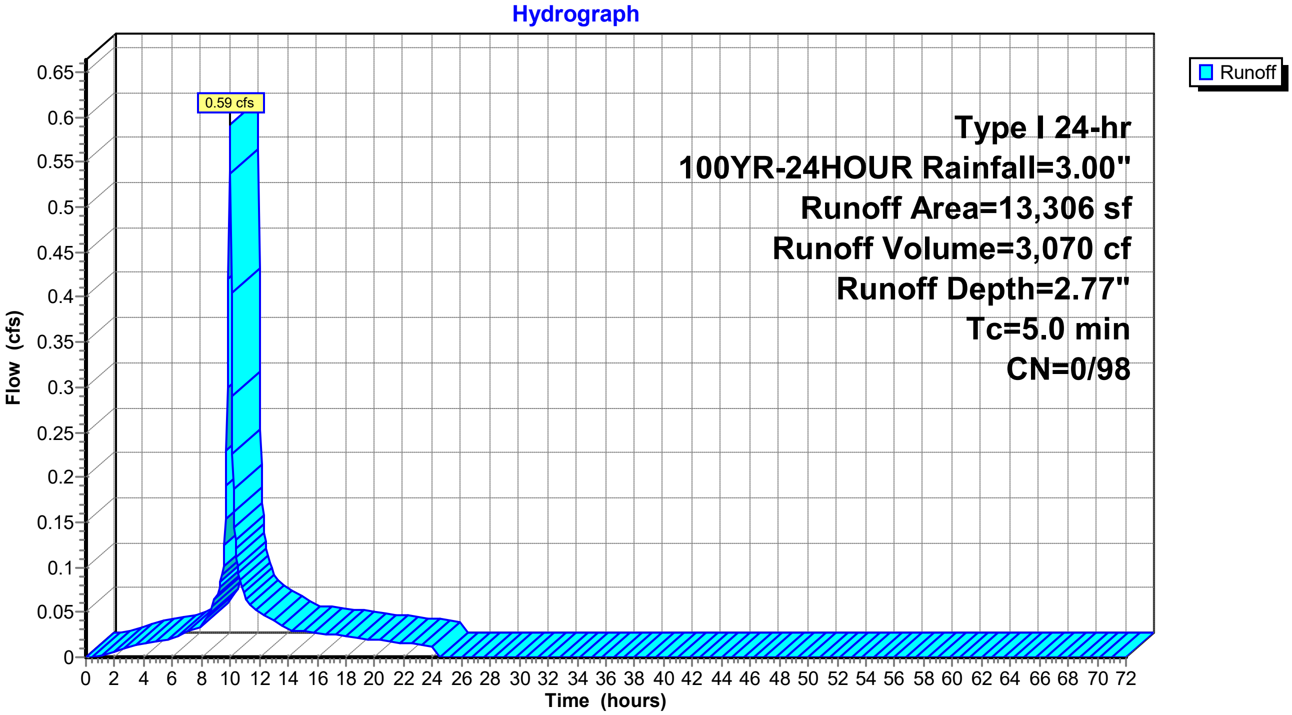
Runoff = 0.59 cfs @ 9.95 hrs, Volume= 3,070 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
13,306	98	Paved roads w/curbs & sewers, HSG A
13,306	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment G27: GREENWOOD 27



Summary for Subcatchment G28: GREENWOOD 28

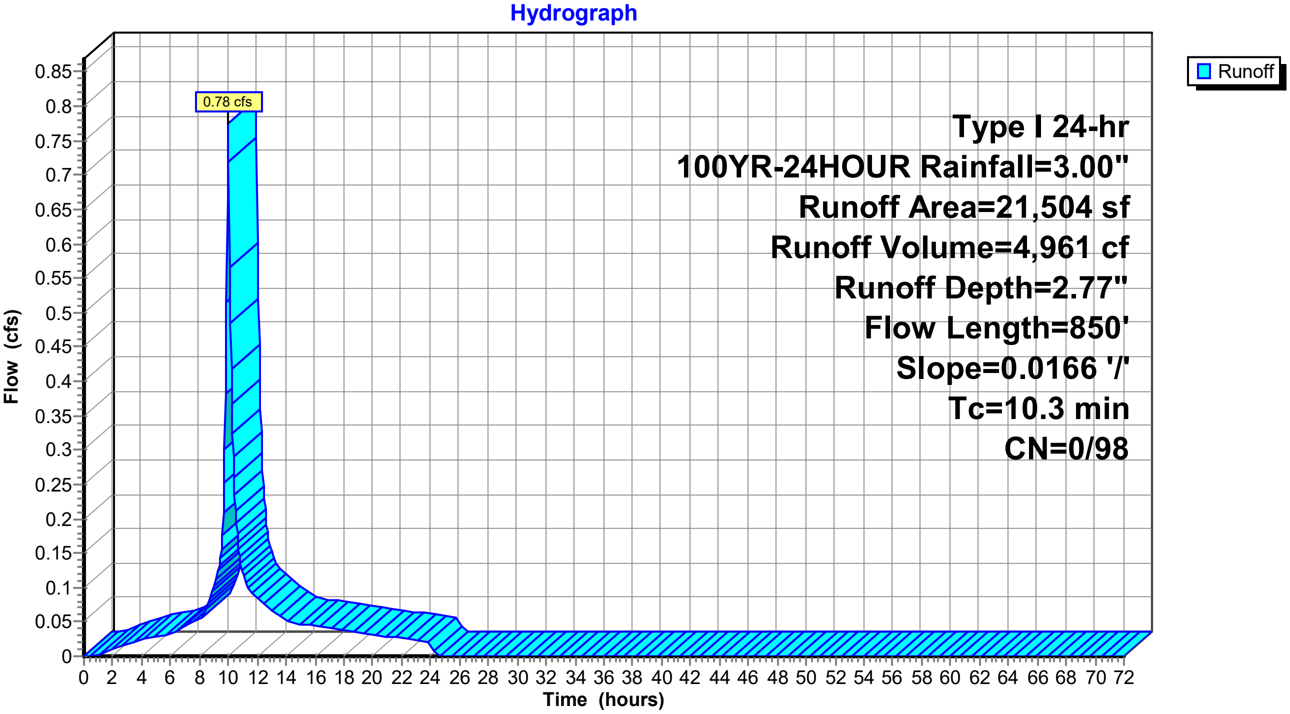
Runoff = 0.78 cfs @ 9.97 hrs, Volume= 4,961 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
21,504	98	Paved roads w/curbs & sewers, HSG A
21,504	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.3	850	0.0166	1.38		**Lag/CN Method,**

Subcatchment G28: GREENWOOD 28



Summary for Subcatchment G29: GREENWOOD 29

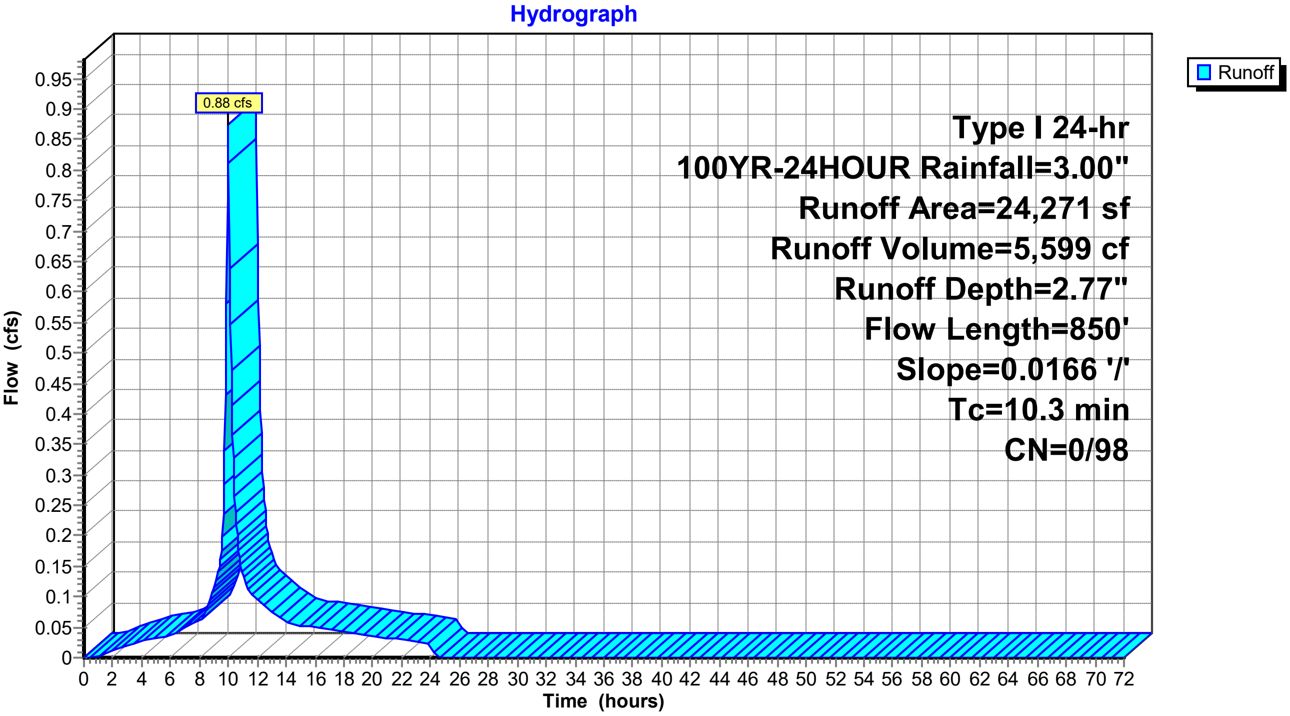
Runoff = 0.88 cfs @ 9.97 hrs, Volume= 5,599 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
24,271	98	Paved roads w/curbs & sewers, HSG A
24,271	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.3	850	0.0166	1.38		**Lag/CN Method,**

Subcatchment G29: GREENWOOD 29



Summary for Subcatchment G3: GREENWOOD 3

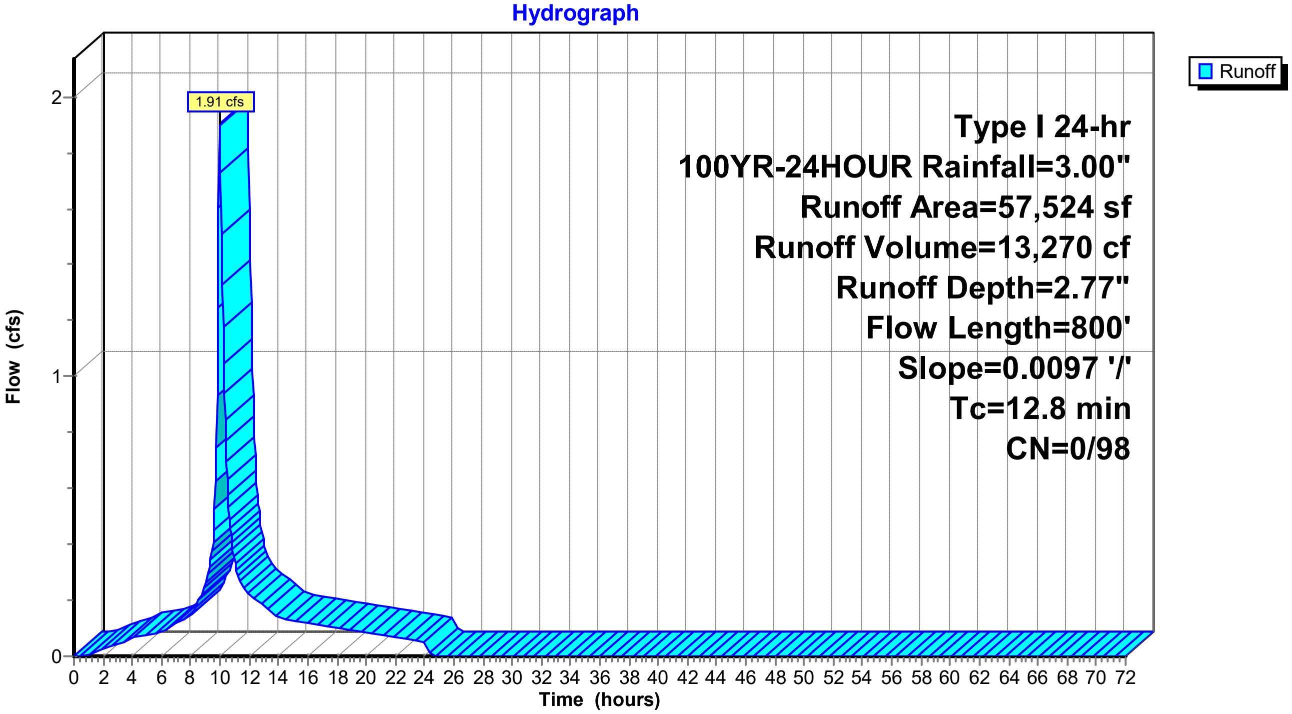
Runoff = 1.91 cfs @ 9.98 hrs, Volume= 13,270 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
57,524	98	Paved roads w/curbs & sewers, HSG A
57,524	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.8	800	0.0097	1.04		**Lag/CN Method,**

Subcatchment G3: GREENWOOD 3



Summary for Subcatchment G30: GREENWOOD 30

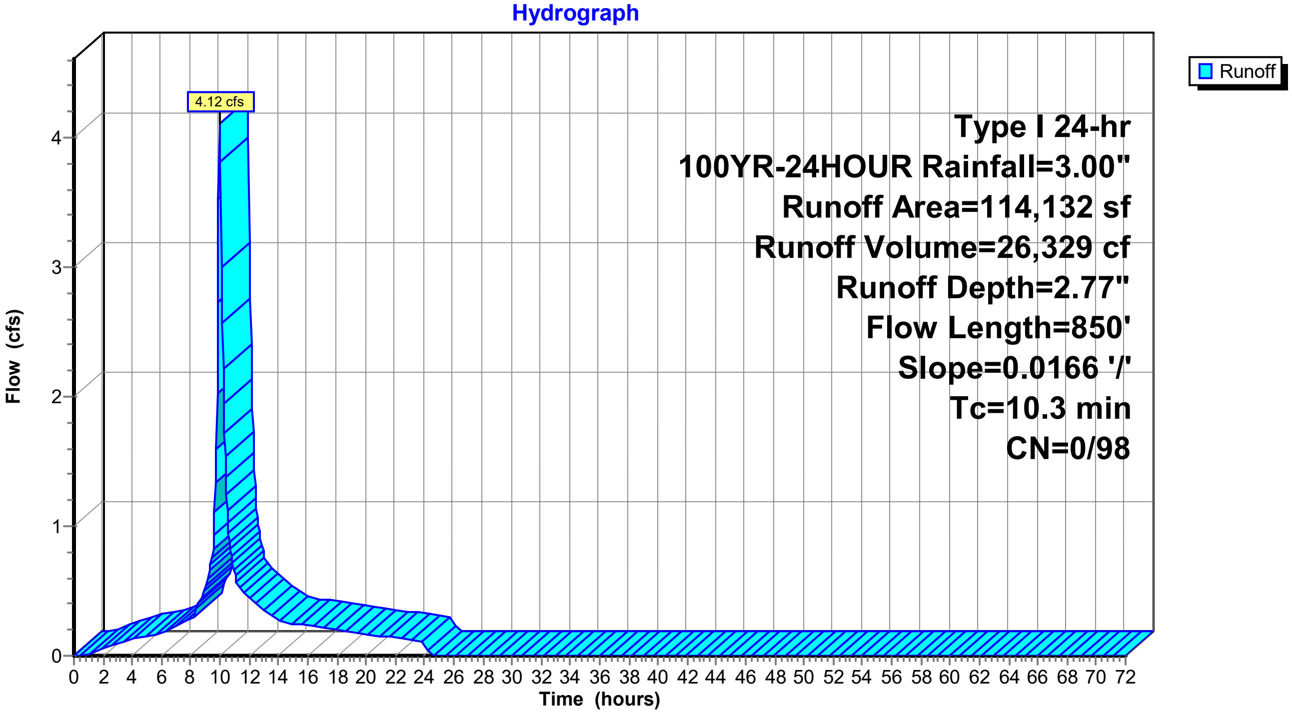
Runoff = 4.12 cfs @ 9.97 hrs, Volume= 26,329 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
114,132	98	Paved roads w/curbs & sewers, HSG A
114,132	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.3	850	0.0166	1.38		**Lag/CN Method,**

Subcatchment G30: GREENWOOD 30



Summary for Subcatchment G4: GREENWOOD 4

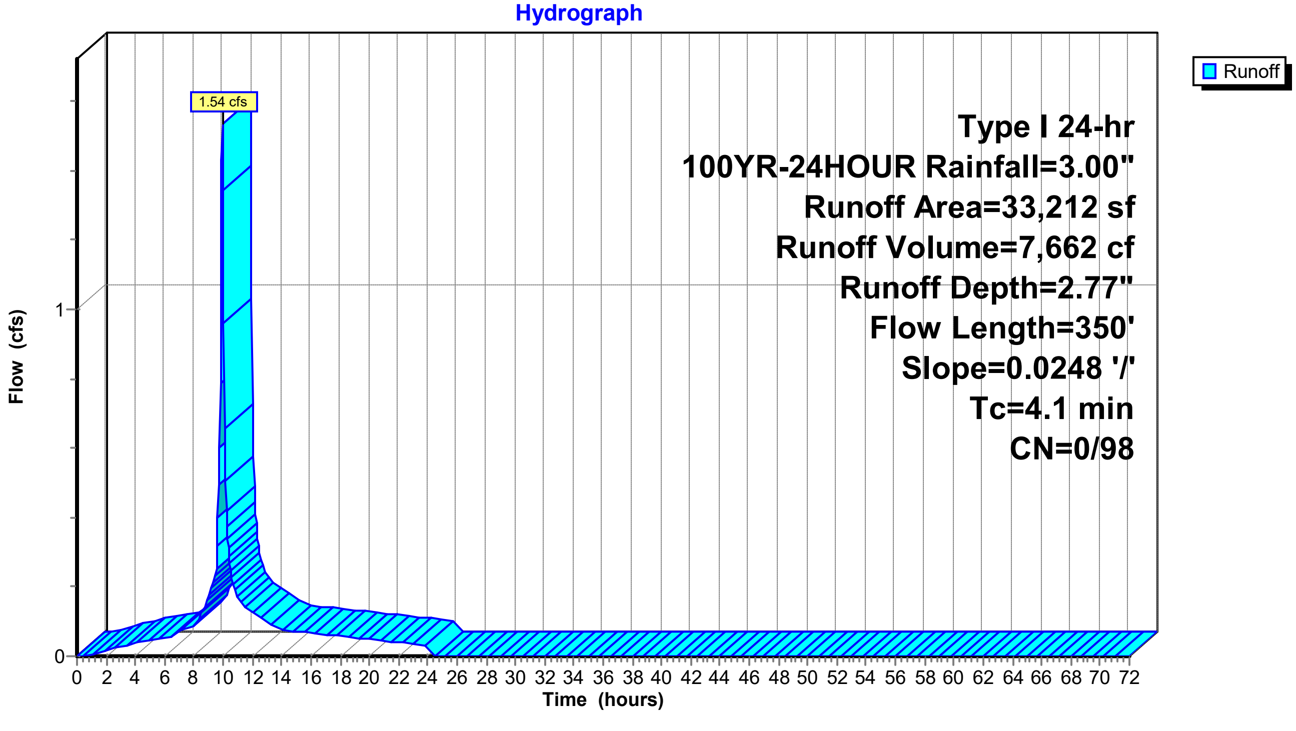
Runoff = 1.54 cfs @ 9.94 hrs, Volume= 7,662 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
33,212	98	Paved roads w/curbs & sewers, HSG A
33,212	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.1	350	0.0248	1.41		**Lag/CN Method,**

Subcatchment G4: GREENWOOD 4



Summary for Subcatchment G5: GREENWOOD 5

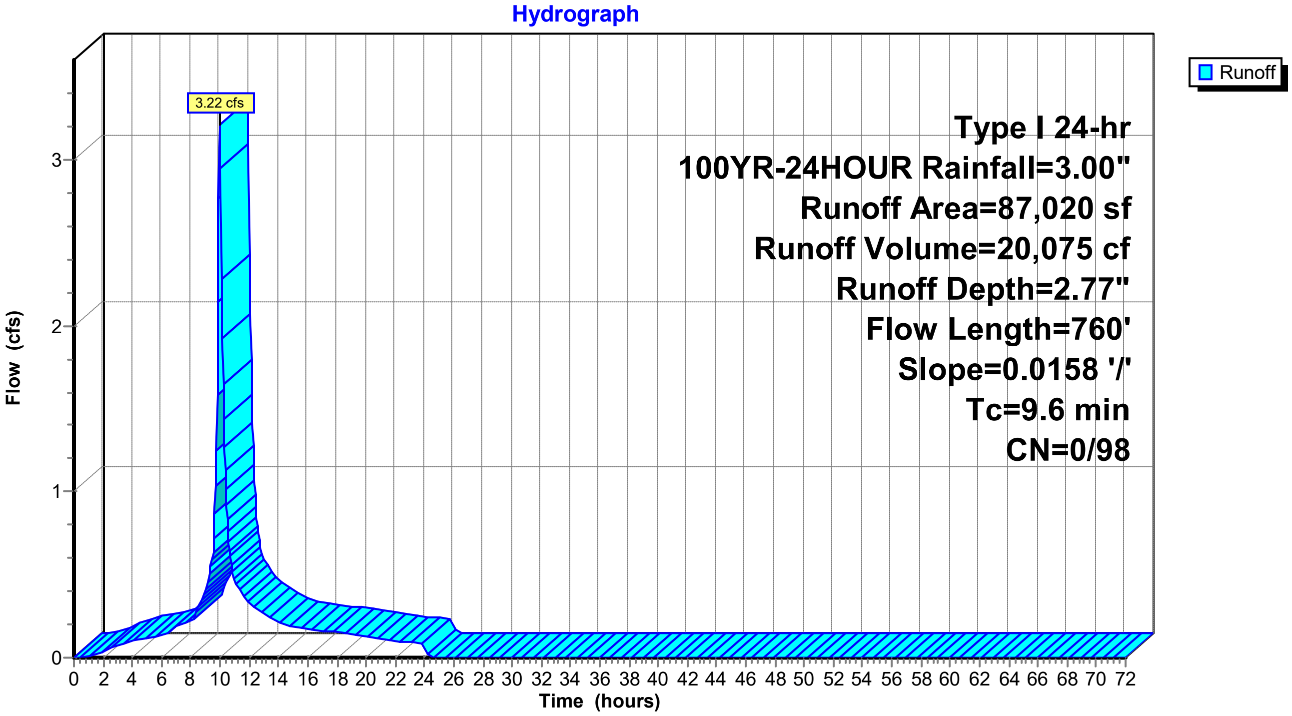
Runoff = 3.22 cfs @ 9.97 hrs, Volume= 20,075 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
87,020	98	Paved roads w/curbs & sewers, HSG A
87,020	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.6	760	0.0158	1.32		**Lag/CN Method,**

Subcatchment G5: GREENWOOD 5



Summary for Subcatchment G6: GREENWOOD 6

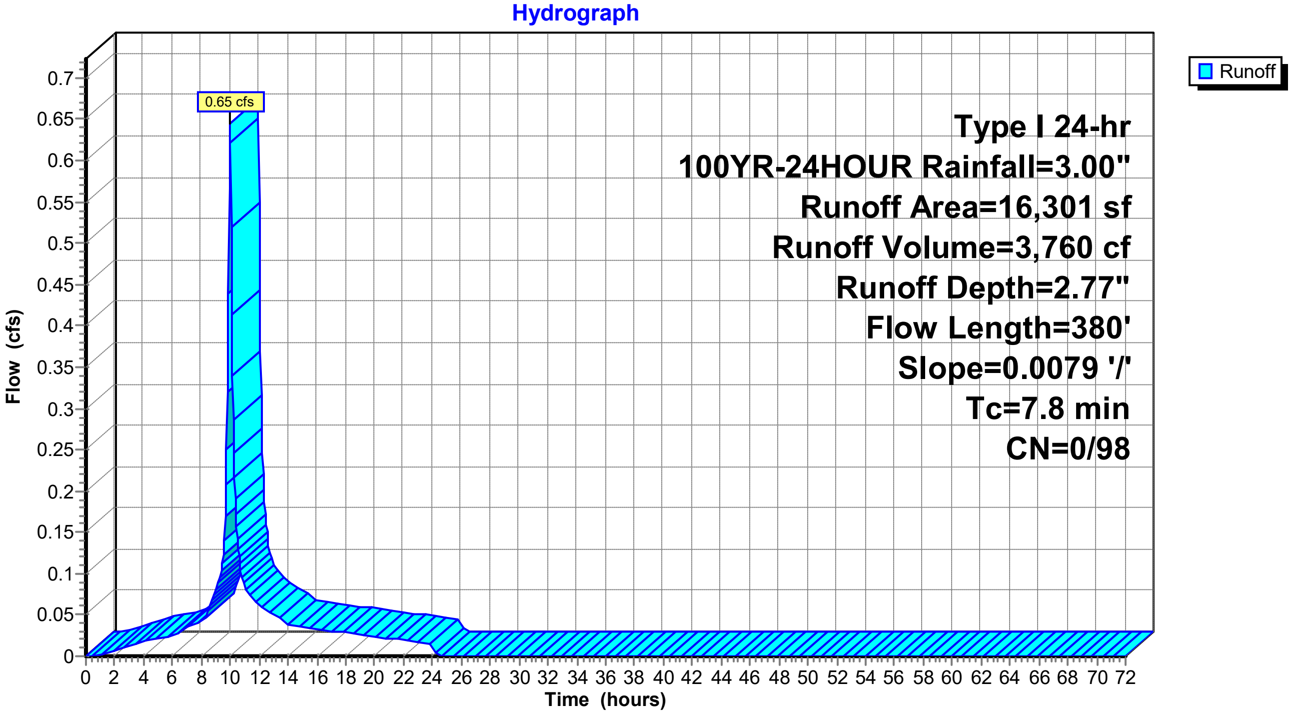
Runoff = 0.65 cfs @ 9.96 hrs, Volume= 3,760 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
16,301	98	Paved roads w/curbs & sewers, HSG A
16,301	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.8	380	0.0079	0.81		**Lag/CN Method,**

Subcatchment G6: GREENWOOD 6



Summary for Subcatchment G7: GREENWOOD 7

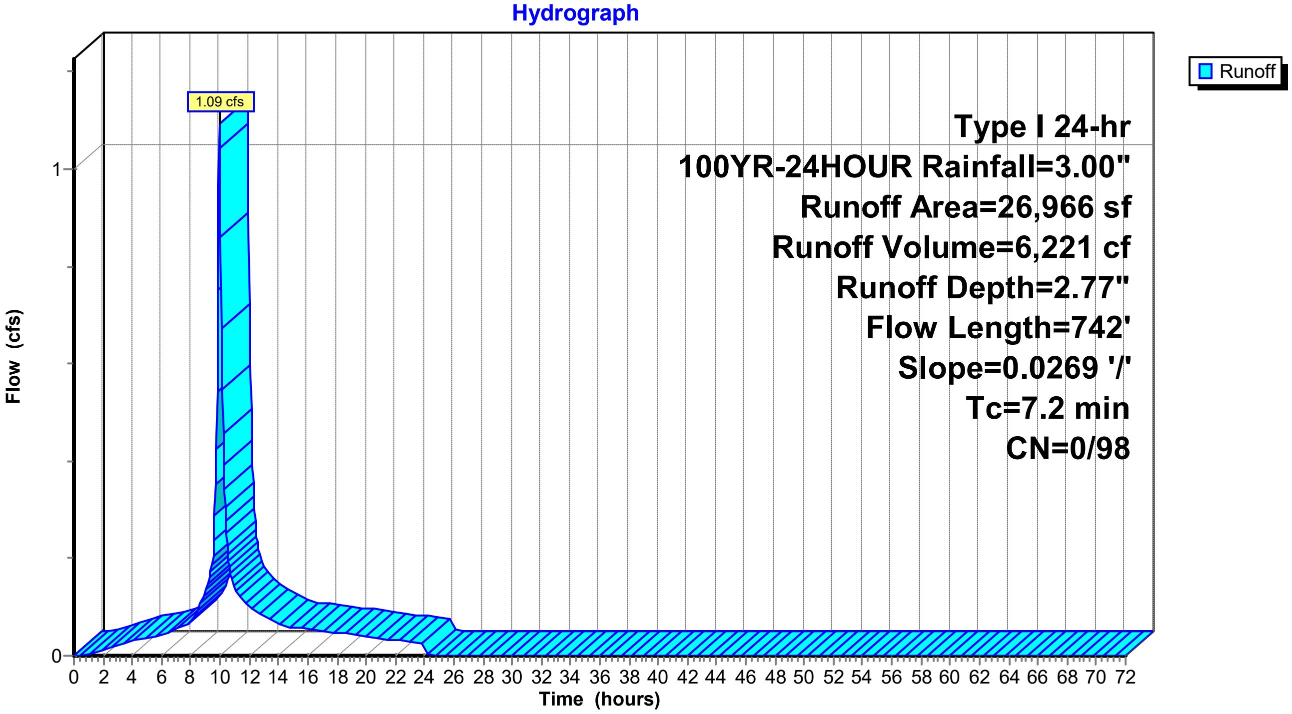
Runoff = 1.09 cfs @ 9.96 hrs, Volume= 6,221 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
26,966	98	Paved roads w/curbs & sewers, HSG A
26,966	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.2	742	0.0269	1.71		**Lag/CN Method,**

Subcatchment G7: GREENWOOD 7



Summary for Subcatchment G8: GREENWOOD 8

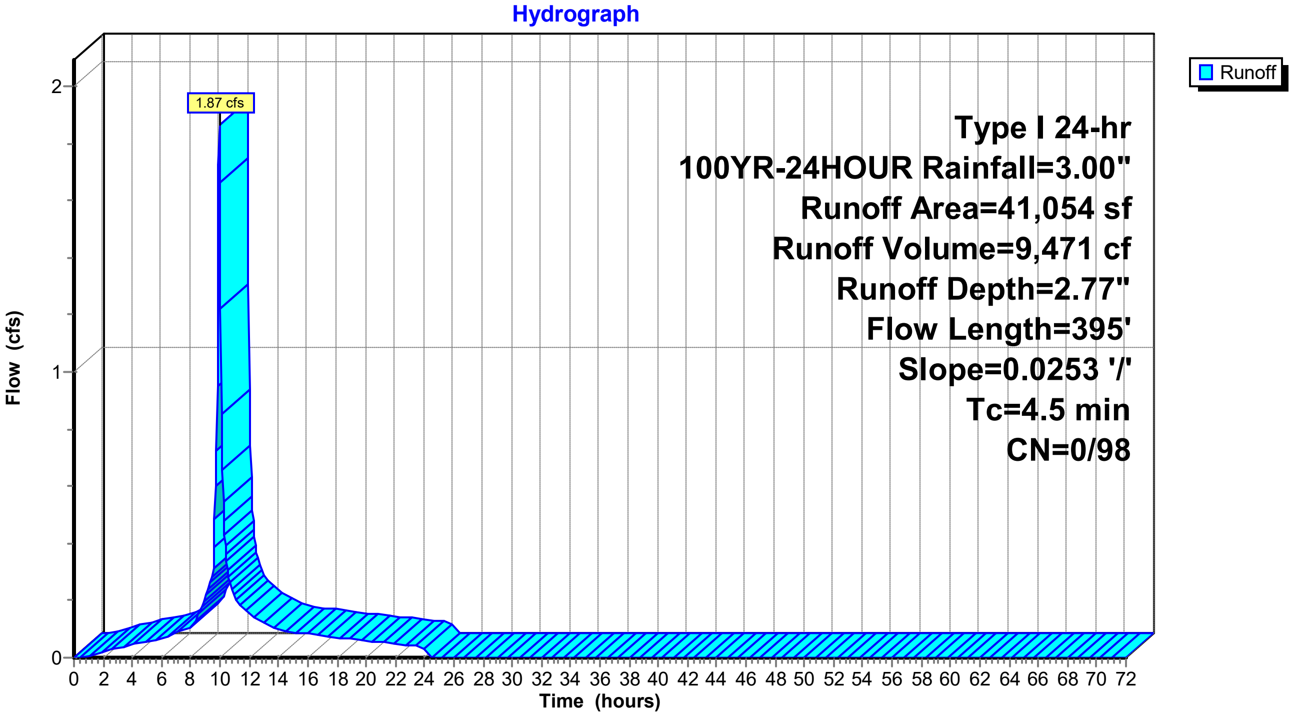
Runoff = 1.87 cfs @ 9.95 hrs, Volume= 9,471 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

Area (sf)	CN	Description
41,054	98	Paved roads w/curbs & sewers, HSG A
41,054	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.5	395	0.0253	1.46		**Lag/CN Method,**

Subcatchment G8: GREENWOOD 8



Summary for Subcatchment G9: GREENWOOD 9

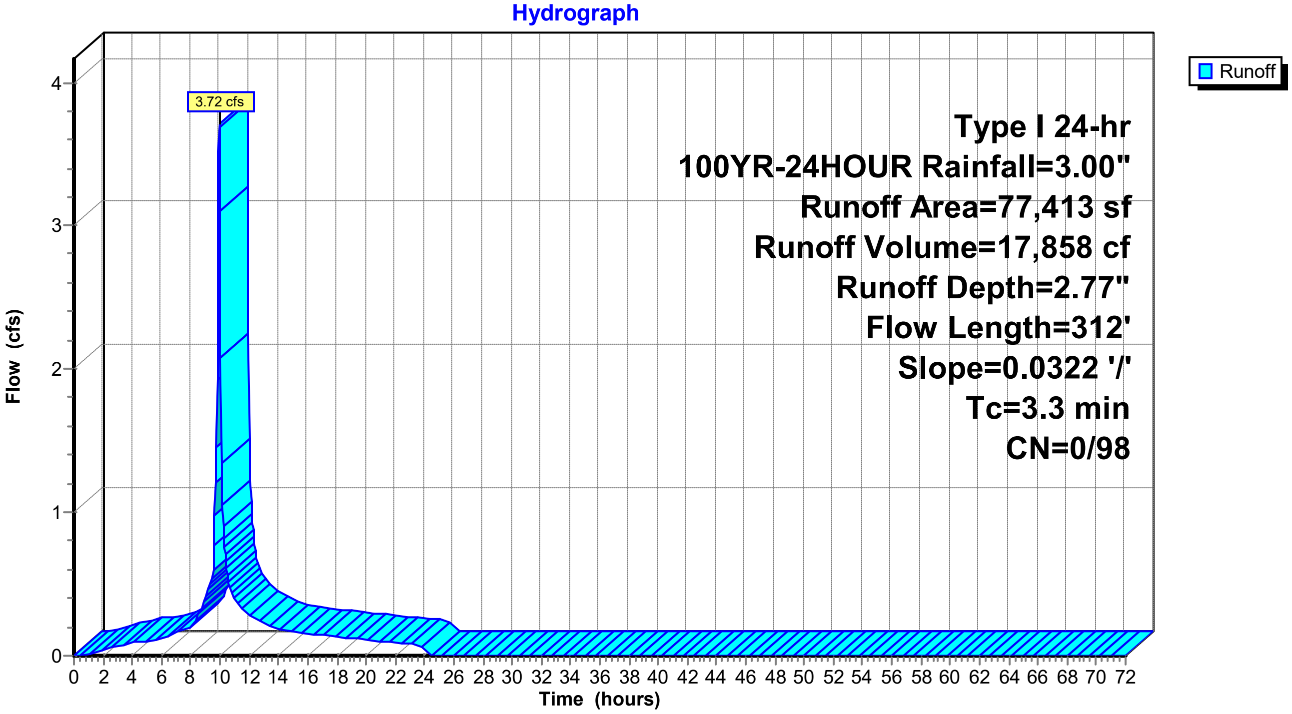
Runoff = 3.72 cfs @ 9.94 hrs, Volume= 17,858 cf, Depth= 2.77"
Routed to nonexistent node DW-1A-B

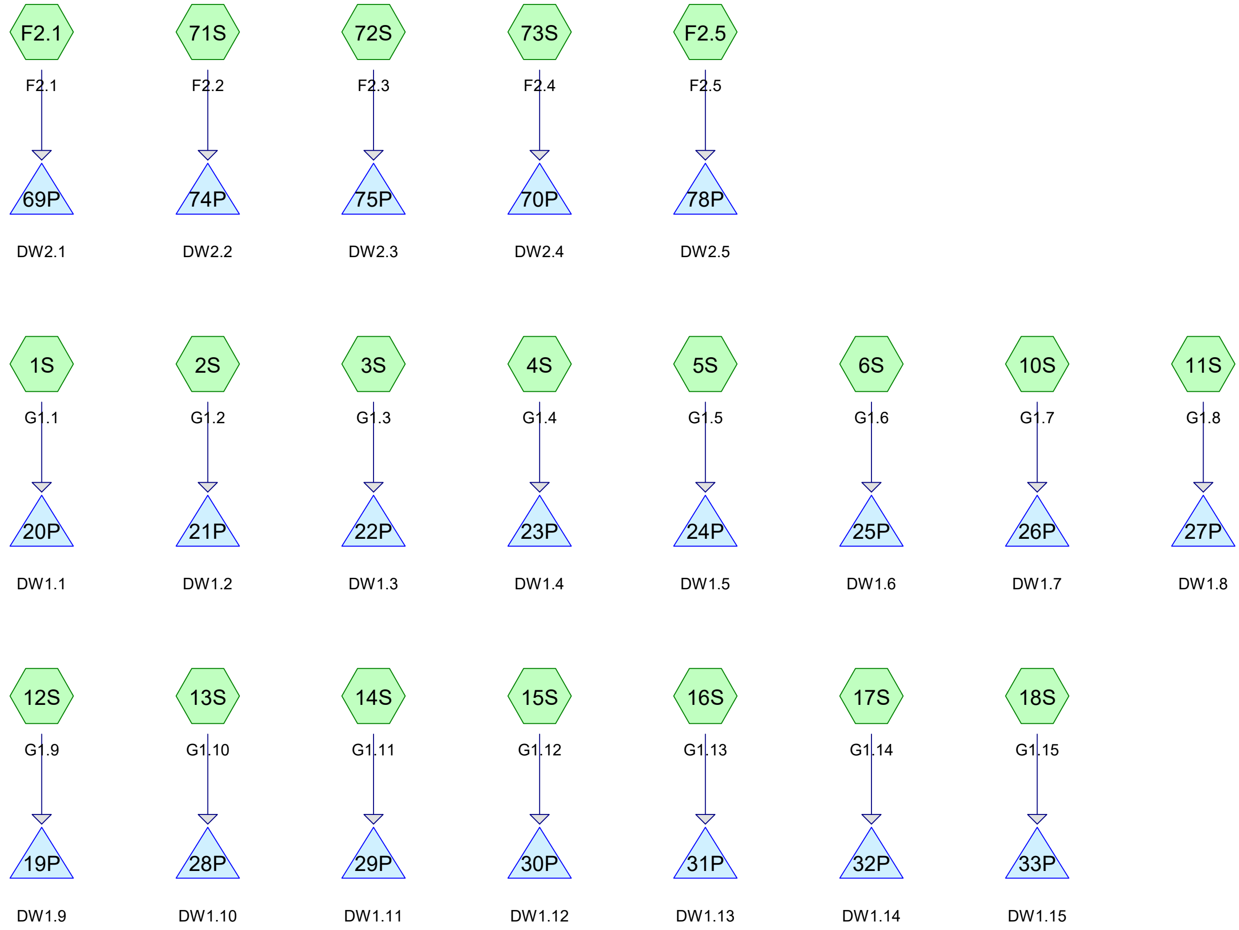
Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

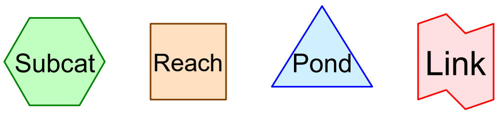
Area (sf)	CN	Description
77,413	98	Paved roads w/curbs & sewers, HSG A
77,413	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.3	312	0.0322	1.57		**Lag/CN Method,**

Subcatchment G9: GREENWOOD 9







Routing Diagram for Midtown Crossings_ROW+20
Prepared by DOWL, Printed 10/16/2024
HydroCAD® 10.20-5a s/n 05397 © 2023 HydroCAD Software Solutions LLC

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	6MO-24HOUR	Type I 24-hr		Default	24.00	1	1.00	2
2	25YR-24HOUR	Type I 24-hr		Default	24.00	1	2.50	2

Summary for Subcatchment 1S: G1.1

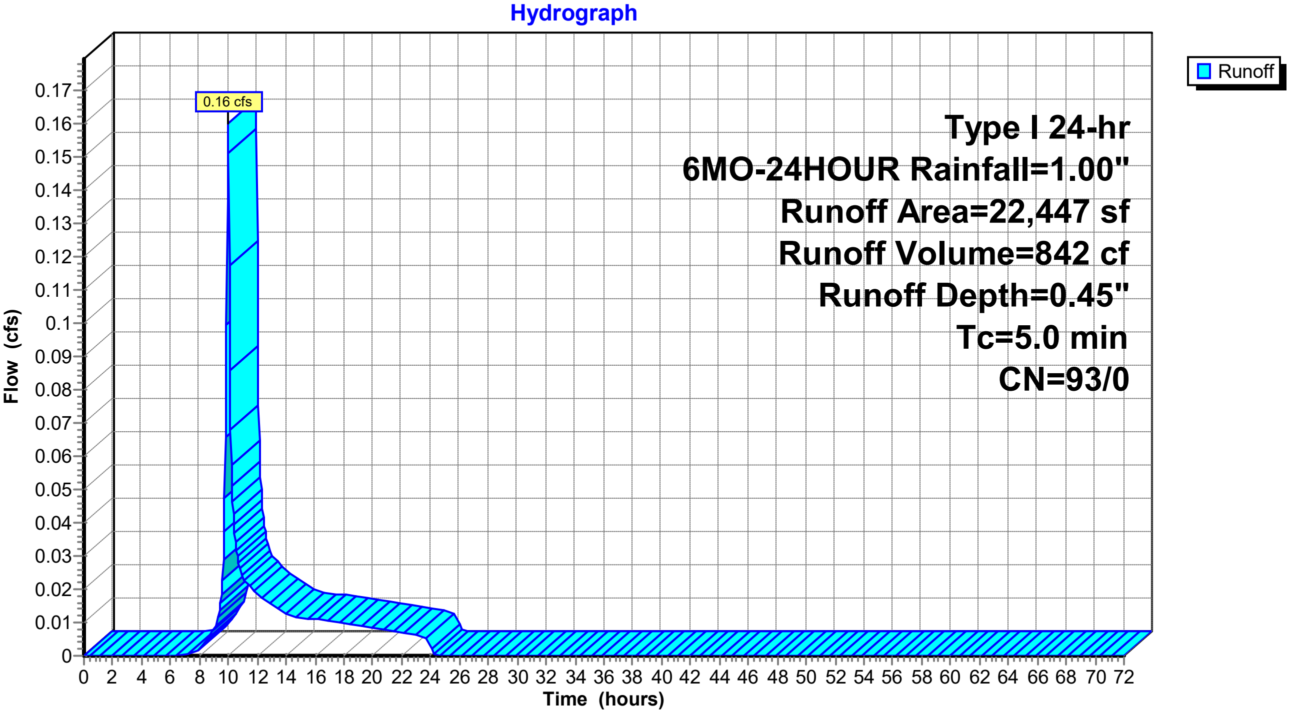
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 842 cf, Depth= 0.45"
Routed to Pond 20P : DW1.1

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,447	93	Paved roads w/curbs & sewers, HSG A
	22,447	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 1S: G1.1



Summary for Subcatchment 2S: G1.2

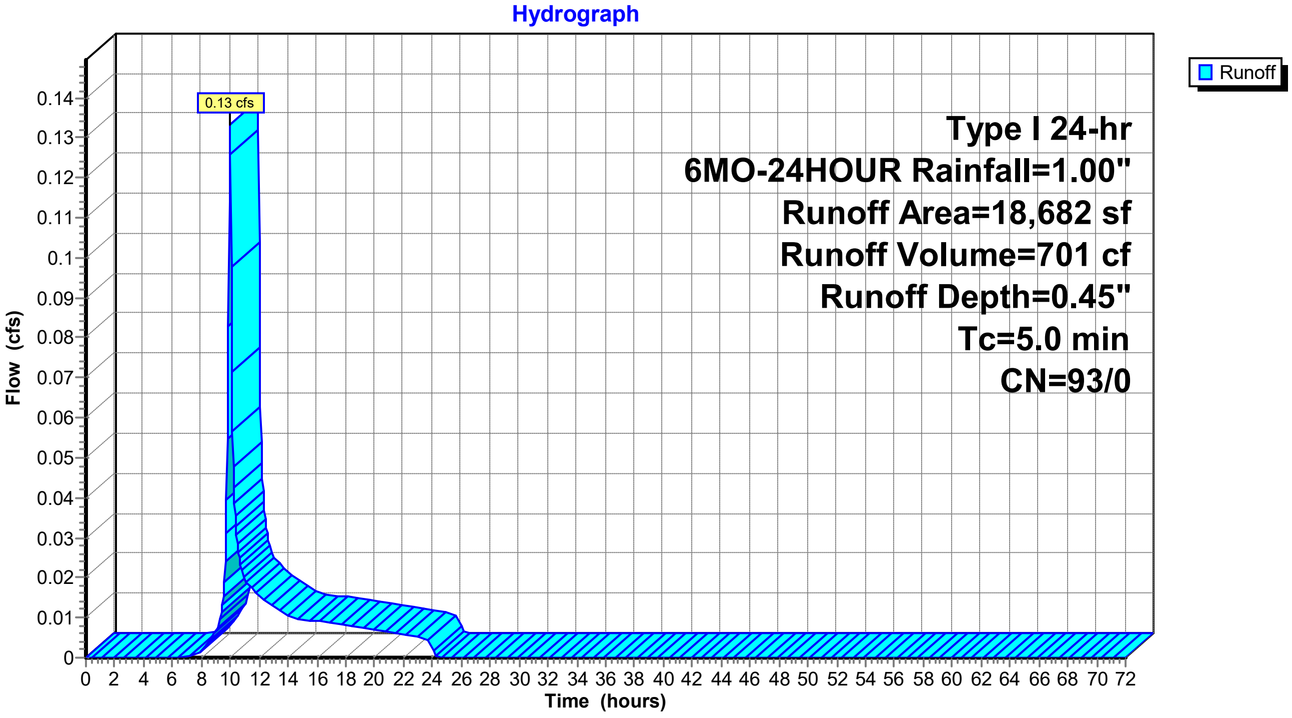
Runoff = 0.13 cfs @ 9.96 hrs, Volume= 701 cf, Depth= 0.45"
Routed to Pond 21P : DW1.2

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	18,682	93	Paved roads w/curbs & sewers, HSG A
	18,682	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 2S: G1.2



Summary for Subcatchment 3S: G1.3

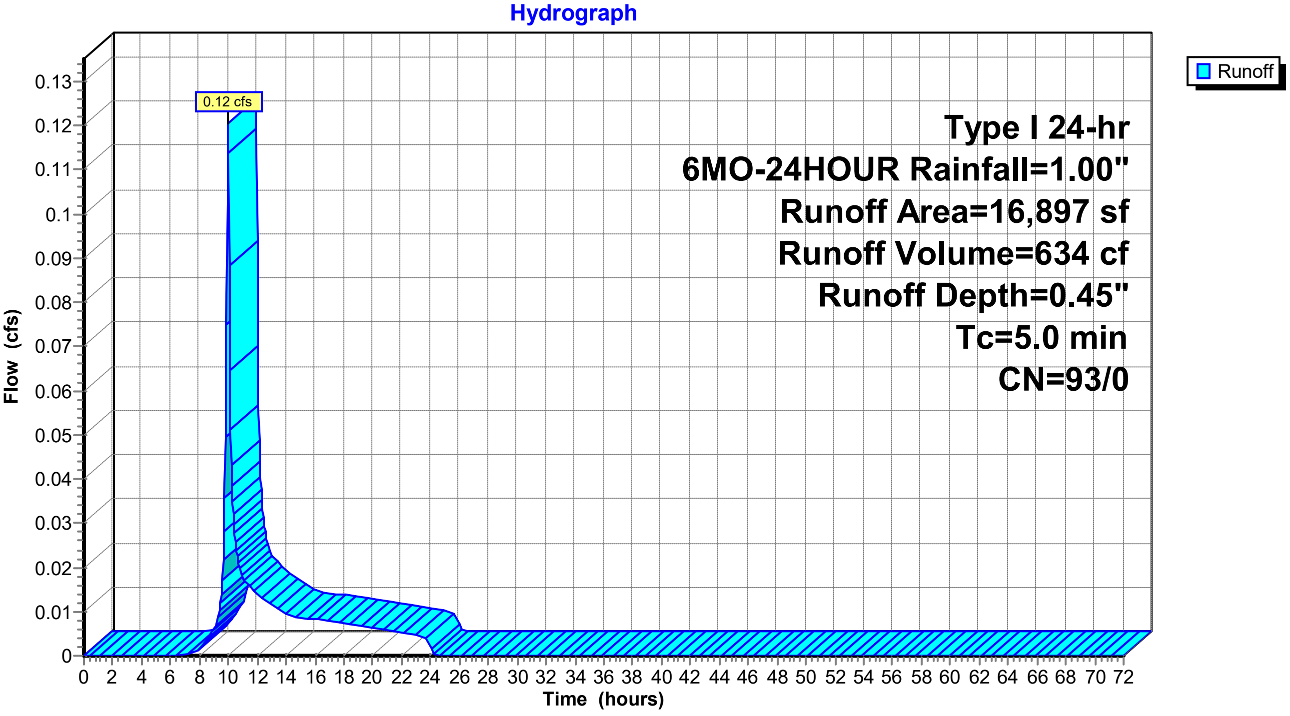
Runoff = 0.12 cfs @ 9.96 hrs, Volume= 634 cf, Depth= 0.45"
Routed to Pond 22P : DW1.3

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	16,897	93	Paved roads w/curbs & sewers, HSG A
	16,897	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 3S: G1.3



Summary for Subcatchment 4S: G1.4

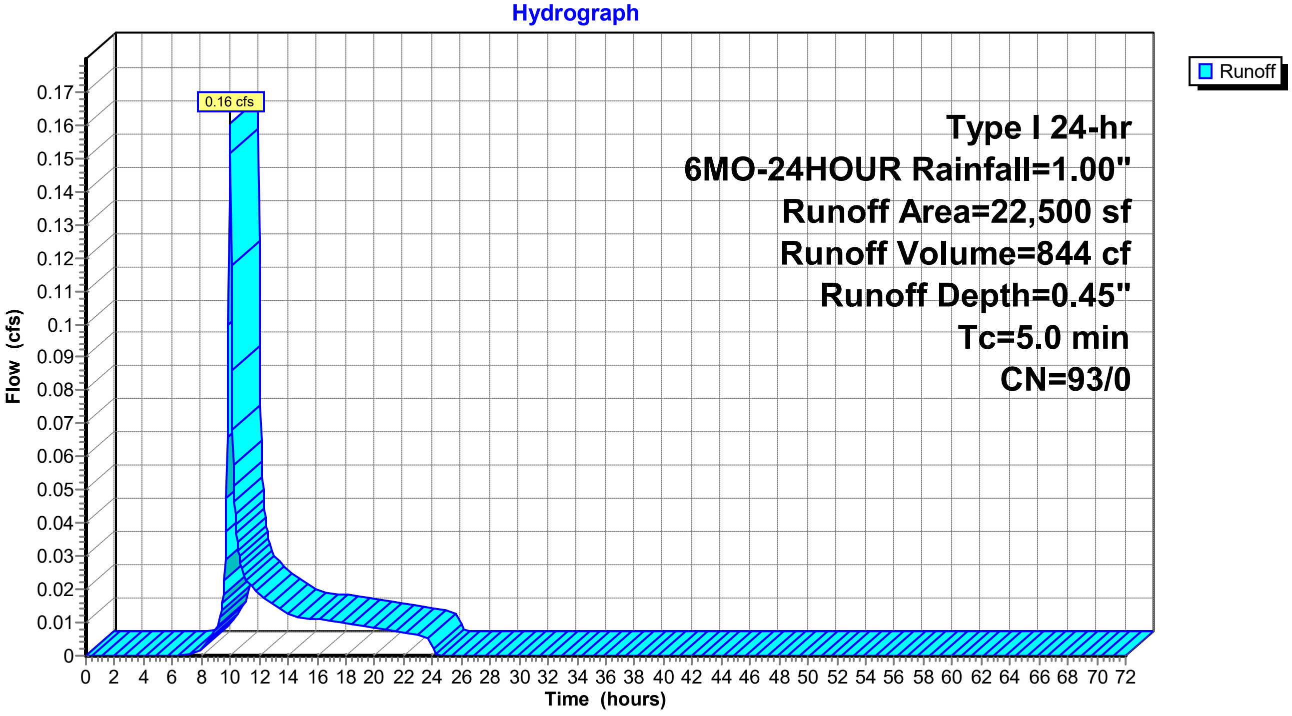
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 844 cf, Depth= 0.45"
Routed to Pond 23P : DW1.4

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 4S: G1.4



Summary for Subcatchment 5S: G1.5

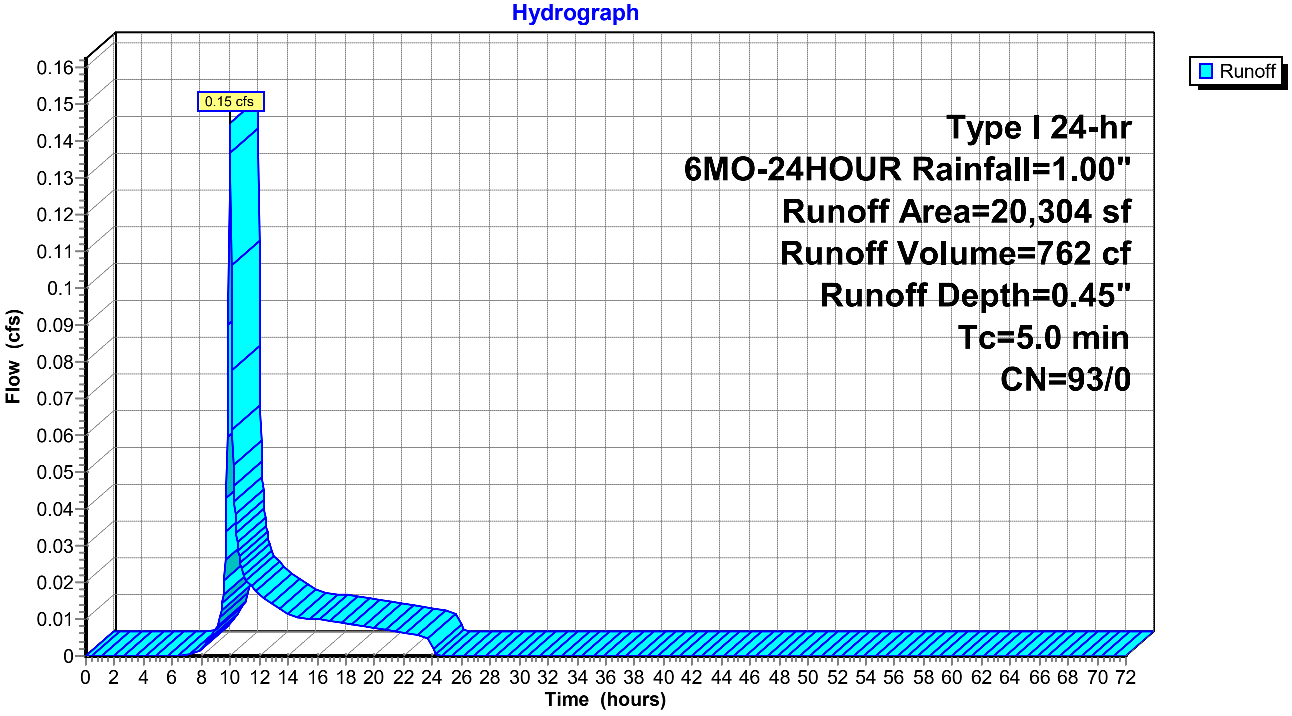
Runoff = 0.15 cfs @ 9.96 hrs, Volume= 762 cf, Depth= 0.45"
Routed to Pond 24P : DW1.5

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	20,304	93	Paved roads w/curbs & sewers, HSG A
	20,304	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 5S: G1.5



Summary for Subcatchment 6S: G1.6

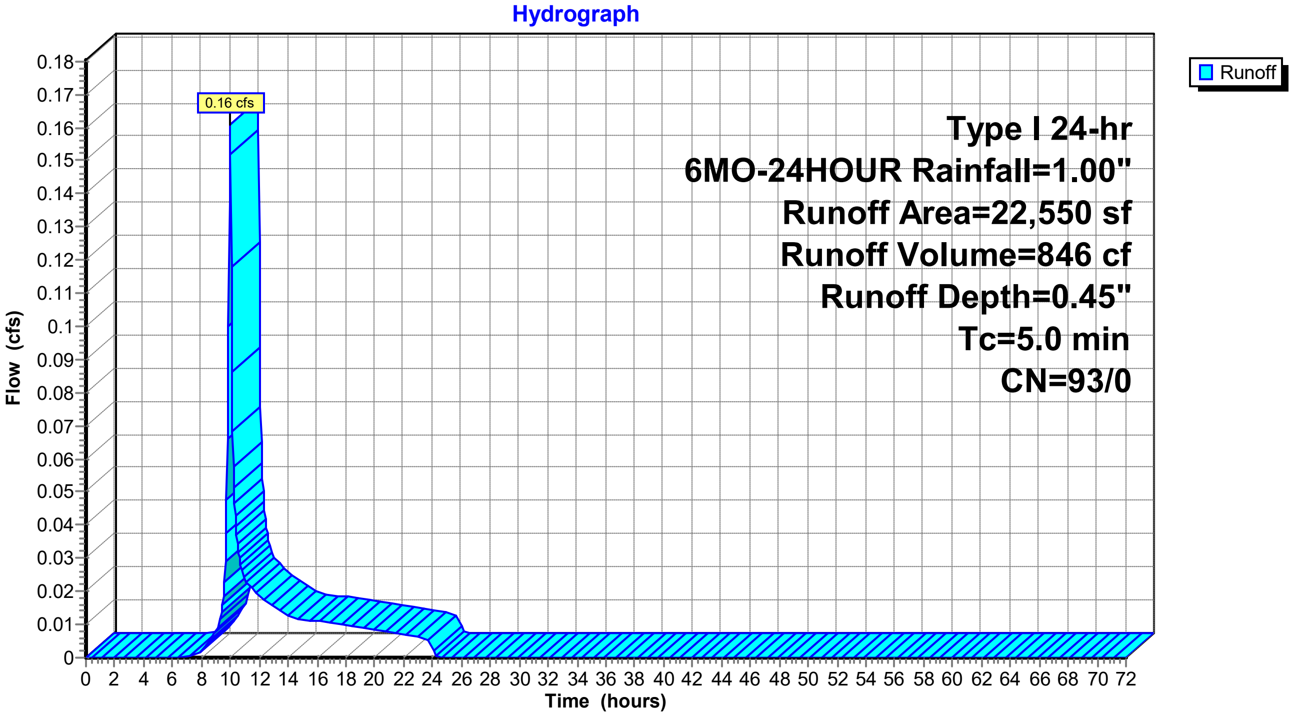
```
Runoff     =        0.16 cfs @    9.96 hrs,  Volume=             846 cf,  Depth=  0.45"
    Routed to Pond 25P : DW1.6
```

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,550	93	Paved roads w/curbs & sewers, HSG A
	22,550	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 6S: G1.6



Summary for Subcatchment 10S: G1.7

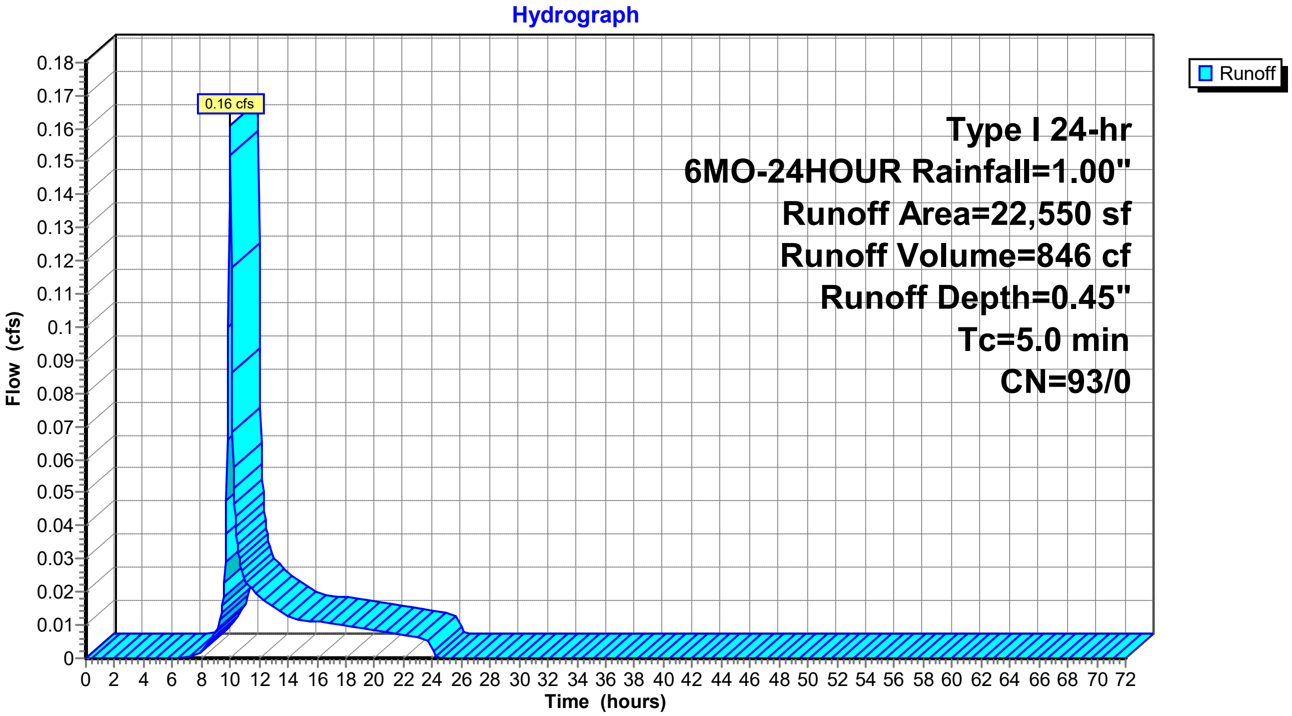
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 846 cf, Depth= 0.45"
Routed to Pond 26P : DW1.7

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,550	93	Paved roads w/curbs & sewers, HSG A
	22,550	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 10S: G1.7



Summary for Subcatchment 11S: G1.8

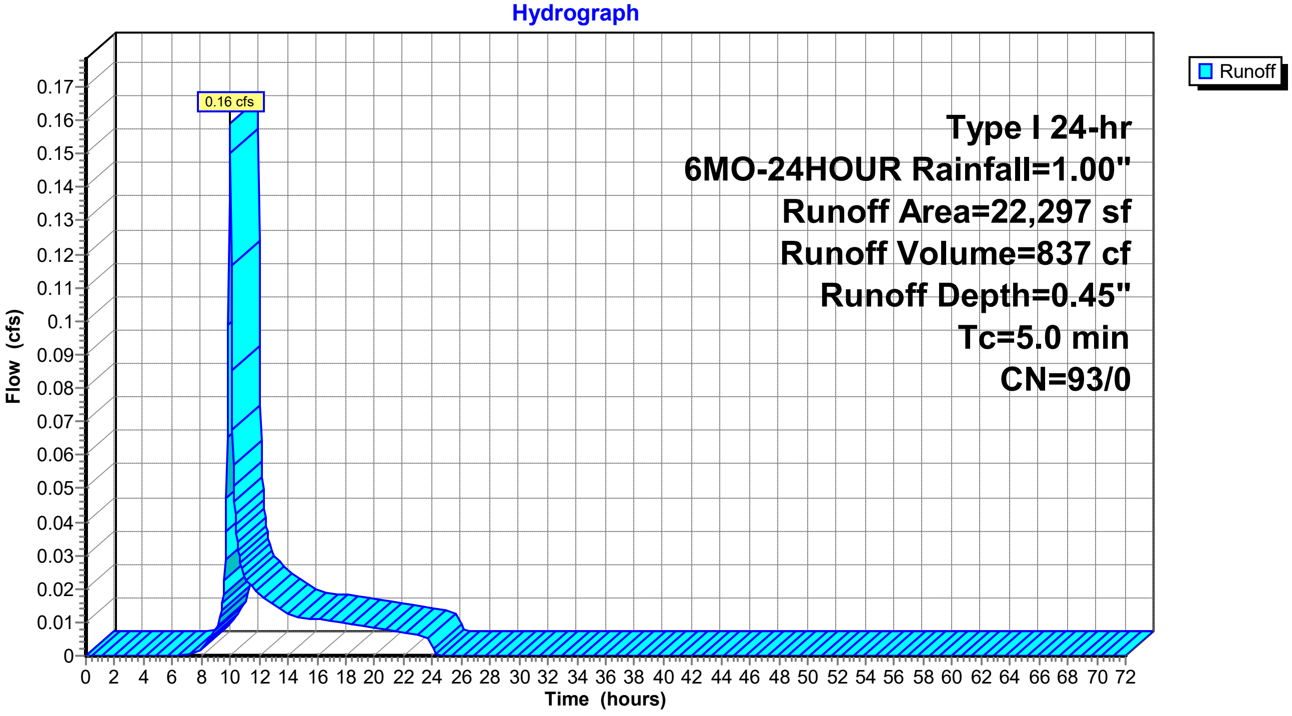
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 837 cf, Depth= 0.45"
Routed to Pond 27P : DW1.8

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,297	93	Paved roads w/curbs & sewers, HSG A
	22,297	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 11S: G1.8



Summary for Subcatchment 12S: G1.9

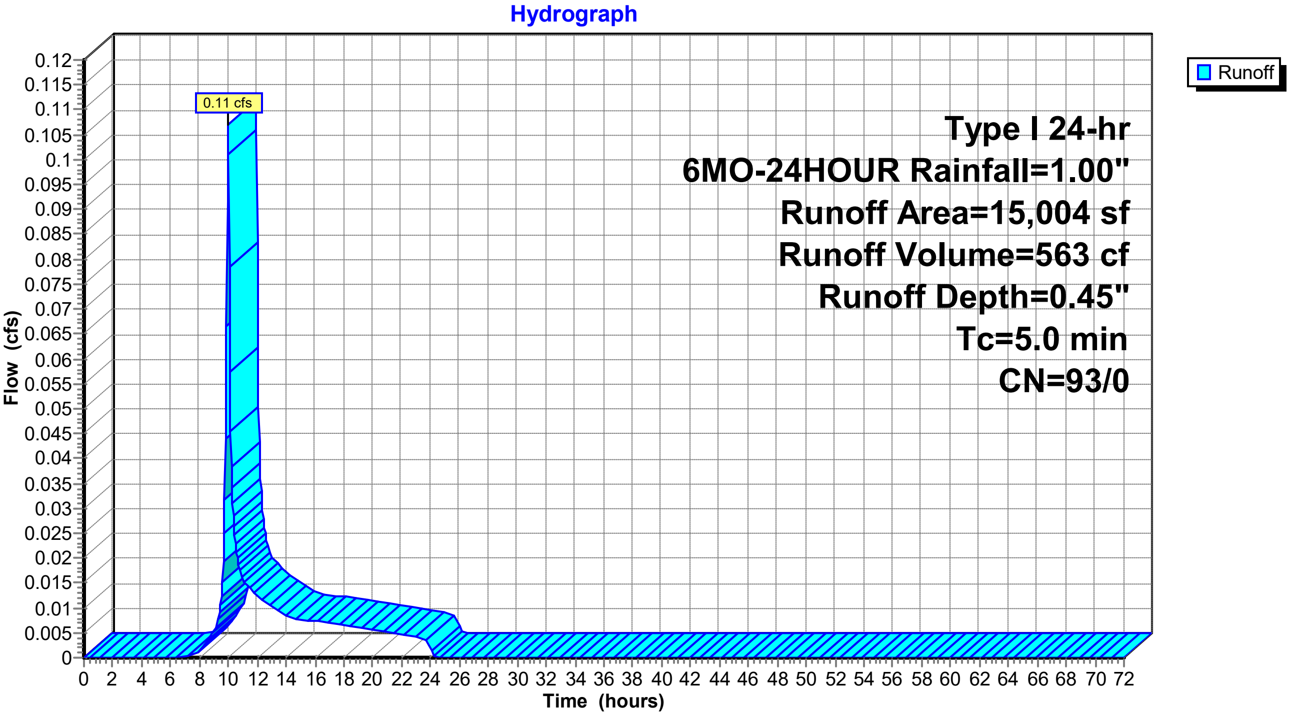
Runoff = 0.11 cfs @ 9.96 hrs, Volume= 563 cf, Depth= 0.45"
Routed to Pond 19P : DW1.9

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	15,004	93	Paved roads w/curbs & sewers, HSG A
	15,004	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 12S: G1.9



Summary for Subcatchment 13S: G1.10

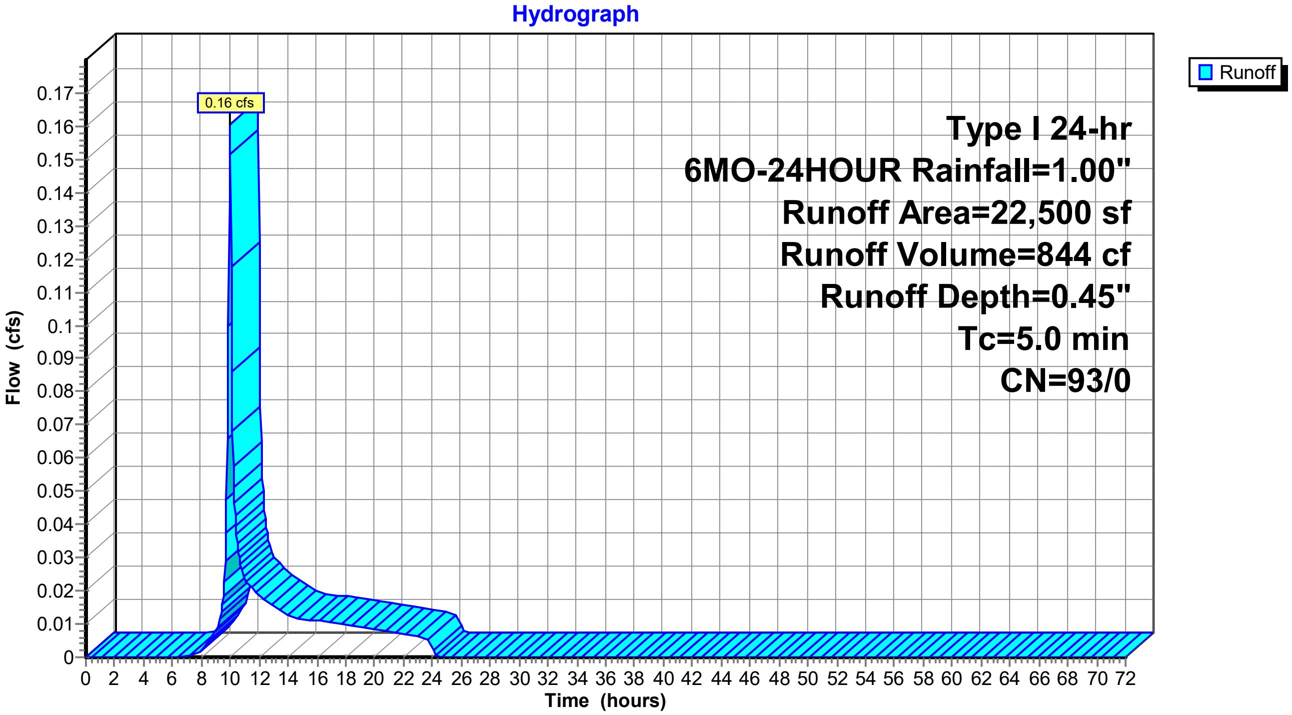
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 844 cf, Depth= 0.45"
Routed to Pond 28P : DW1.10

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 13S: G1.10



Summary for Subcatchment 14S: G1.11

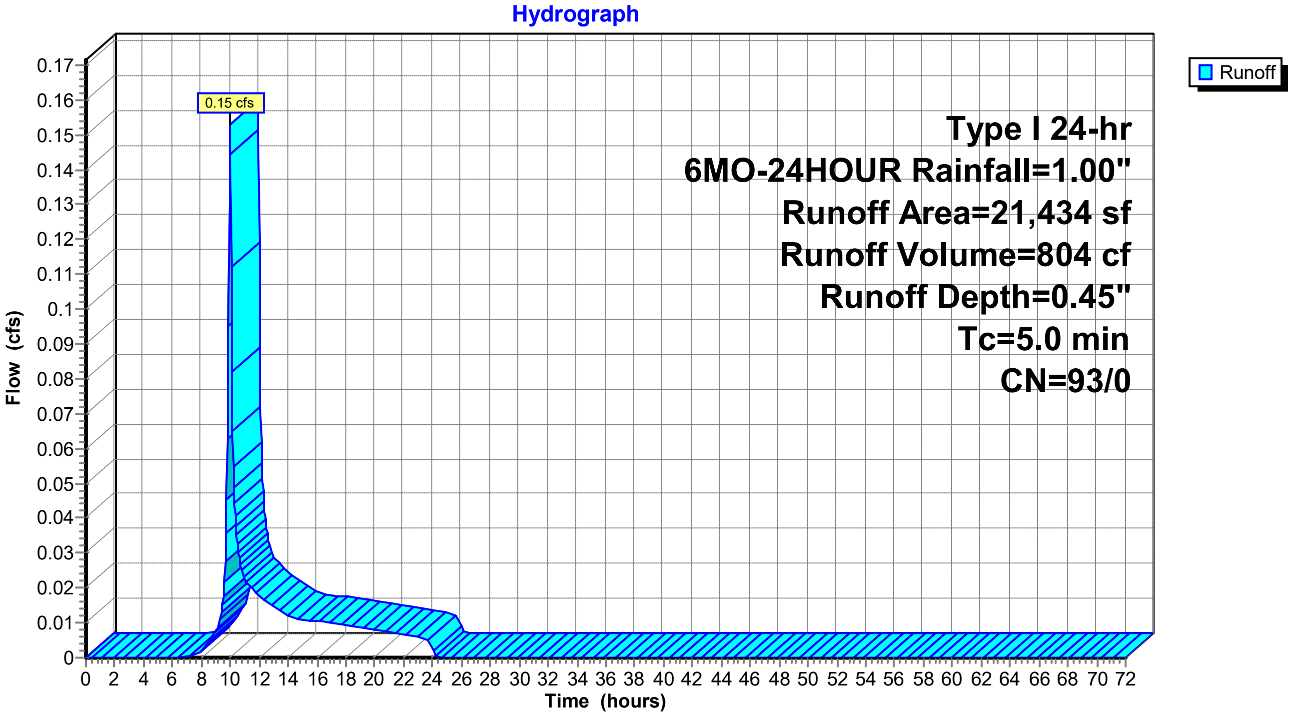
Runoff = 0.15 cfs @ 9.96 hrs, Volume= 804 cf, Depth= 0.45"
Routed to Pond 29P : DW1.11

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	21,434	93	Paved roads w/curbs & sewers, HSG A
	21,434	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 14S: G1.11



Summary for Subcatchment 15S: G1.12

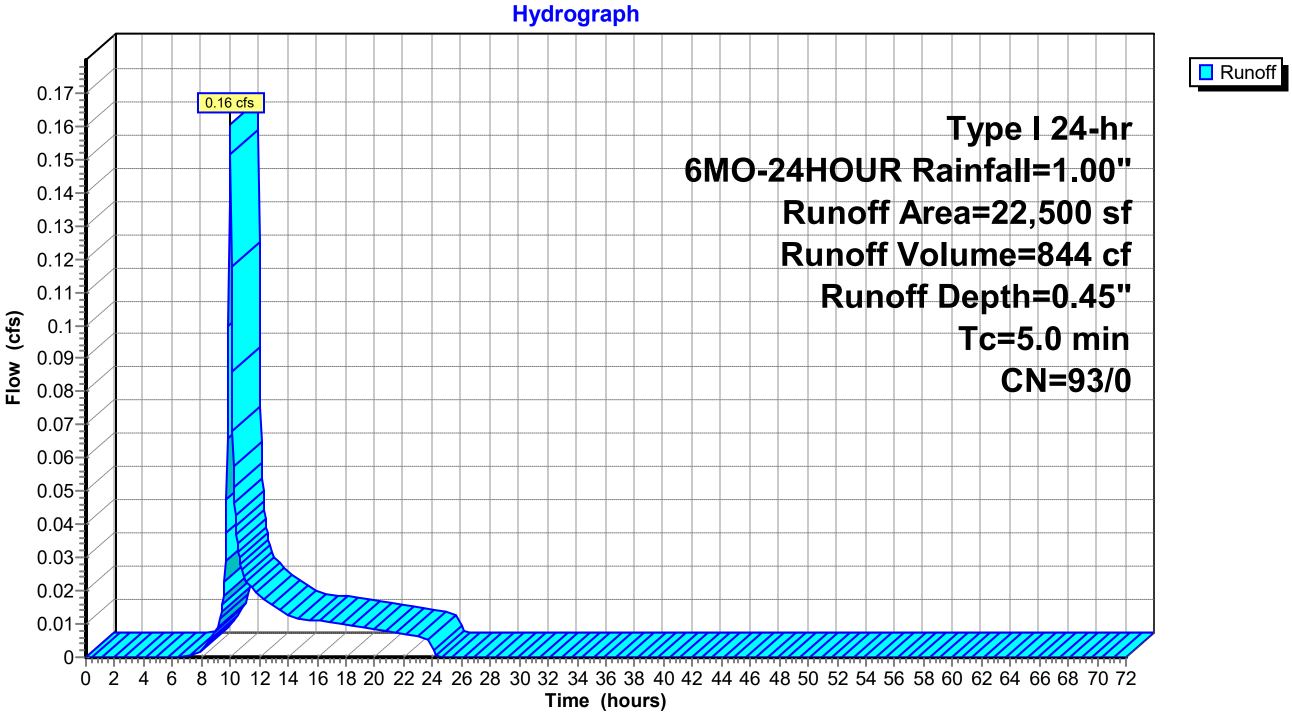
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 844 cf, Depth= 0.45"
Routed to Pond 30P : DW1.12

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 15S: G1.12



Summary for Subcatchment 16S: G1.13

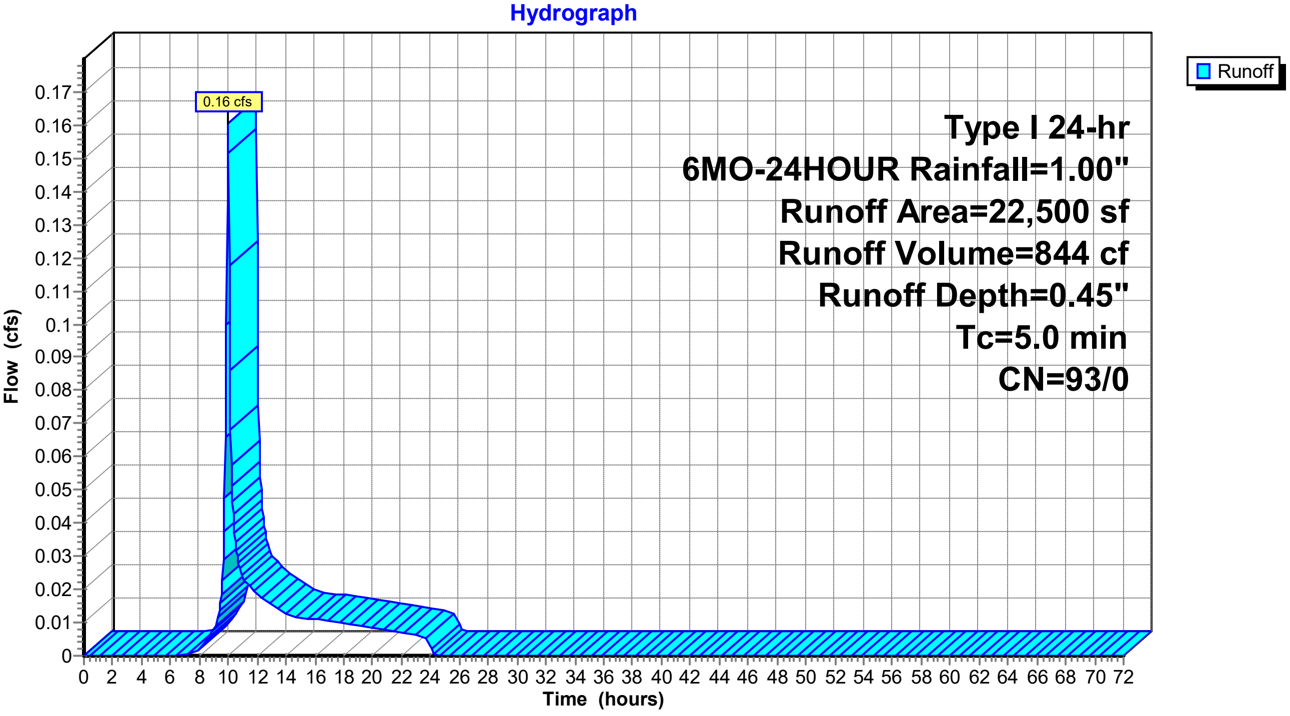
```
Runoff      =         0.16 cfs @     9.96 hrs,  Volume=               844 cf,  Depth=  0.45"
    Routed to Pond 31P : DW1.13
```

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 16S: G1.13



Summary for Subcatchment 17S: G1.14

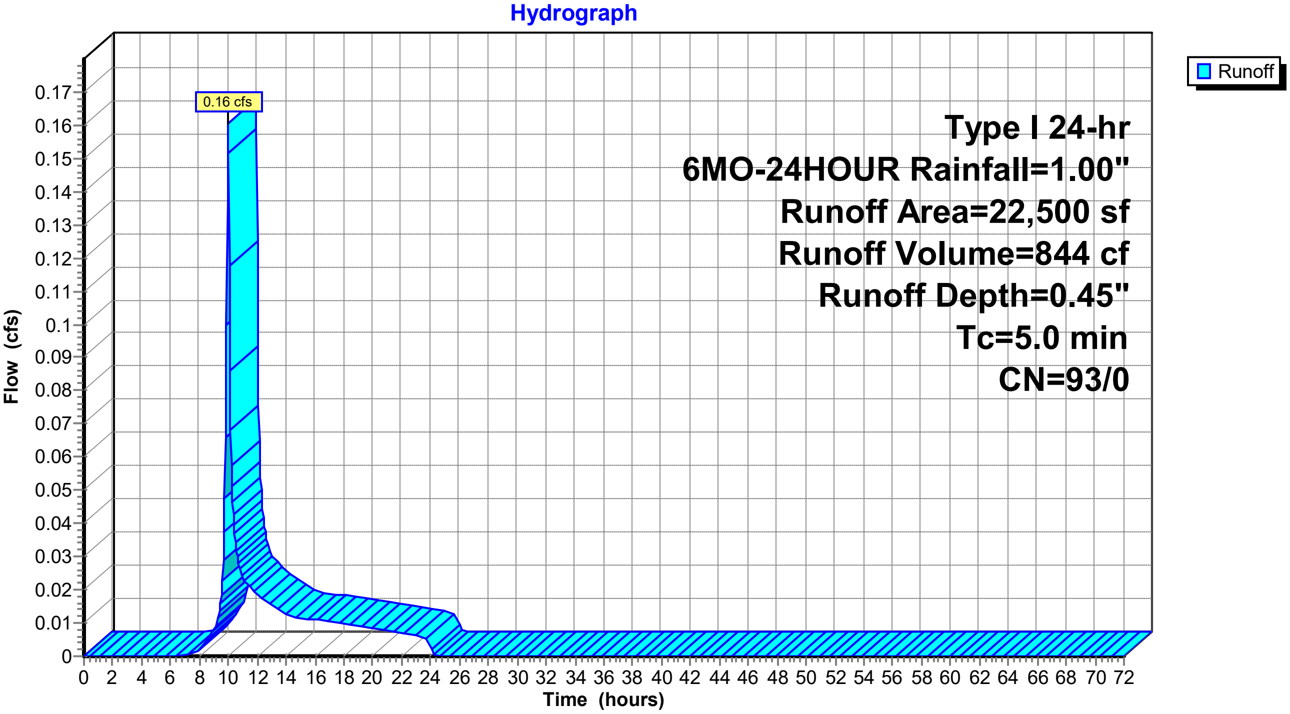
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 844 cf, Depth= 0.45"
Routed to Pond 32P : DW1.14

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 17S: G1.14



Summary for Subcatchment 18S: G1.15

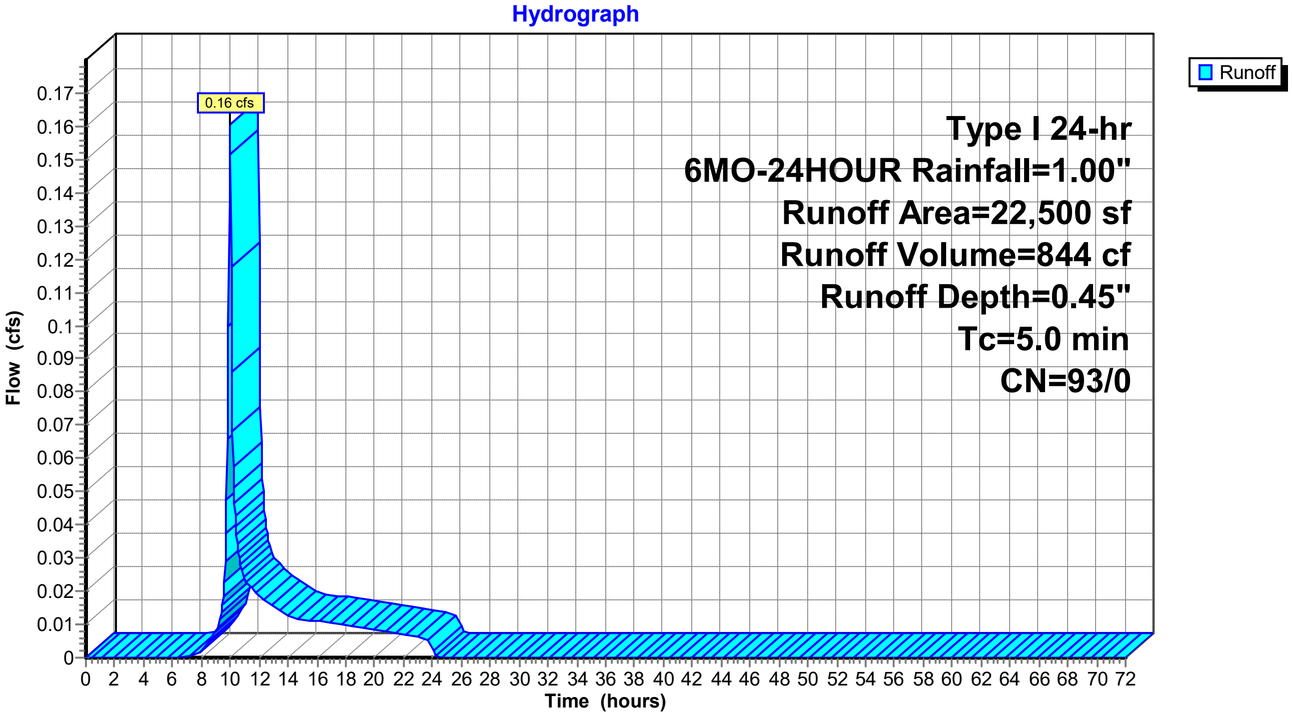
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 844 cf, Depth= 0.45"
Routed to Pond 33P : DW1.15

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 18S: G1.15



Summary for Pond 19P: DW1.9

Inflow Area = 15,004 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.11 cfs @ 9.96 hrs, Volume= 563 cf
Outflow = 0.08 cfs @ 9.95 hrs, Volume= 563 cf, Atten= 22%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.95 hrs, Volume= 563 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.22' @ 10.04 hrs Surf.Area= 225 sf Storage= 20 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 2.7 min calculated for 563 cf (100% of inflow)
Center-of-Mass det. time= 2.7 min (827.4 - 824.7)

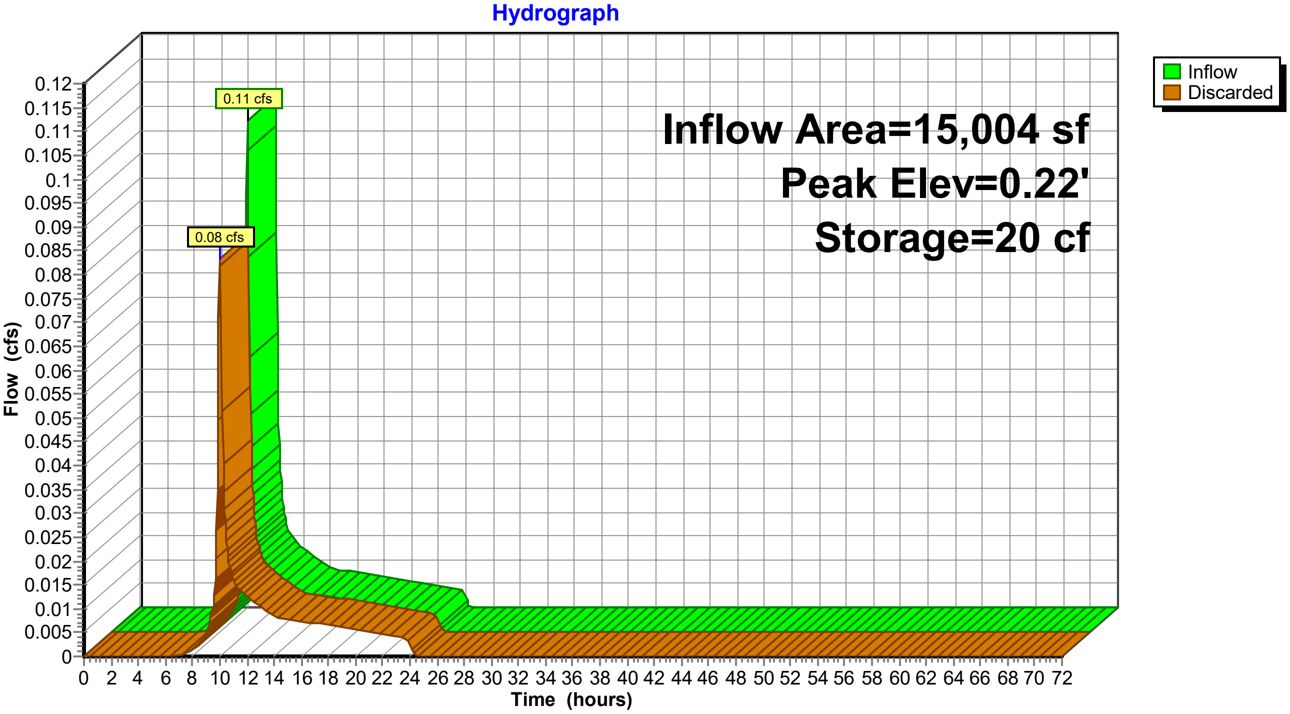
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.95 hrs HW=0.17' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 19P: DW1.9



Summary for Pond 20P: DW1.1

Inflow Area = 22,447 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.16 cfs @ 9.96 hrs, Volume= 842 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 842 cf, Atten= 48%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 842 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.62' @ 10.11 hrs Surf.Area= 225 sf Storage= 56 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 842 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

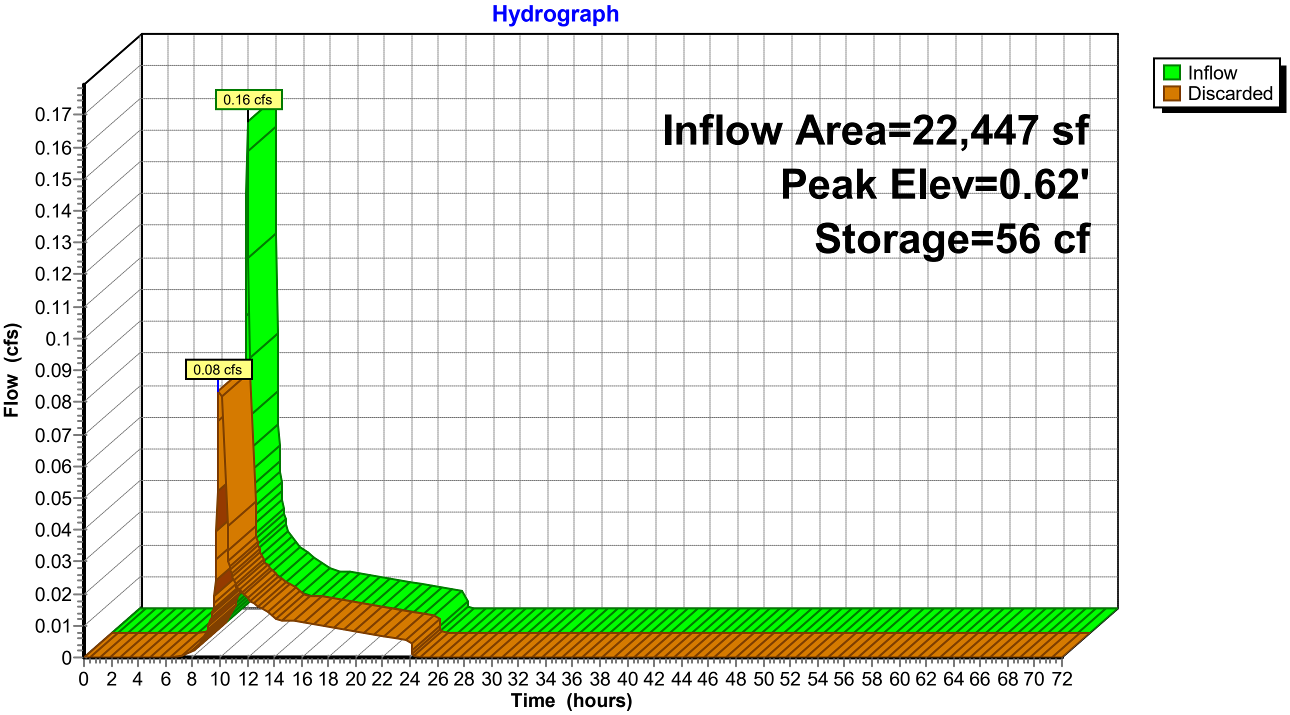
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 20P: DW1.1



Summary for Pond 21P: DW1.2

Inflow Area = 18,682 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.13 cfs @ 9.96 hrs, Volume= 701 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 701 cf, Atten= 38%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 701 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.39' @ 10.08 hrs Surf.Area= 225 sf Storage= 35 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.1 min calculated for 701 cf (100% of inflow)
Center-of-Mass det. time= 3.1 min (827.8 - 824.7)

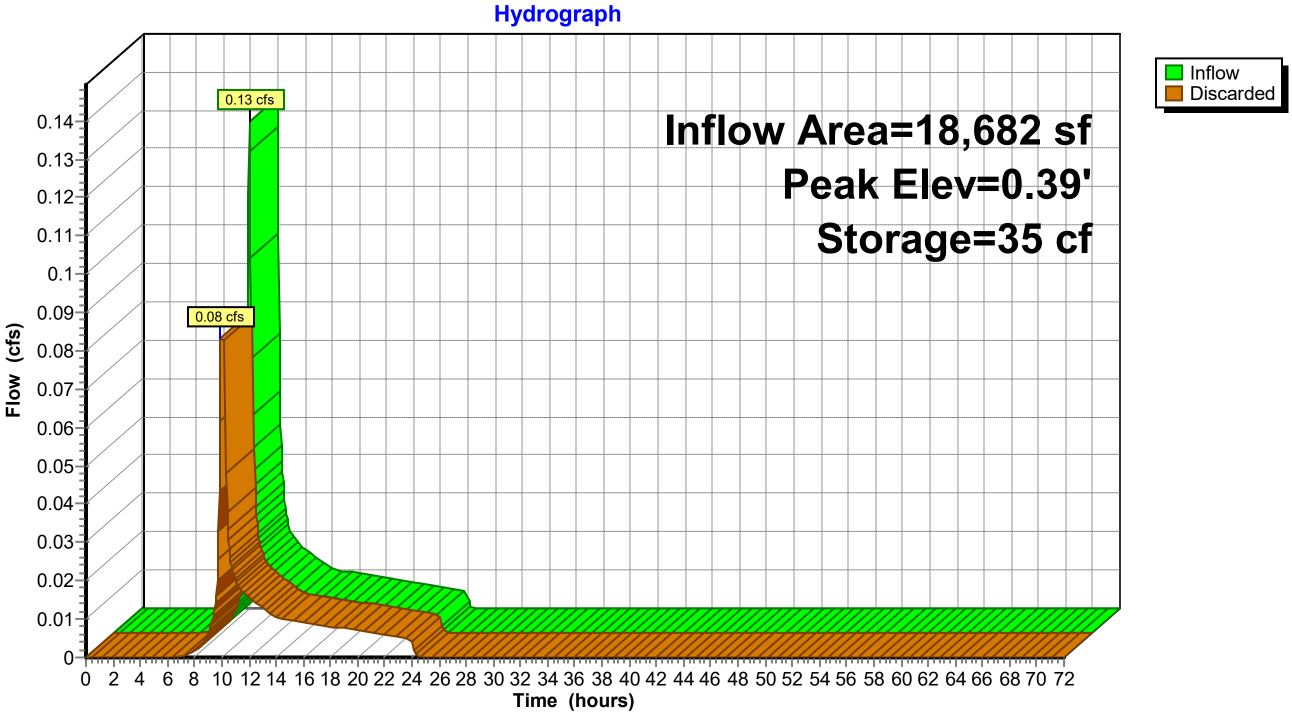
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.16' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 21P: DW1.2



Summary for Pond 22P: DW1.3

Inflow Area = 16,897 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.12 cfs @ 9.96 hrs, Volume= 634 cf
Outflow = 0.08 cfs @ 9.95 hrs, Volume= 634 cf, Atten= 31%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.95 hrs, Volume= 634 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.30' @ 10.06 hrs Surf.Area= 225 sf Storage= 27 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 2.9 min calculated for 634 cf (100% of inflow)
Center-of-Mass det. time= 2.9 min (827.6 - 824.7)

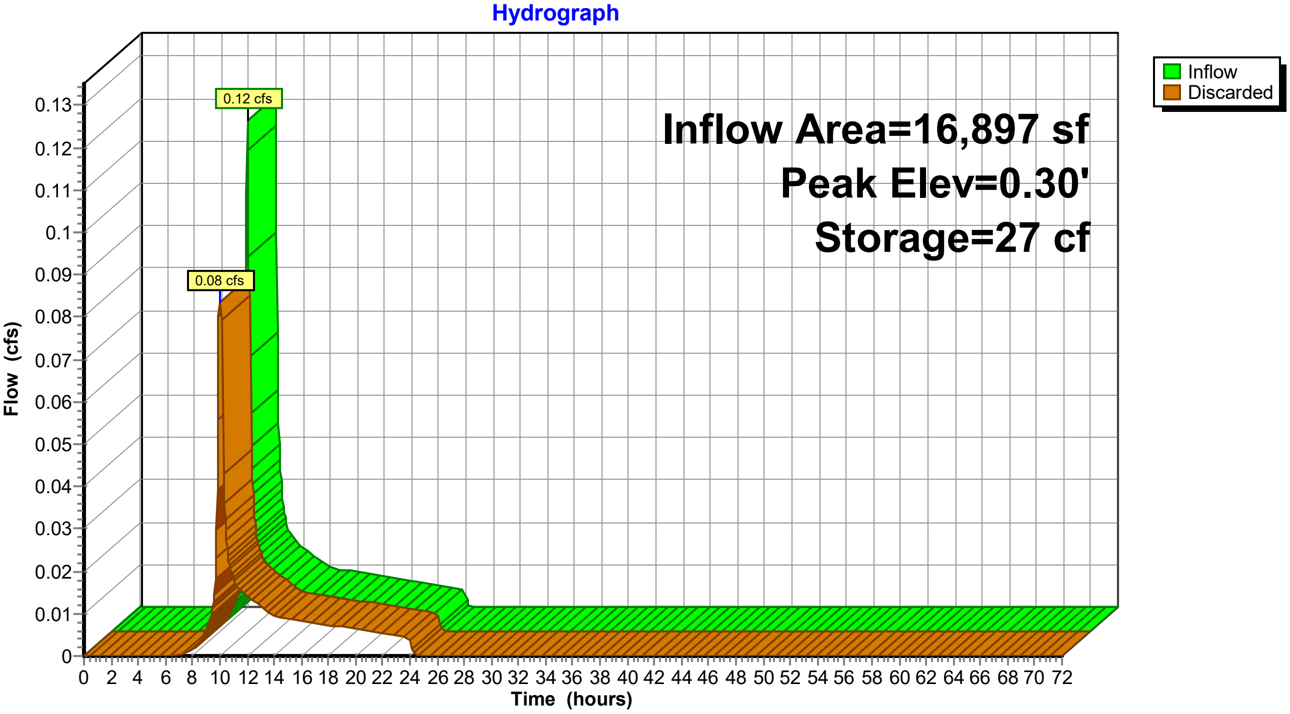
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.95 hrs HW=0.20' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 22P: DW1.3



Summary for Pond 23P: DW1.4

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.16 cfs @ 9.96 hrs, Volume= 844 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 844 cf, Atten= 48%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 844 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs Surf.Area= 225 sf Storage= 56 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 844 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

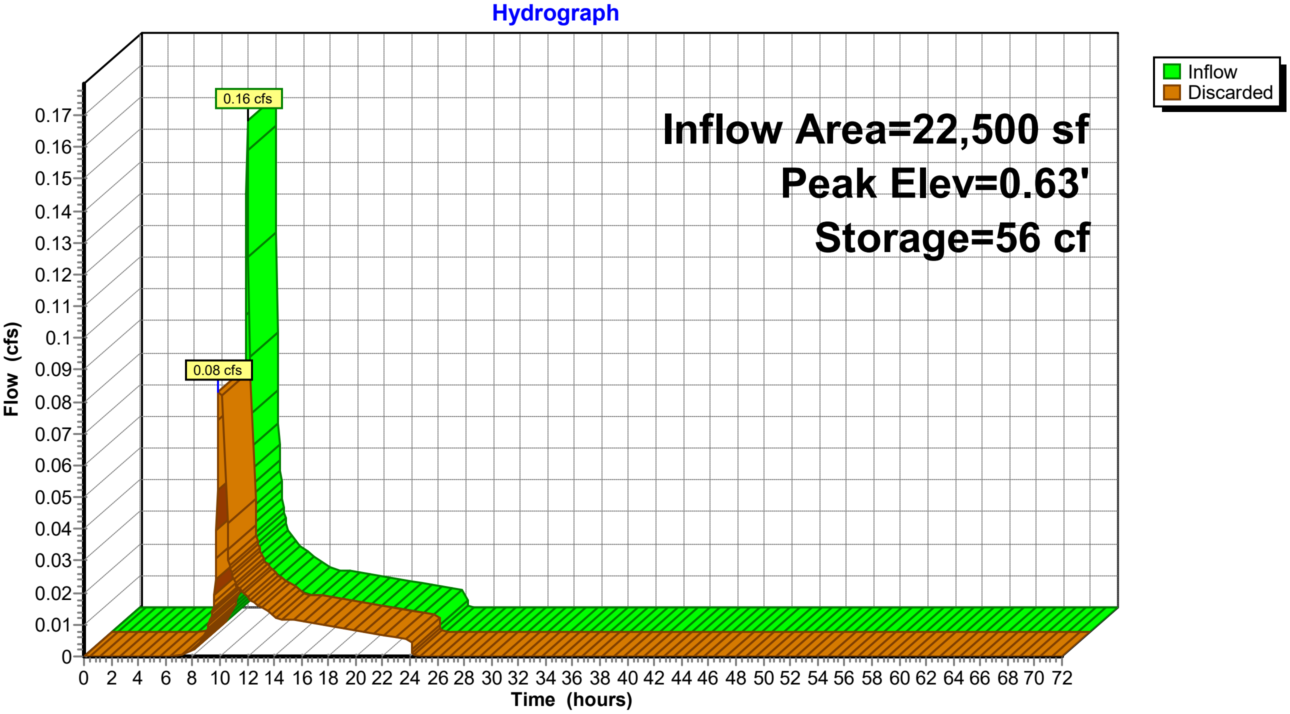
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 23P: DW1.4



Summary for Pond 24P: DW1.5

Inflow Area = 20,304 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.15 cfs @ 9.96 hrs, Volume= 762 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 762 cf, Atten= 43%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 762 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.49' @ 10.09 hrs Surf.Area= 225 sf Storage= 44 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.3 min calculated for 762 cf (100% of inflow)
Center-of-Mass det. time= 3.3 min (828.0 - 824.7)

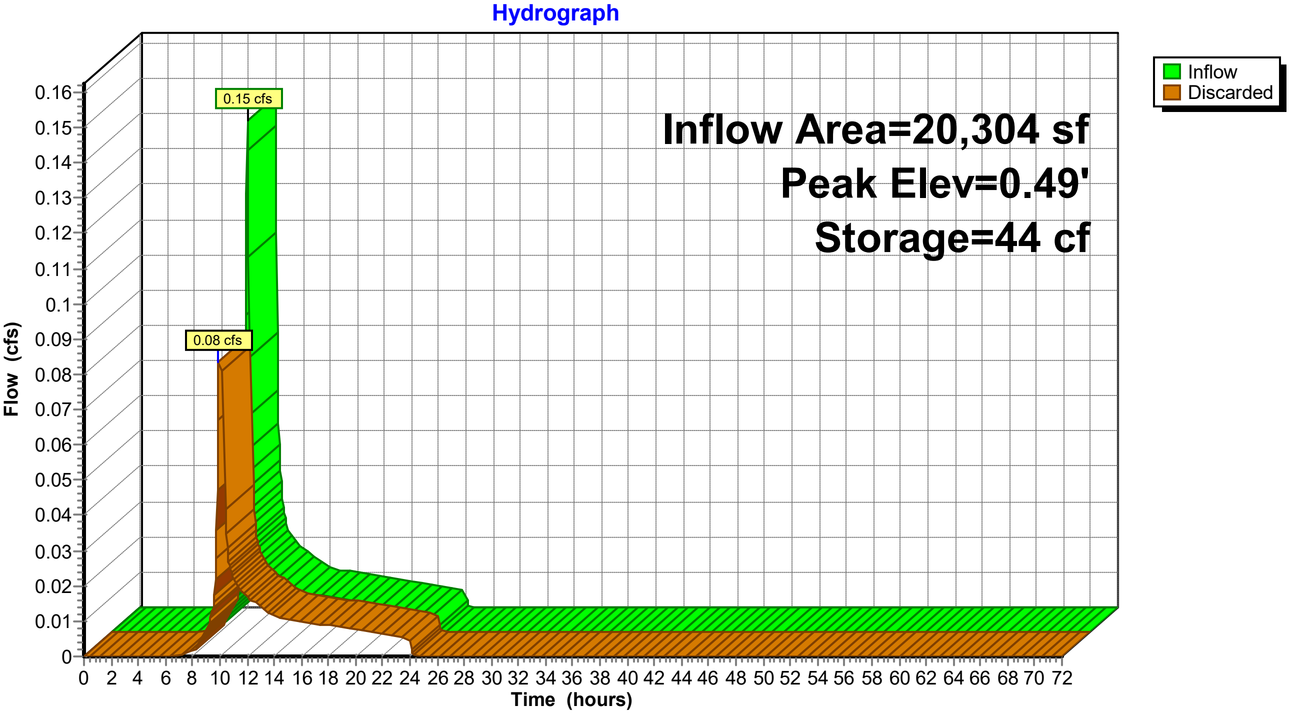
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.18' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 24P: DW1.5



Summary for Pond 25P: DW1.6

Inflow Area = 22,550 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.16 cfs @ 9.96 hrs, Volume= 846 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 846 cf, Atten= 48%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 846 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs Surf.Area= 225 sf Storage= 57 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 846 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

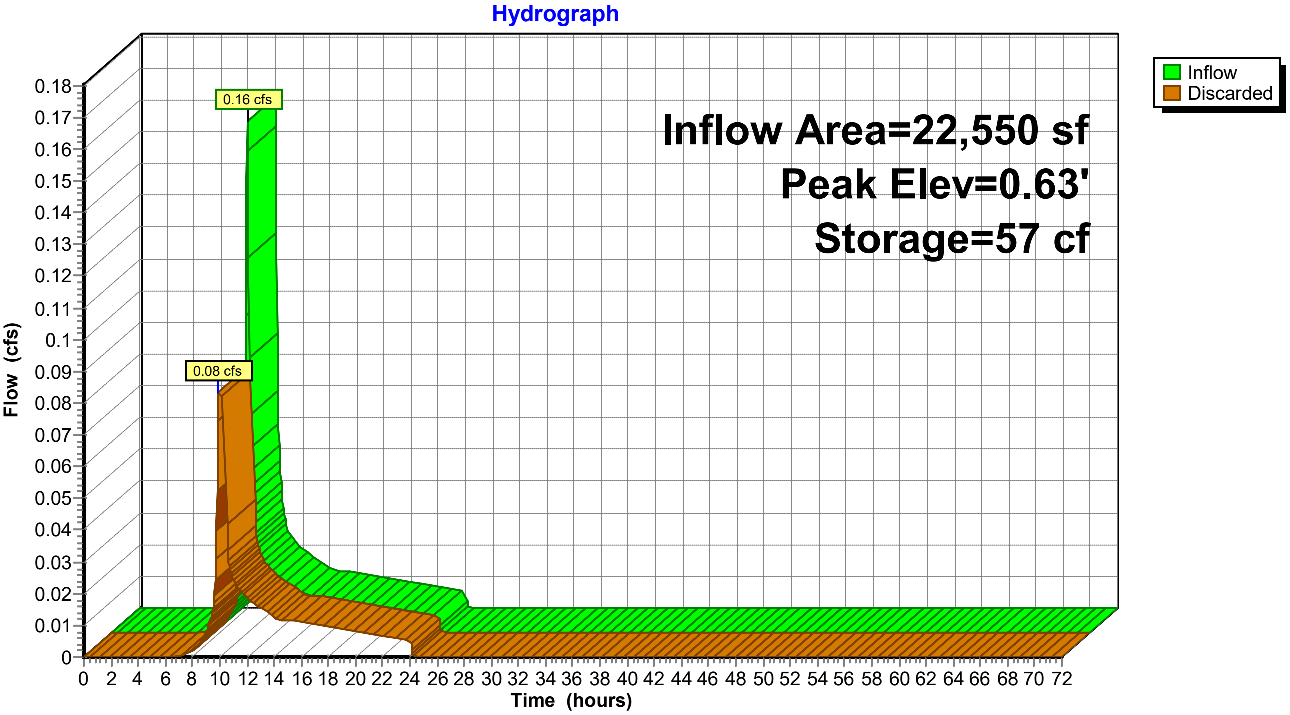
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 25P: DW1.6



Summary for Pond 26P: DW1.7

Inflow Area = 22,550 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.16 cfs @ 9.96 hrs, Volume= 846 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 846 cf, Atten= 48%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 846 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs Surf.Area= 225 sf Storage= 57 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 846 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

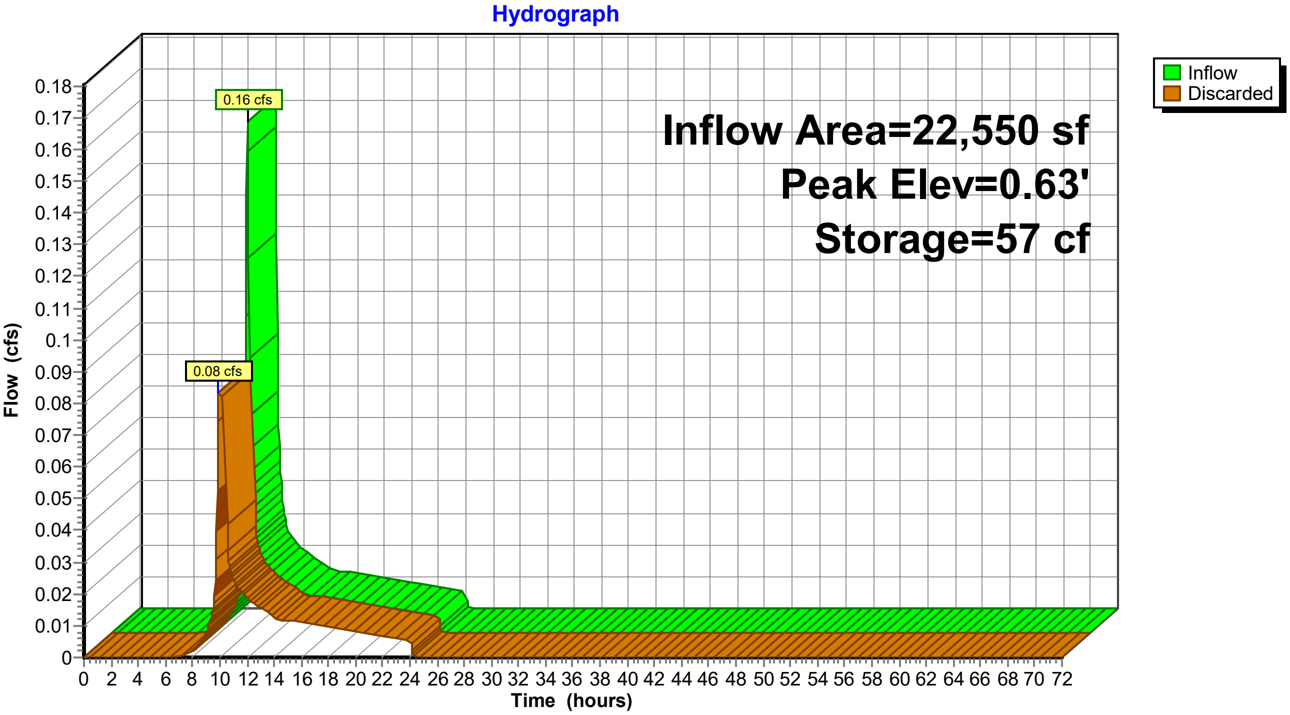
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
⬑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 26P: DW1.7



Summary for Pond 27P: DW1.8

Inflow Area = 22,297 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.16 cfs @ 9.96 hrs, Volume= 837 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 837 cf, Atten= 48%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 837 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.61' @ 10.11 hrs Surf.Area= 225 sf Storage= 55 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 836 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

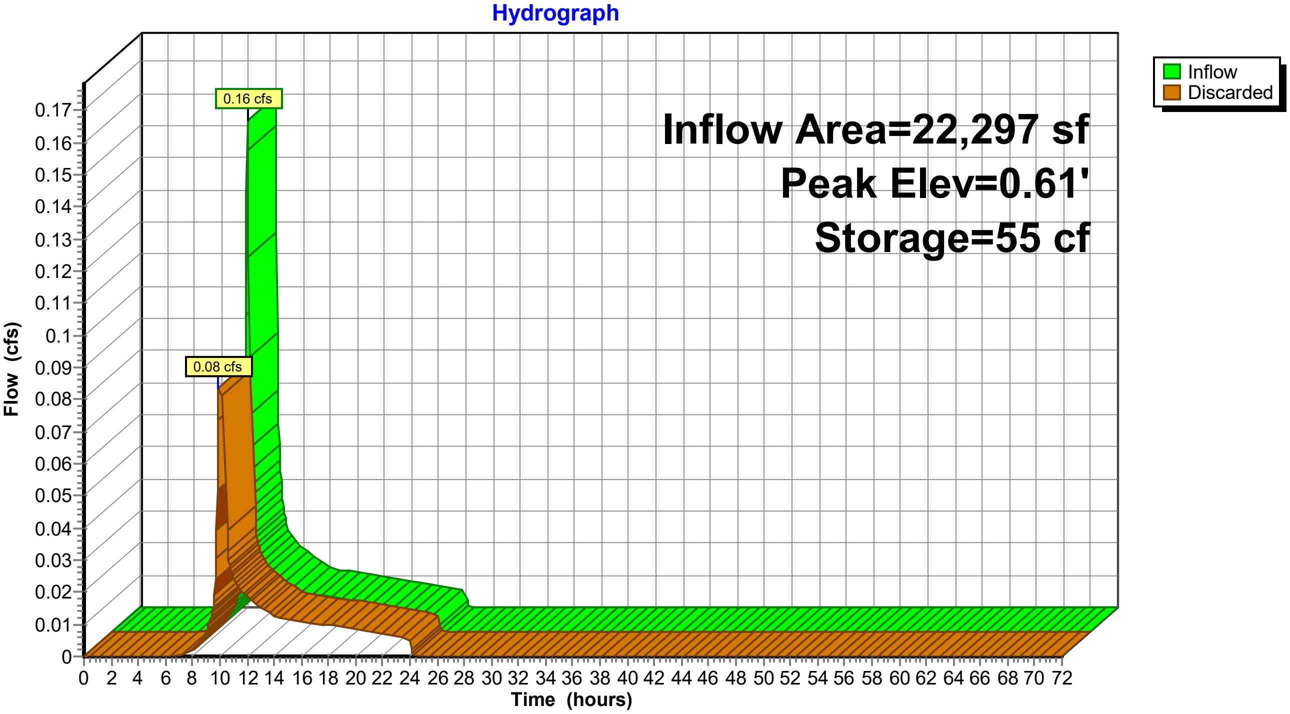
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 27P: DW1.8



Summary for Pond 28P: DW1.10

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.16 cfs @ 9.96 hrs, Volume= 844 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 844 cf, Atten= 48%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 844 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs Surf.Area= 225 sf Storage= 56 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 844 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

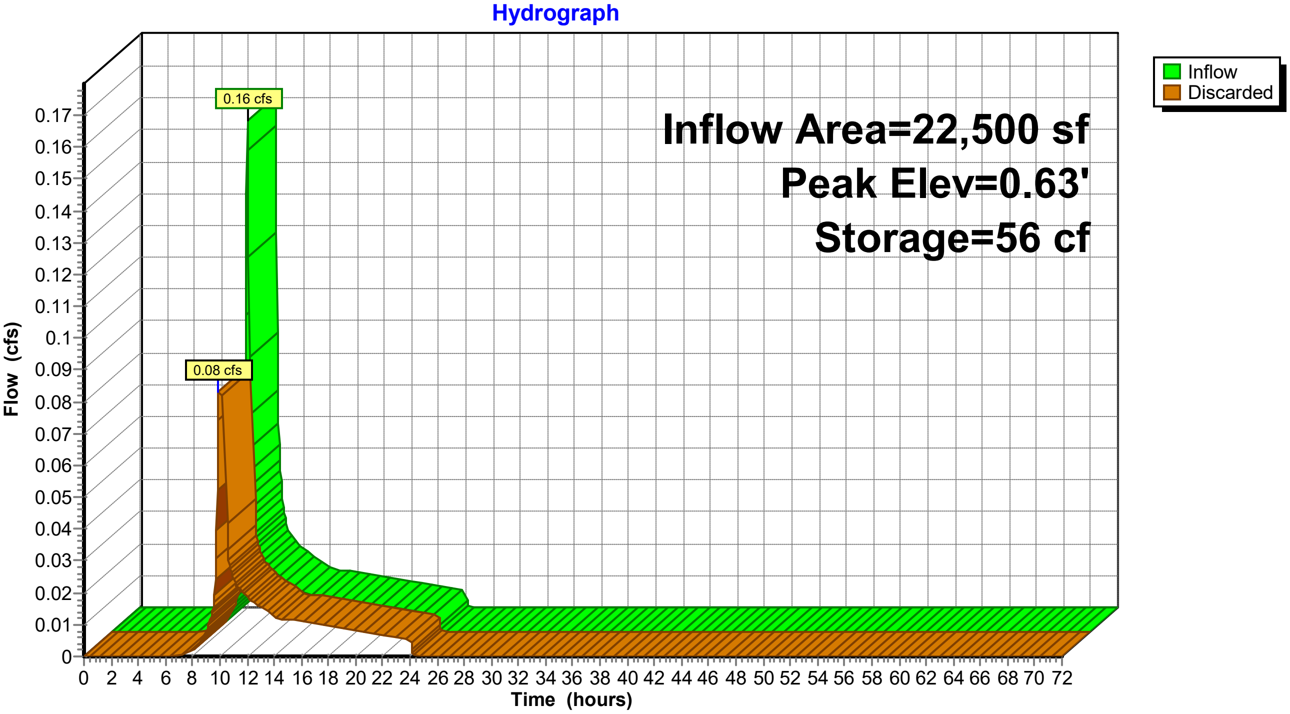
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 28P: DW1.10



Summary for Pond 29P: DW1.11

Inflow Area = 21,434 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.15 cfs @ 9.96 hrs, Volume= 804 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 804 cf, Atten= 46%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 804 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.56' @ 10.10 hrs Surf.Area= 225 sf Storage= 50 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.5 min calculated for 804 cf (100% of inflow)
Center-of-Mass det. time= 3.5 min (828.2 - 824.7)

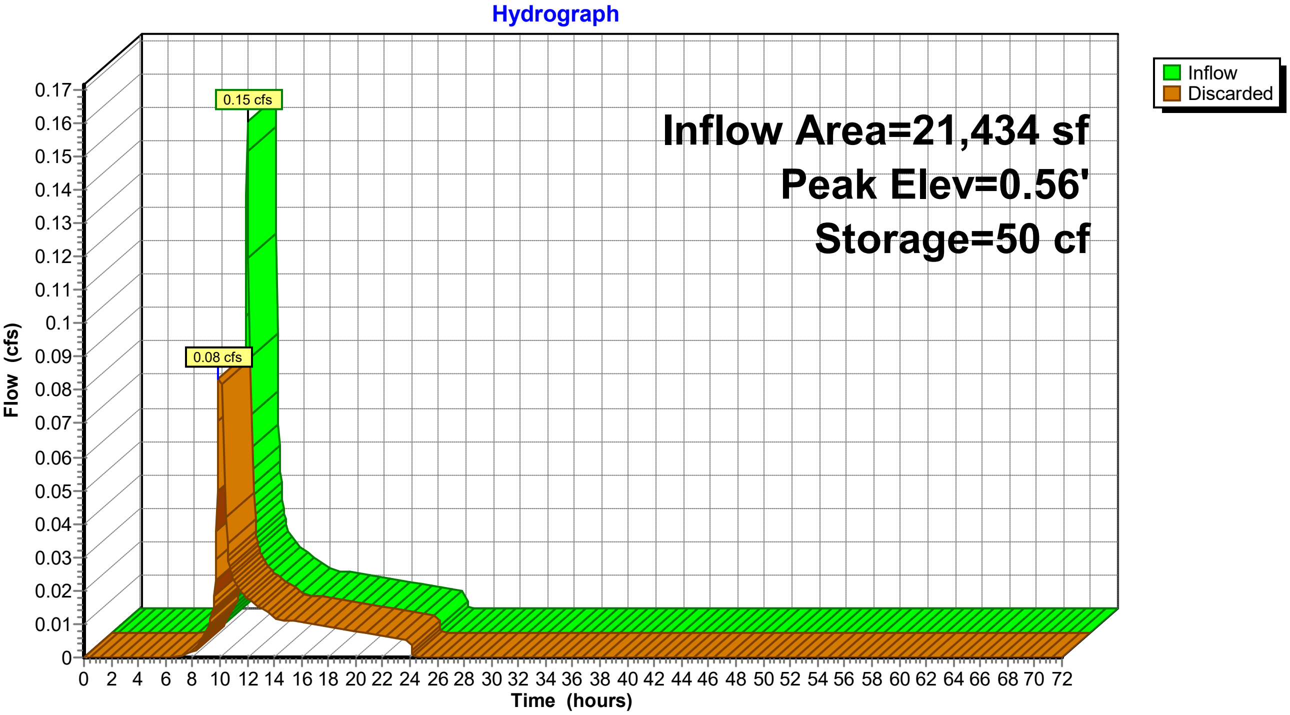
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.20' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

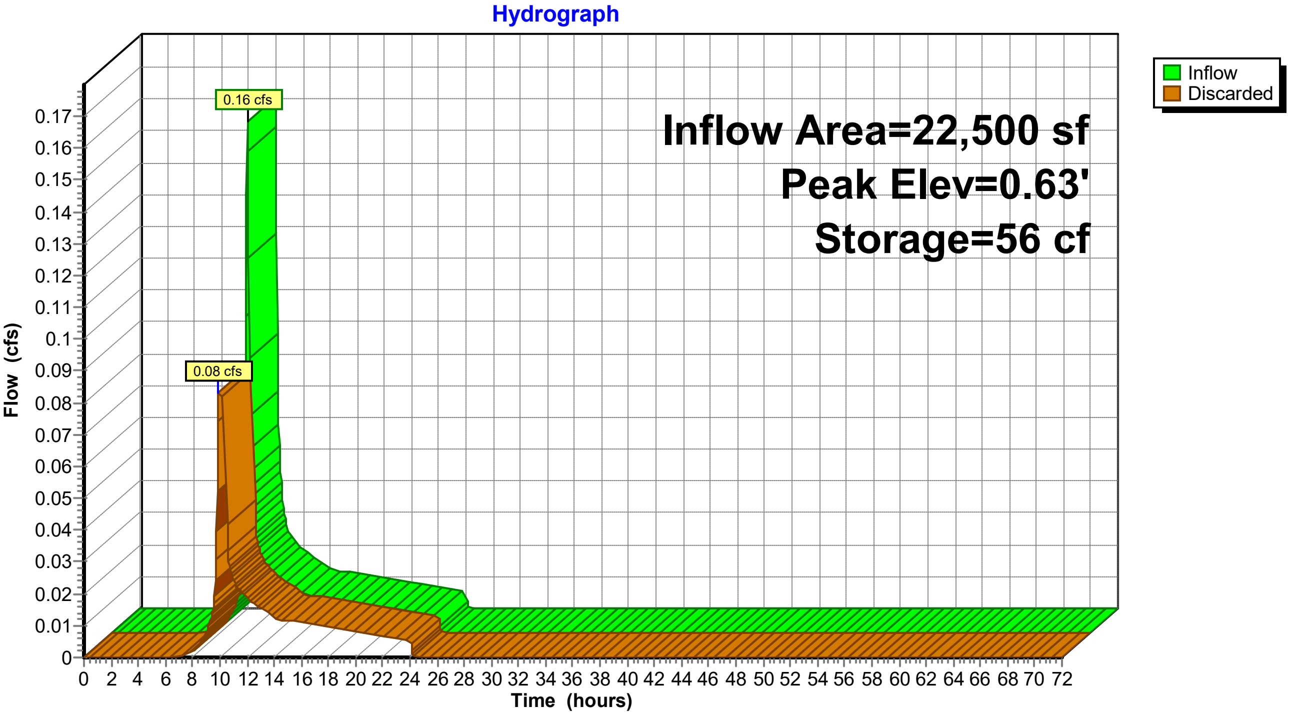
Pond 29P: DW1.11



Summary for Pond 30P: DW1.12

```
Inflow Area =          22,500 sf,   0.00% Impervious,  Inflow Depth =   0.45"    for  6MO-24HOUR event
Inflow      =       0.16 cfs @    9.96 hrs,  Volume=              844 cf
Outflow     =       0.08 cfs @    9.90 hrs,  Volume=              844 cf,  Atten= 48%,  Lag= 0.0 min
Discarded  =        0.08 cfs @    9.90 hrs,  Volume=              844 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs   Surf.Area= 225 sf   Storage= 56 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 844 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min ( 828.4 - 824.7 )

Volume        Invert     Avail.Storage   Storage Description
   #1          0.00'            767 cf   DW (Pyramidal) Listed below
                                         2,166 cf Overall - 248 cf Embedded = 1,918 cf  x 40.0% Voids
   #2          1.00'            170 cf   4.00'D x 13.50'H Vertical Cone/Cylinder  Inside #1
                                         248 cf Overall - 5.0" Wall Thickness = 170 cf
                                937 cf   Total Available Storage

 Elevation         Surf.Area          Inc.Store         Cum.Store          Wet.Area
    (feet)             (sq-ft)     (cubic-feet)      (cubic-feet)              (sq-ft)
      0.00                 225                 0                 0                 225
      9.00                 225             2,025             2,025                 765
      9.50                  18                51             2,076                 973
     14.50                  18                90             2,166               1,058

Device   Routing            Invert   Outlet Devices
   #1    Discarded           0.00'   16.000 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.08 cfs @ 9.90 hrs  HW=0.21'   (Free Discharge)
└─1=Exfiltration  (Exfiltration Controls 0.08 cfs)
```

Pond 30P: DW1.12



Summary for Pond 31P: DW1.13

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.16 cfs @ 9.96 hrs, Volume= 844 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 844 cf, Atten= 48%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 844 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs Surf.Area= 225 sf Storage= 56 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 844 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

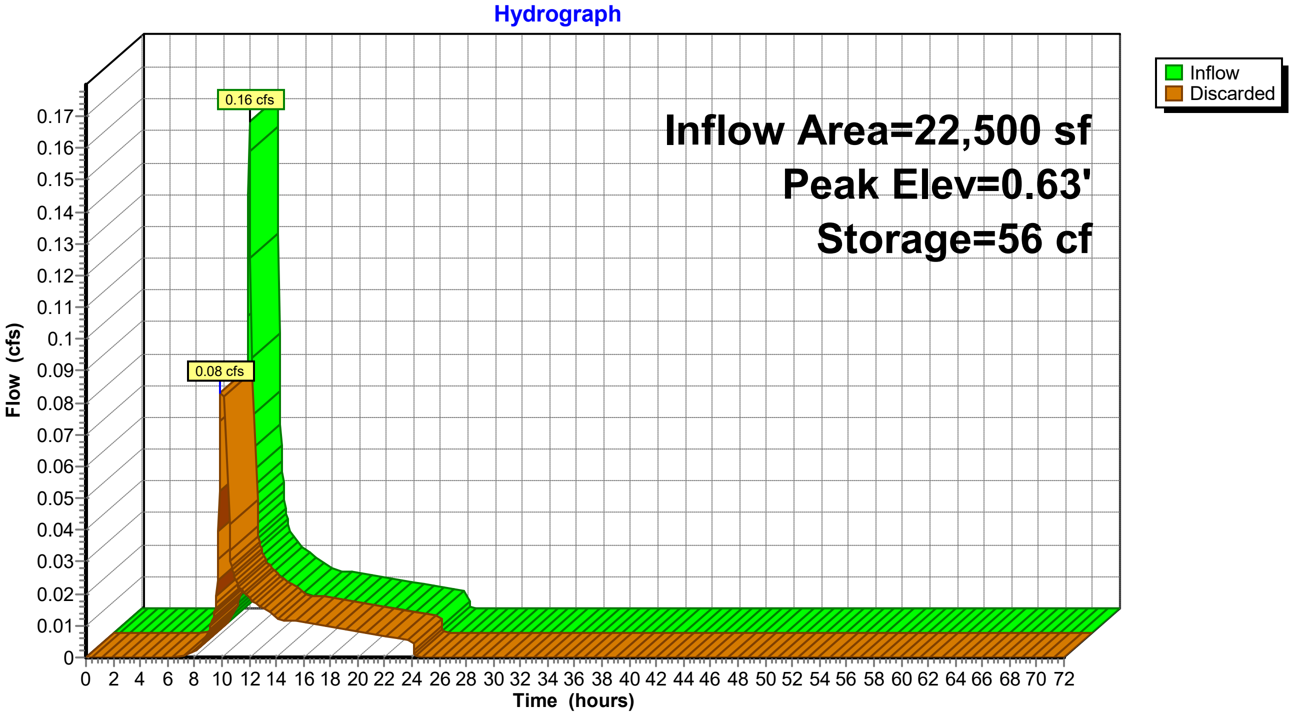
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 31P: DW1.13



Summary for Pond 32P: DW1.14

```
Inflow Area =          22,500 sf,   0.00% Impervious,  Inflow Depth =   0.45"    for  6MO-24HOUR event
Inflow      =       0.16 cfs @    9.96 hrs,  Volume=              844 cf
Outflow     =       0.08 cfs @    9.90 hrs,  Volume=              844 cf,  Atten= 48%,  Lag= 0.0 min
Discarded  =        0.08 cfs @    9.90 hrs,  Volume=              844 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs   Surf.Area= 225 sf   Storage= 56 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 844 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

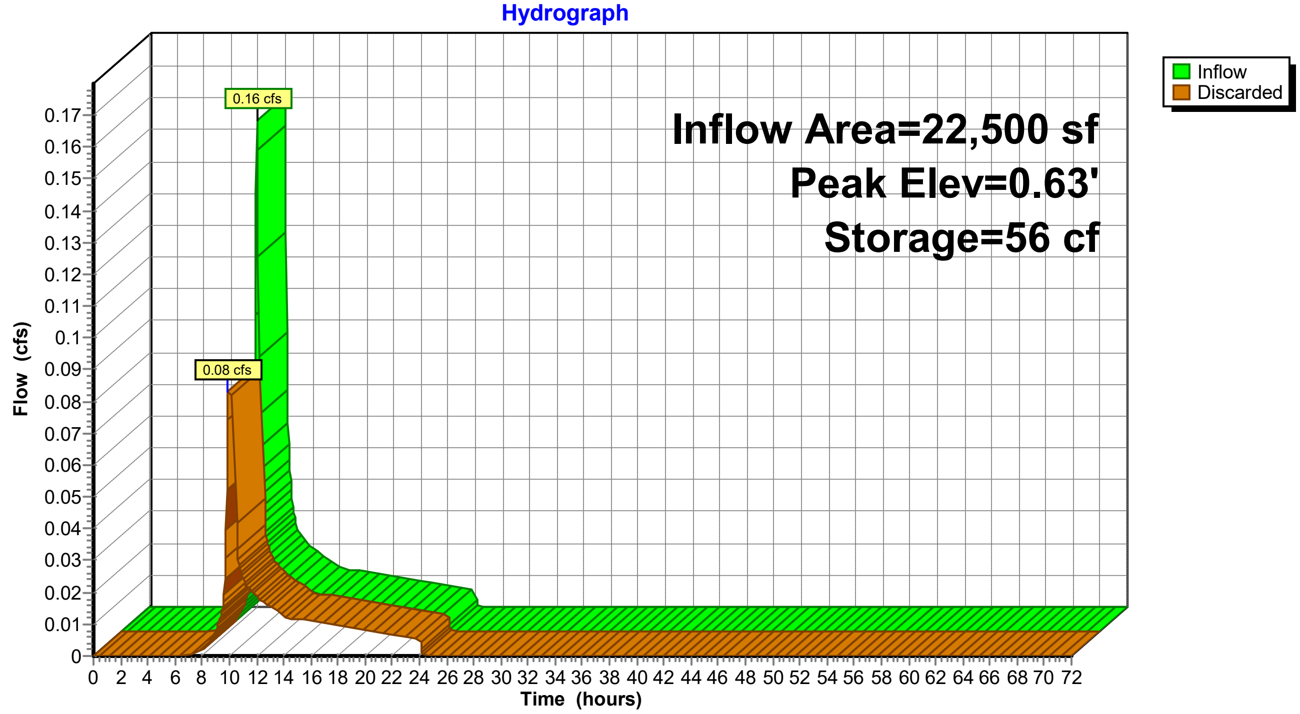
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 32P: DW1.14



Summary for Pond 33P: DW1.15

```
Inflow Area =        22,500 sf,   0.00% Impervious,  Inflow Depth =   0.45"    for  6MO-24HOUR event
Inflow      =      0.16 cfs @    9.96 hrs,  Volume=              844 cf
Outflow     =      0.08 cfs @    9.90 hrs,  Volume=              844 cf,  Atten= 48%,  Lag= 0.0 min
Discarded  =       0.08 cfs @    9.90 hrs,  Volume=              844 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs Surf.Area= 225 sf Storage= 56 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 844 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

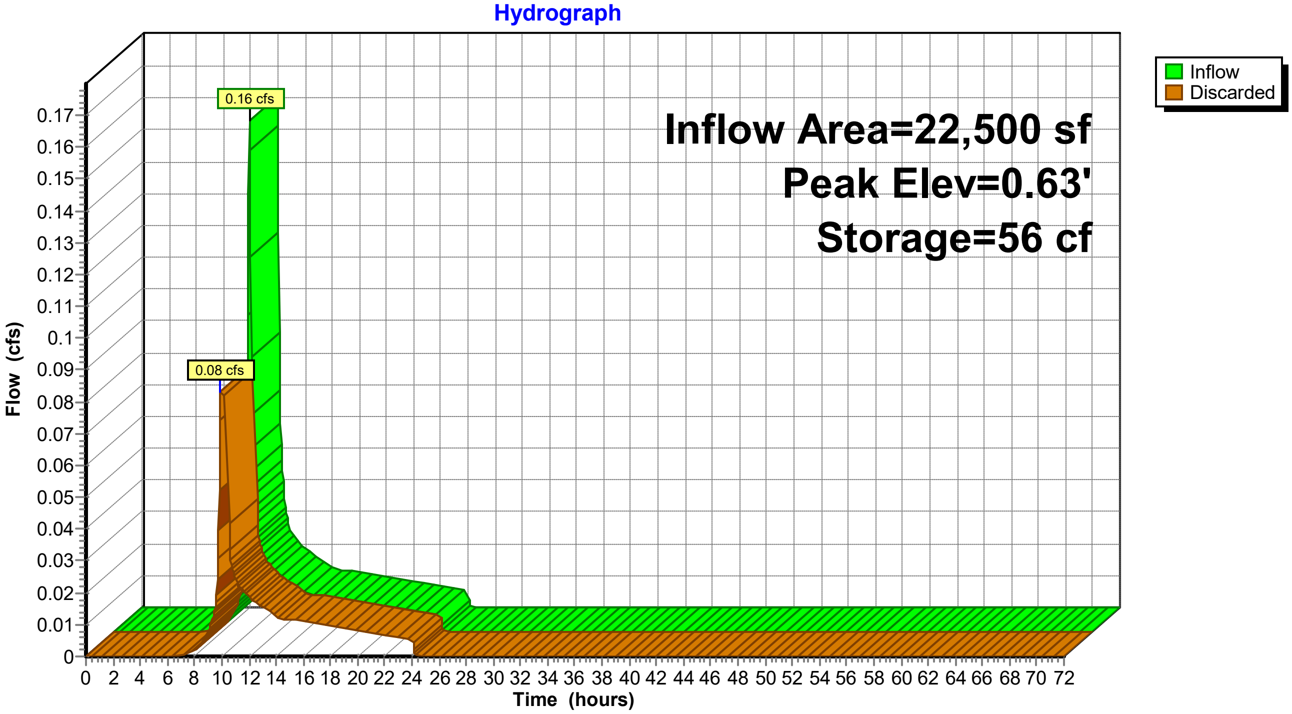
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 33P: DW1.15



Summary for Pond 69P: DW2.1

```
Inflow Area =          7,700 sf,   0.00% Impervious,  Inflow Depth =   0.45"    for  6MO-24HOUR event
Inflow      =       0.05 cfs @    9.96 hrs,  Volume=             289 cf
Outflow     =       0.05 cfs @   10.00 hrs,  Volume=             289 cf,  Atten= 6%,  Lag= 2.4 min
Discarded   =       0.05 cfs @   10.00 hrs,  Volume=             289 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.09' @ 10.00 hrs Surf.Area= 225 sf Storage= 8 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 2.6 min calculated for 289 cf (100% of inflow)
Center-of-Mass det. time= 2.6 min (827.3 - 824.7)

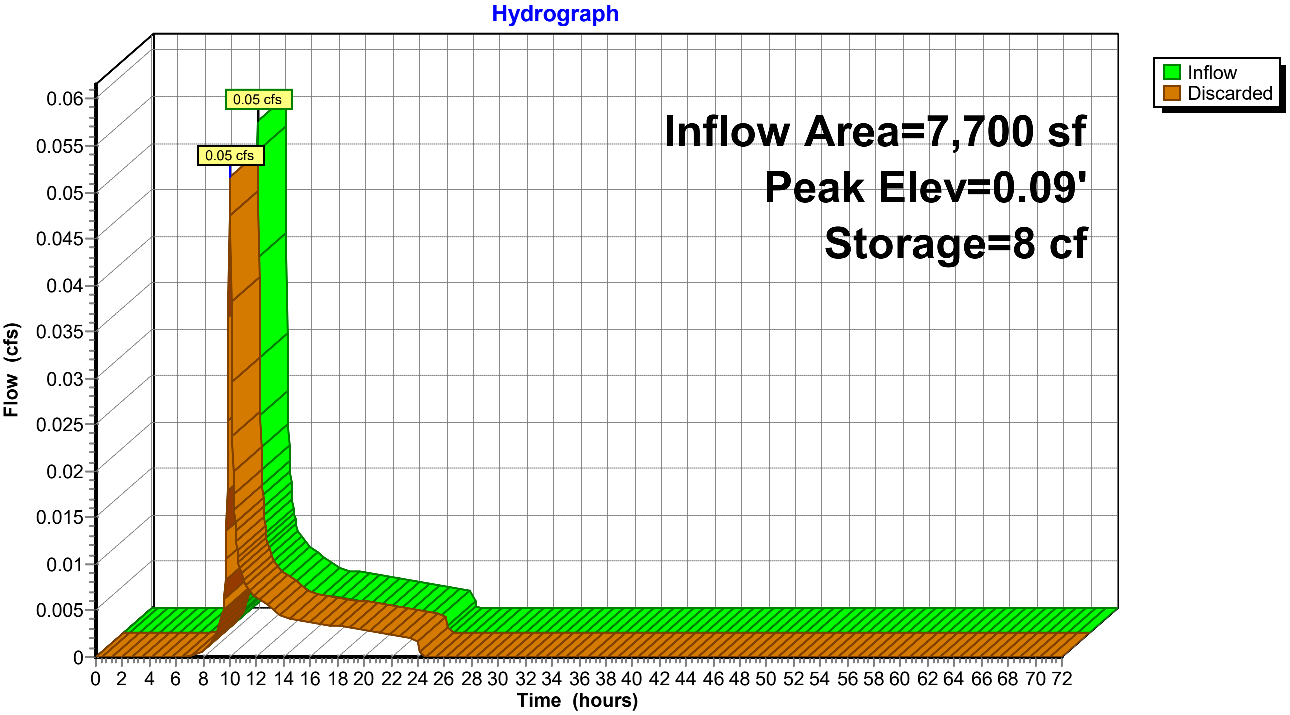
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 10.00 hrs HW=0.09' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 69P: DW2.1



Summary for Pond 70P: DW2.4

```
Inflow Area =        17,300 sf,   0.00% Impervious,  Inflow Depth =   0.45"    for  6MO-24HOUR event
Inflow      =      0.12 cfs @    9.96 hrs,  Volume=            649 cf
Outflow     =      0.08 cfs @    9.95 hrs,  Volume=            649 cf,  Atten= 33%,  Lag= 0.0 min
Discarded  =       0.08 cfs @    9.95 hrs,  Volume=            649 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.32' @ 10.07 hrs   Surf.Area= 225 sf   Storage= 29 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 2.9 min calculated for 649 cf (100% of inflow)
Center-of-Mass det. time= 2.9 min (827.6 - 824.7)

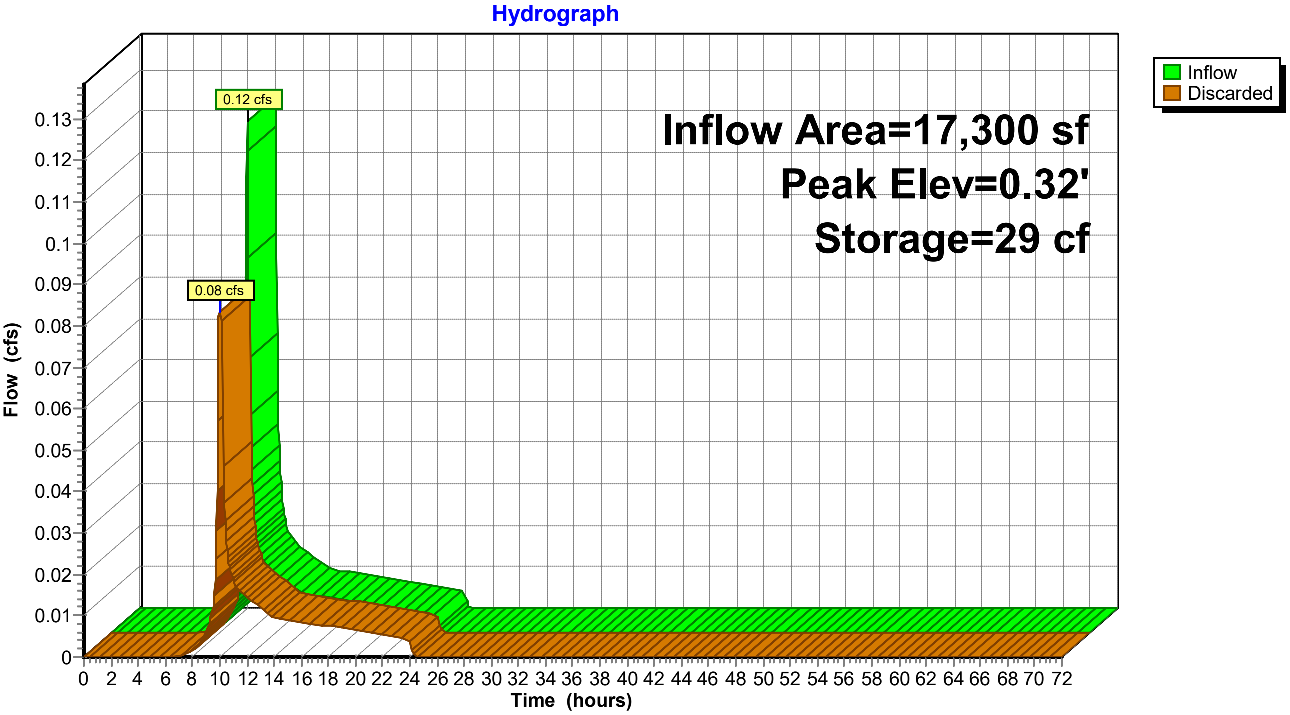
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.95 hrs HW=0.21' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 70P: DW2.4



Summary for Subcatchment 71S: F2.2

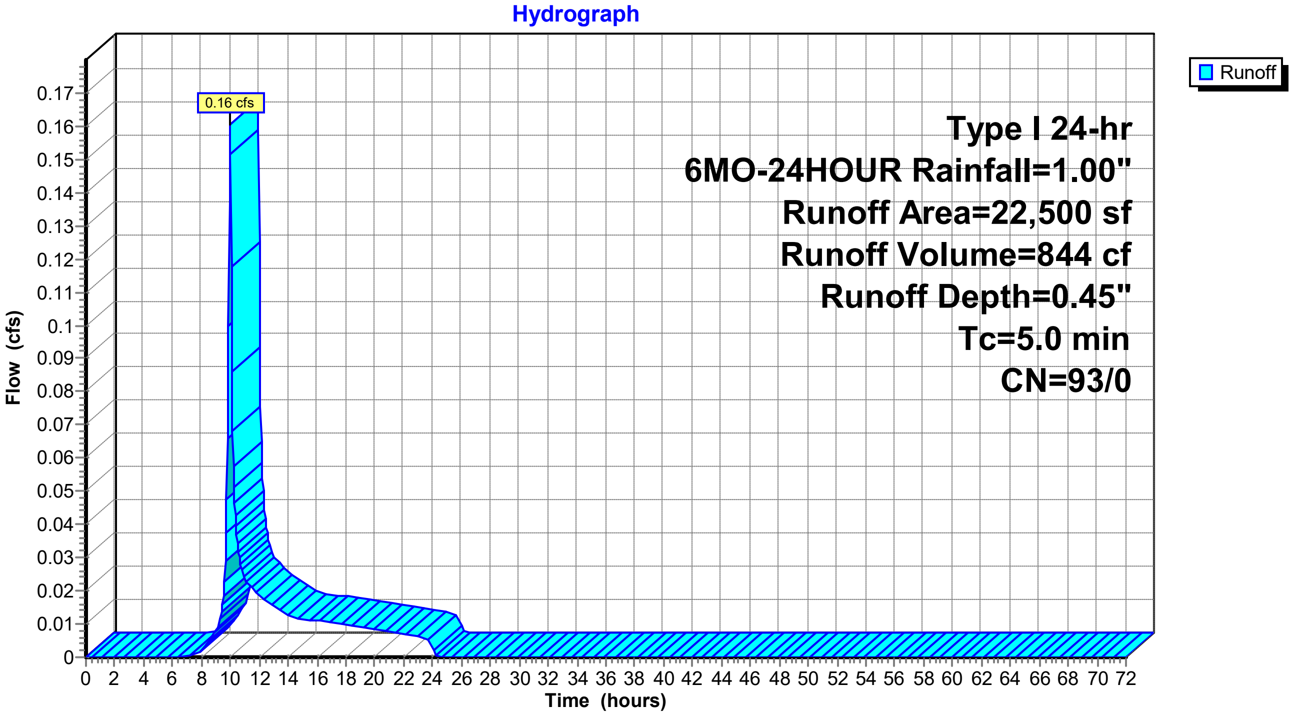
```
Runoff      =        0.16 cfs @    9.96 hrs,  Volume=             844 cf,  Depth=  0.45"
    Routed to Pond 74P : DW2.2
```

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 71S: F2.2



Summary for Subcatchment 72S: F2.3

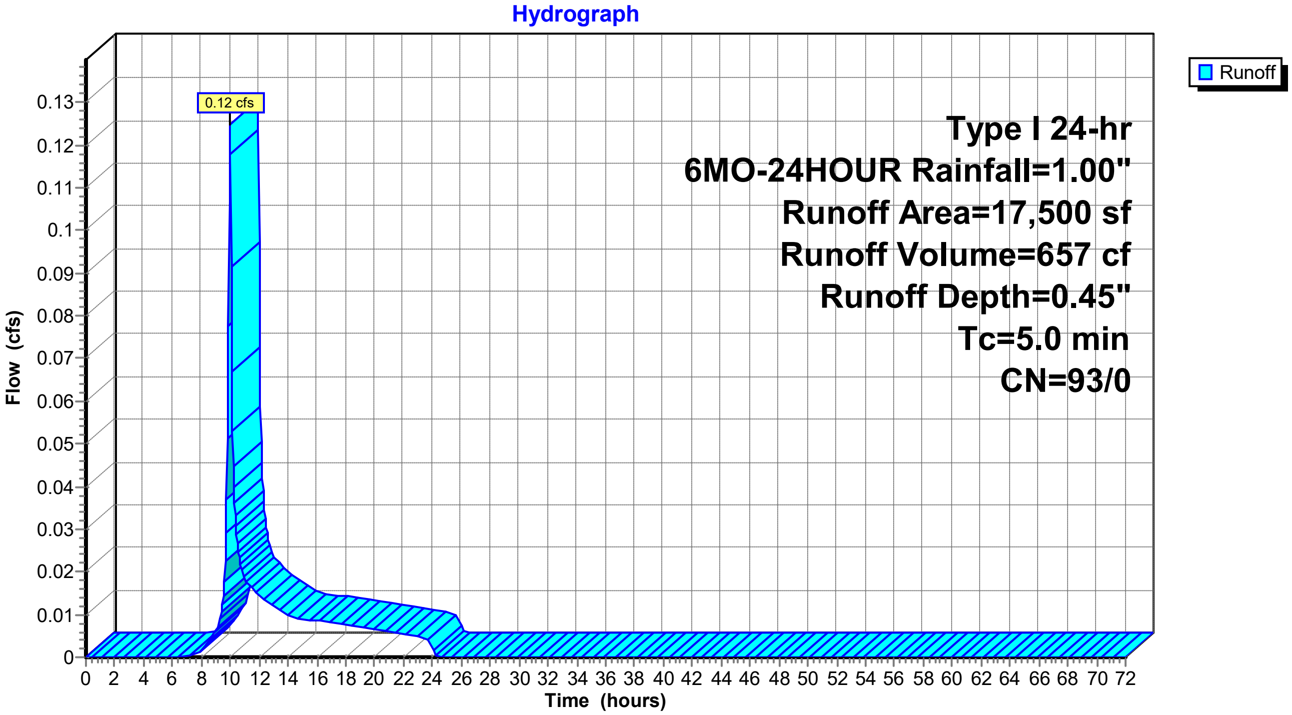
Runoff = 0.12 cfs @ 9.96 hrs, Volume= 657 cf, Depth= 0.45"
Routed to Pond 75P : DW2.3

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	17,500	93	Paved roads w/curbs & sewers, HSG A
	17,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 72S: F2.3



Summary for Subcatchment 73S: F2.4

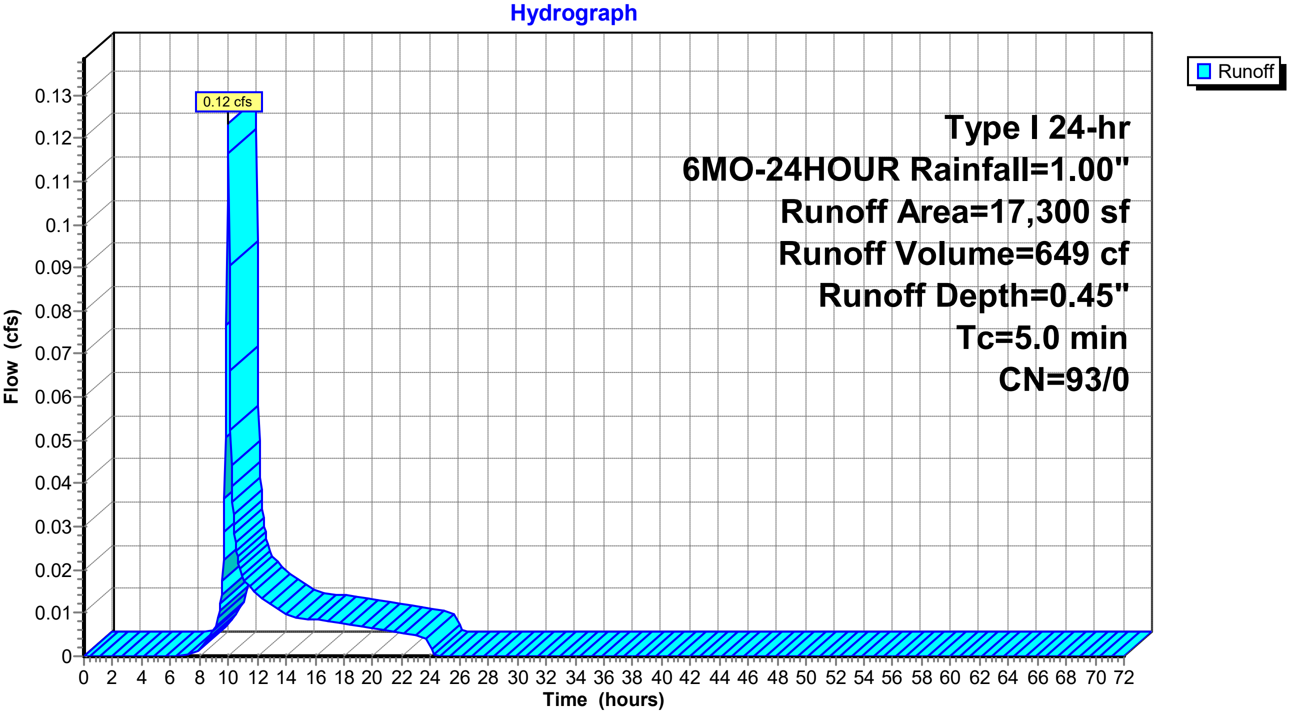
Runoff = 0.12 cfs @ 9.96 hrs, Volume= 649 cf, Depth= 0.45"
Routed to Pond 70P : DW2.4

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	17,300	93	Paved roads w/curbs & sewers, HSG A
	17,300	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 73S: F2.4



Summary for Pond 74P: DW2.2

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.16 cfs @ 9.96 hrs, Volume= 844 cf
Outflow = 0.08 cfs @ 9.90 hrs, Volume= 844 cf, Atten= 48%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.90 hrs, Volume= 844 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs Surf.Area= 225 sf Storage= 56 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 844 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

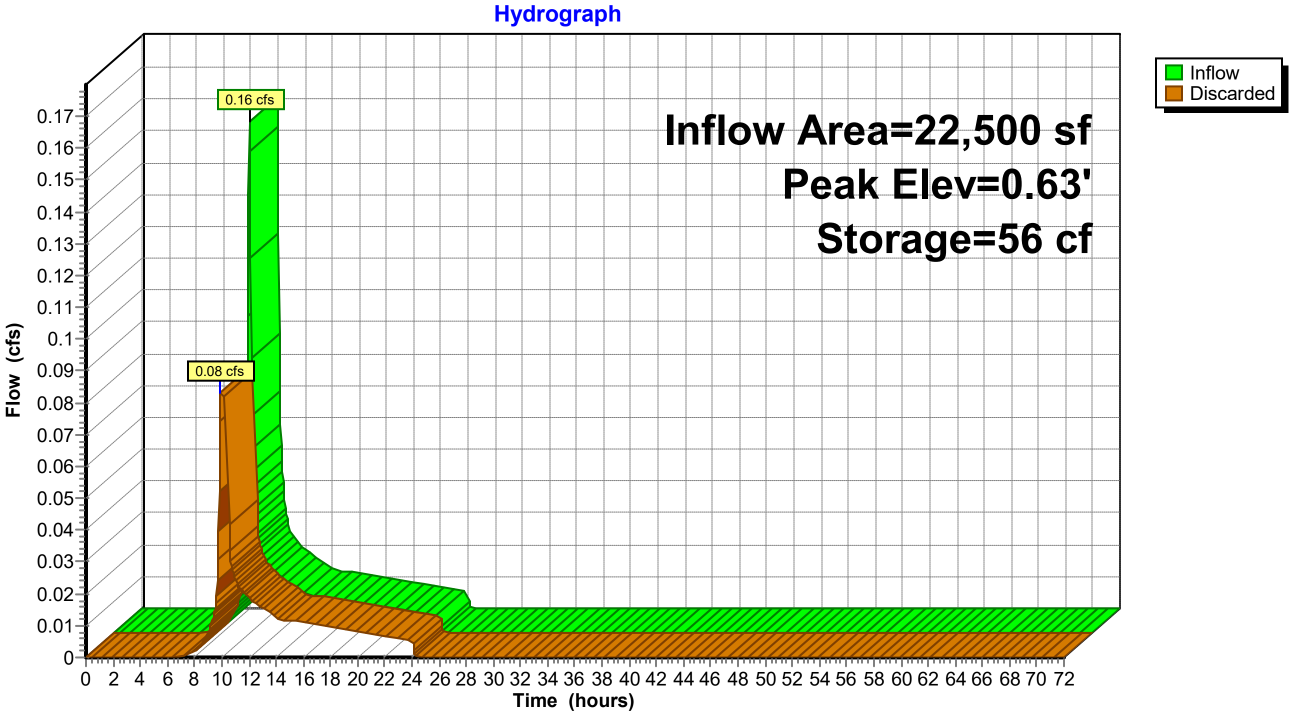
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 74P: DW2.2



Summary for Pond 75P: DW2.3

Inflow Area = 17,500 sf, 0.00% Impervious, Inflow Depth = 0.45" for 6MO-24HOUR event
Inflow = 0.12 cfs @ 9.96 hrs, Volume= 657 cf
Outflow = 0.08 cfs @ 9.95 hrs, Volume= 657 cf, Atten= 33%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.95 hrs, Volume= 657 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.33' @ 10.07 hrs Surf.Area= 225 sf Storage= 30 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 2.9 min calculated for 656 cf (100% of inflow)
Center-of-Mass det. time= 2.9 min (827.6 - 824.7)

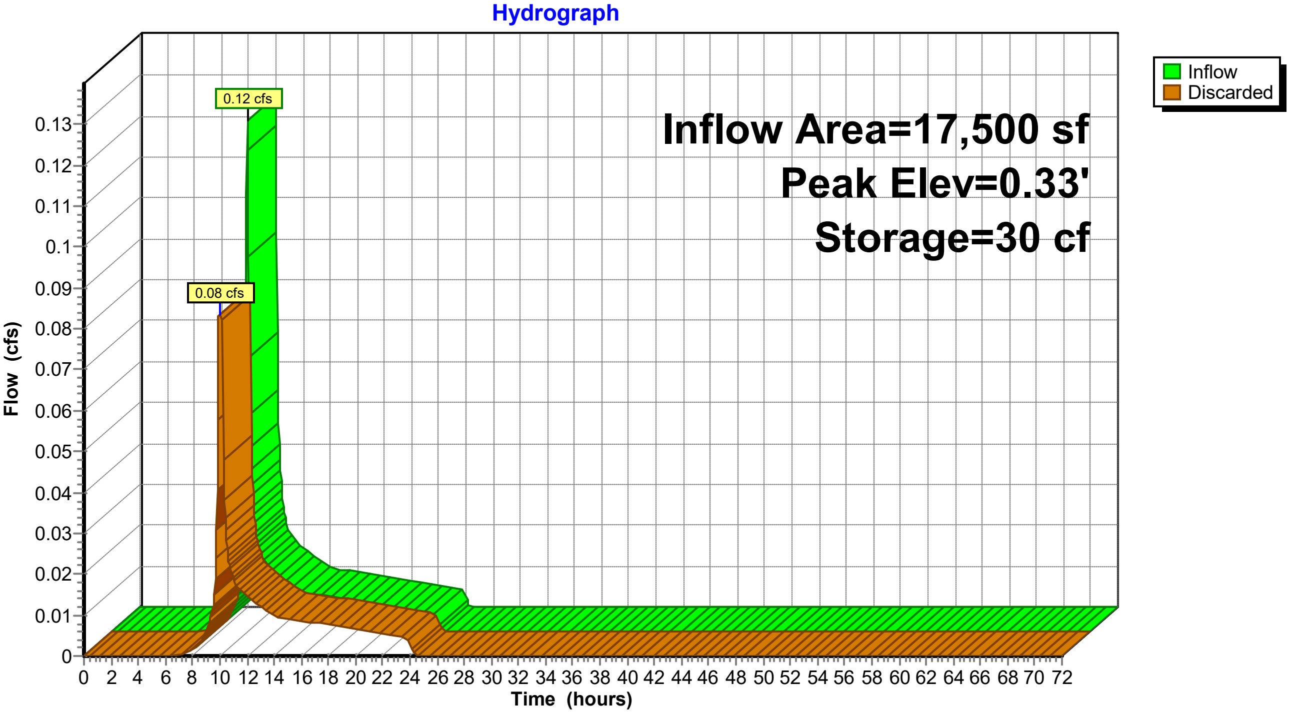
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.95 hrs HW=0.21' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 75P: DW2.3



Summary for Pond 78P: DW2.5

```
Inflow Area =         22,500 sf,   0.00% Impervious,  Inflow Depth =   0.45"    for  6MO-24HOUR event
Inflow      =       0.16 cfs @    9.96 hrs,  Volume=             844 cf
Outflow     =       0.08 cfs @    9.90 hrs,  Volume=             844 cf,  Atten= 48%,  Lag= 0.0 min
Discarded  =        0.08 cfs @    9.90 hrs,  Volume=             844 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 0.63' @ 10.11 hrs Surf.Area= 225 sf Storage= 56 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 3.7 min calculated for 844 cf (100% of inflow)
Center-of-Mass det. time= 3.7 min (828.4 - 824.7)

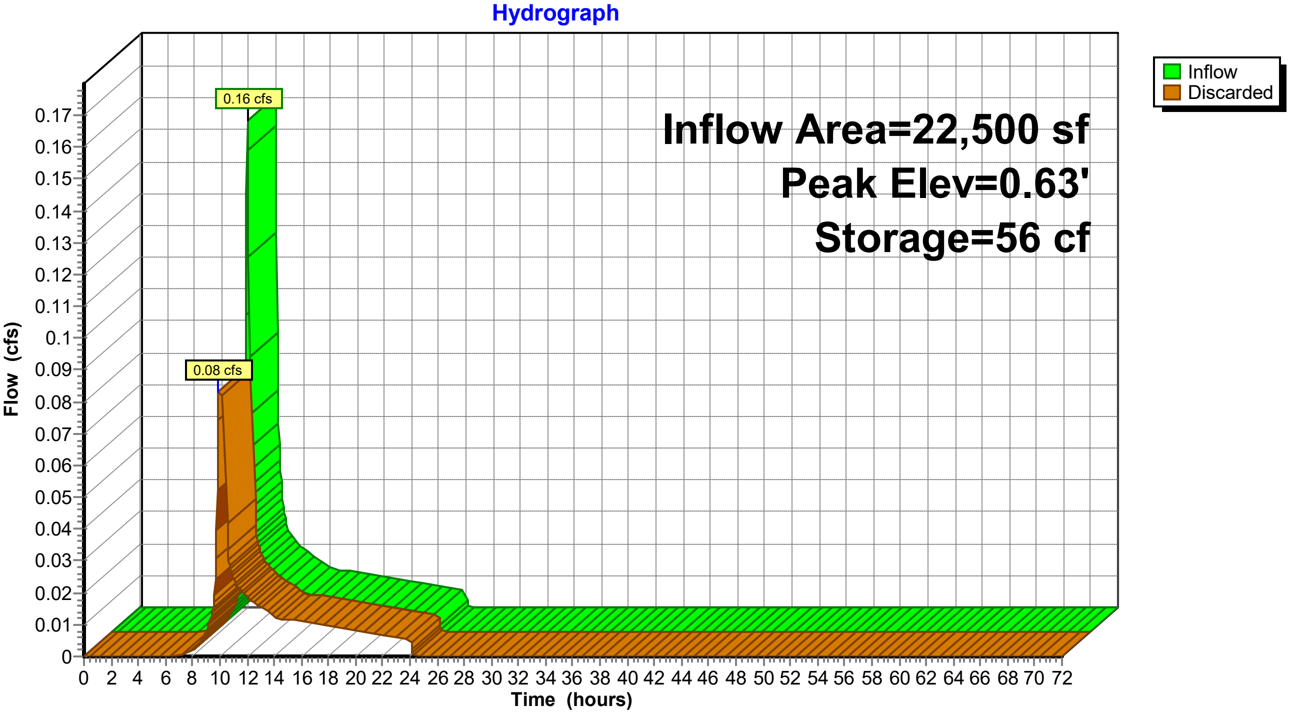
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.90 hrs HW=0.21' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 78P: DW2.5



Summary for Subcatchment F2.1: F2.1

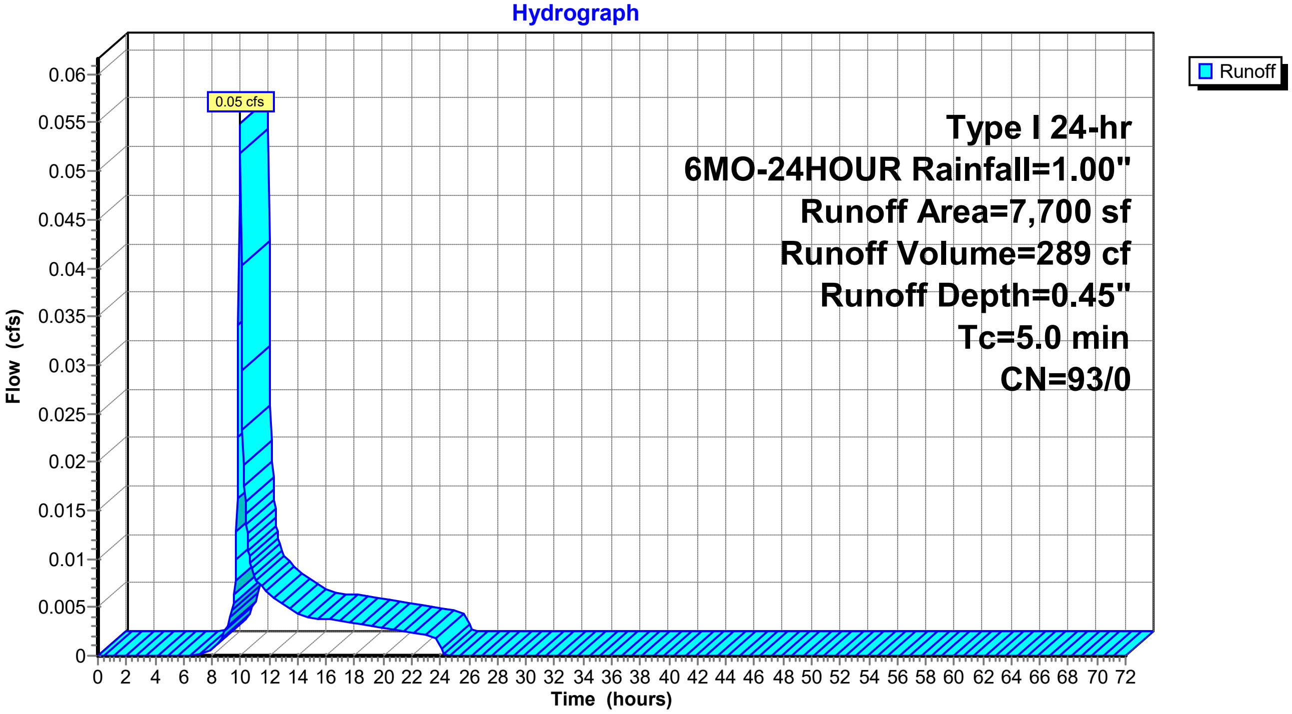
Runoff = 0.05 cfs @ 9.96 hrs, Volume= 289 cf, Depth= 0.45"
Routed to Pond 69P : DW2.1

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	7,700	93	Paved roads w/curbs & sewers, HSG A
	7,700	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment F2.1: F2.1



Summary for Subcatchment F2.5: F2.5

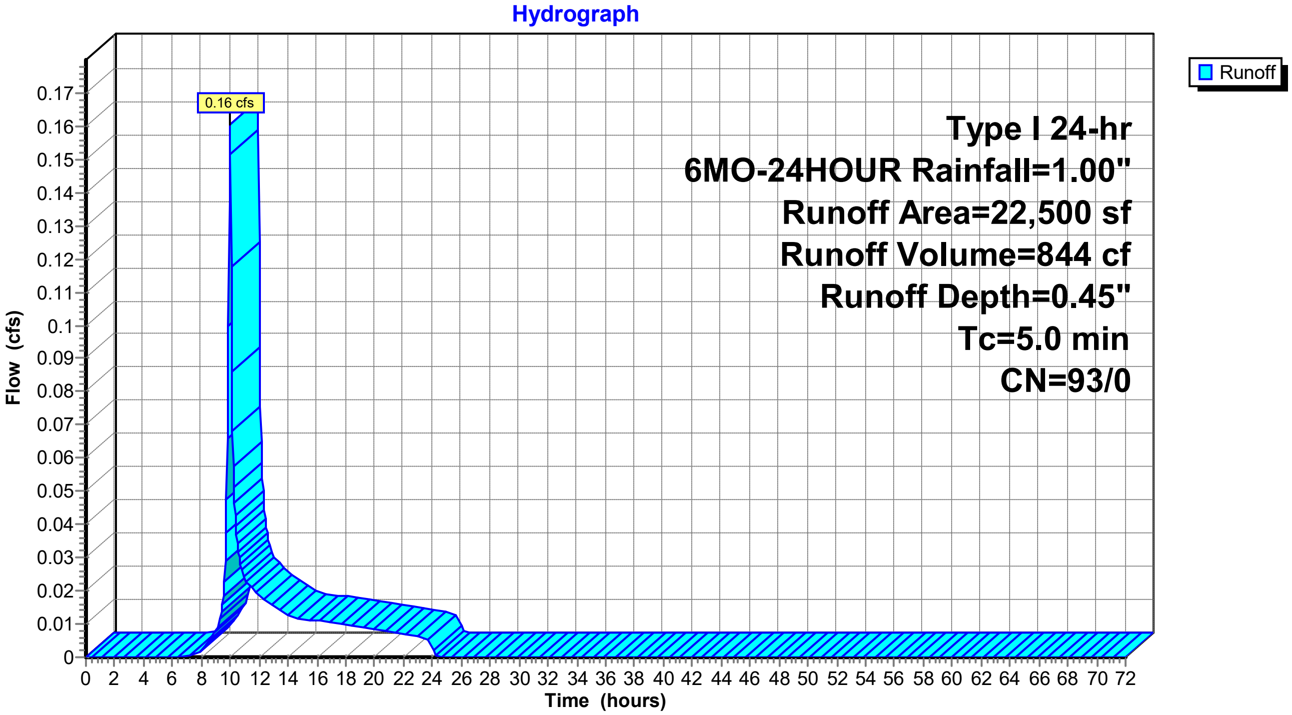
Runoff = 0.16 cfs @ 9.96 hrs, Volume= 844 cf, Depth= 0.45"
Routed to Pond 78P : DW2.5

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 6MO-24HOUR Rainfall=1.00"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment F2.5: F2.5



Summary for Subcatchment 1S: G1.1

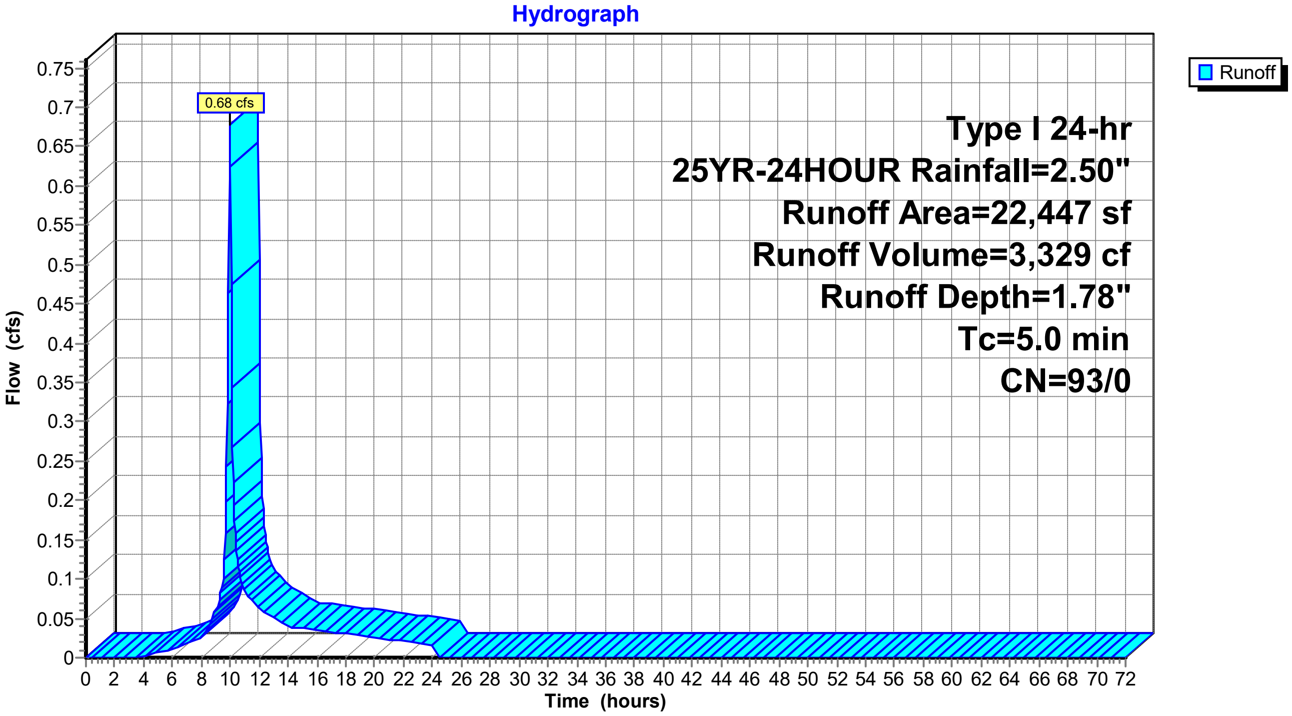
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,329 cf, Depth= 1.78"
Routed to Pond 20P : DW1.1

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,447	93	Paved roads w/curbs & sewers, HSG A
	22,447	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 1S: G1.1



Summary for Subcatchment 2S: G1.2

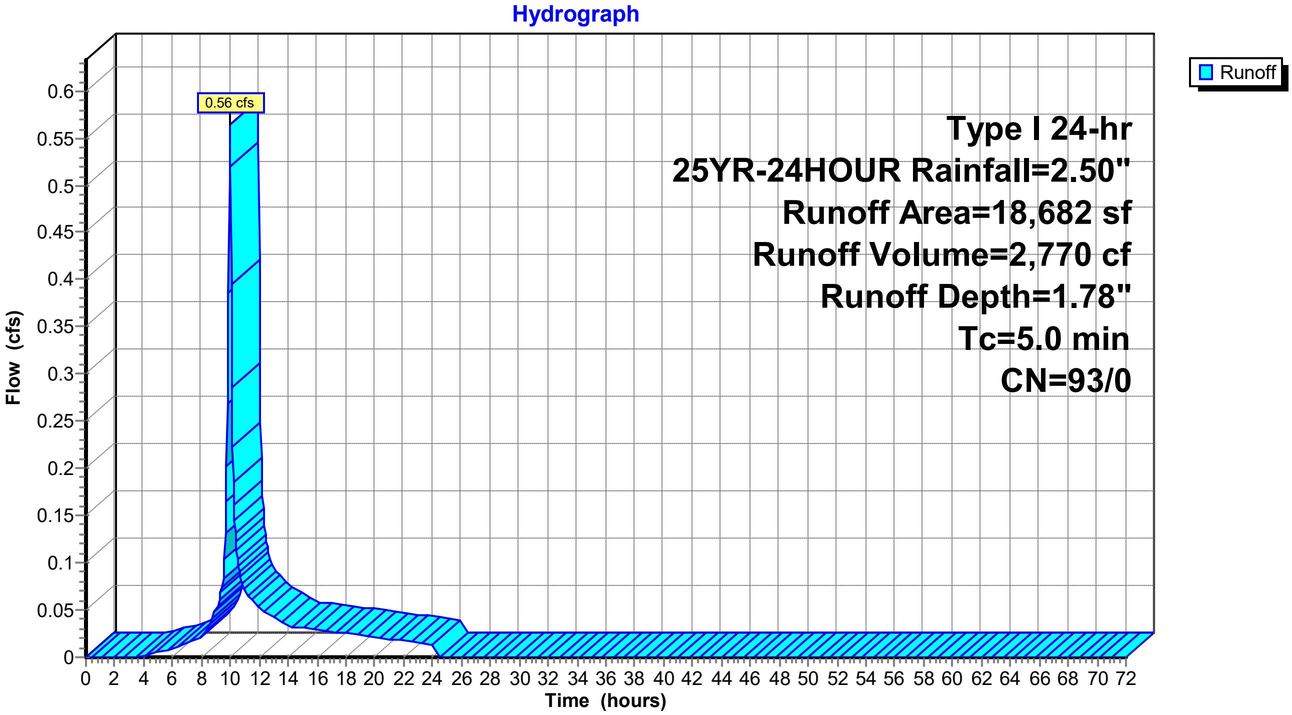
Runoff = 0.56 cfs @ 9.95 hrs, Volume= 2,770 cf, Depth= 1.78"
Routed to Pond 21P : DW1.2

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	18,682	93	Paved roads w/curbs & sewers, HSG A
	18,682	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 2S: G1.2



Summary for Subcatchment 3S: G1.3

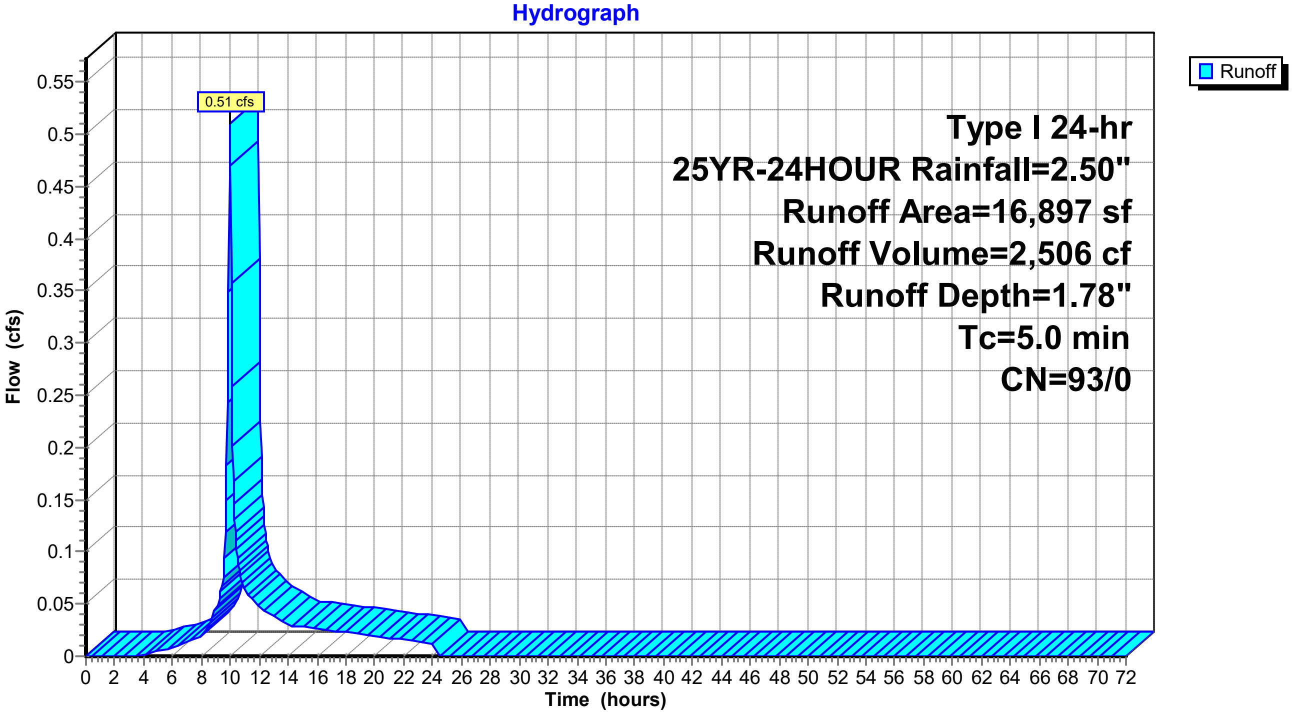
Runoff = 0.51 cfs @ 9.95 hrs, Volume= 2,506 cf, Depth= 1.78"
Routed to Pond 22P : DW1.3

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	16,897	93	Paved roads w/curbs & sewers, HSG A
	16,897	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 3S: G1.3



Summary for Subcatchment 4S: G1.4

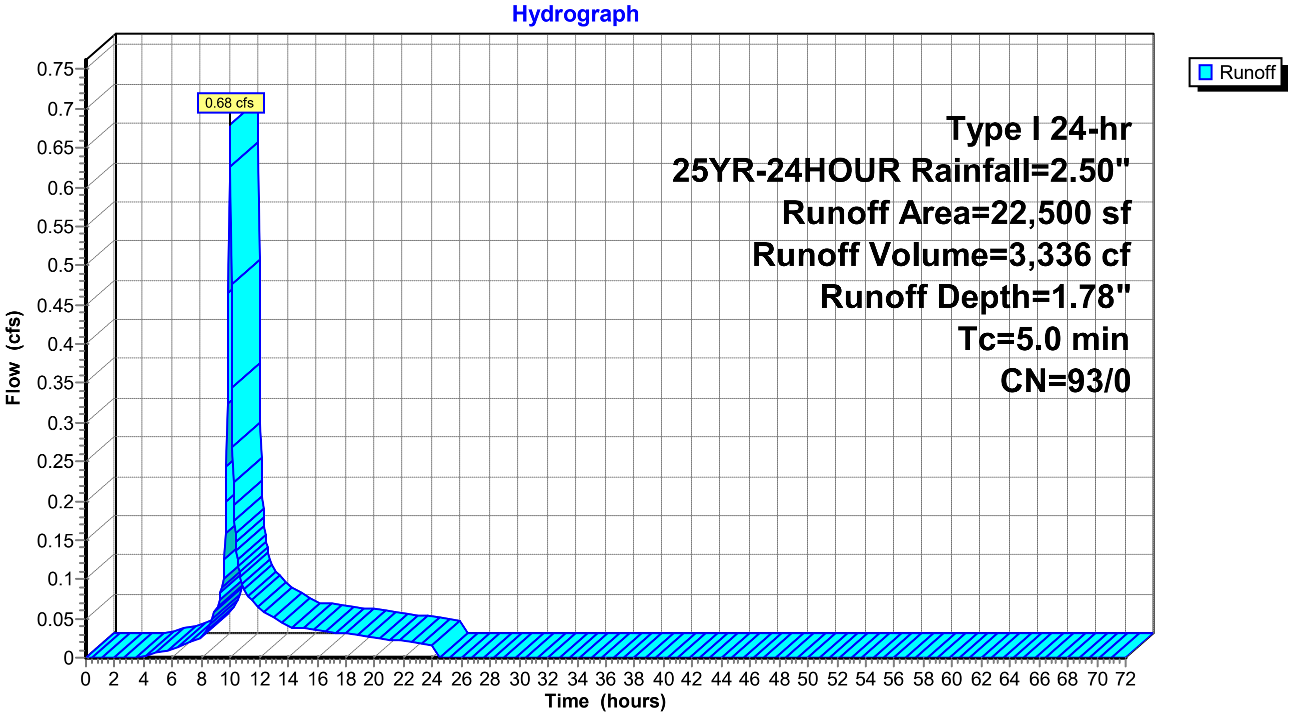
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf, Depth= 1.78"
Routed to Pond 23P : DW1.4

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 4S: G1.4



Summary for Subcatchment 5S: G1.5

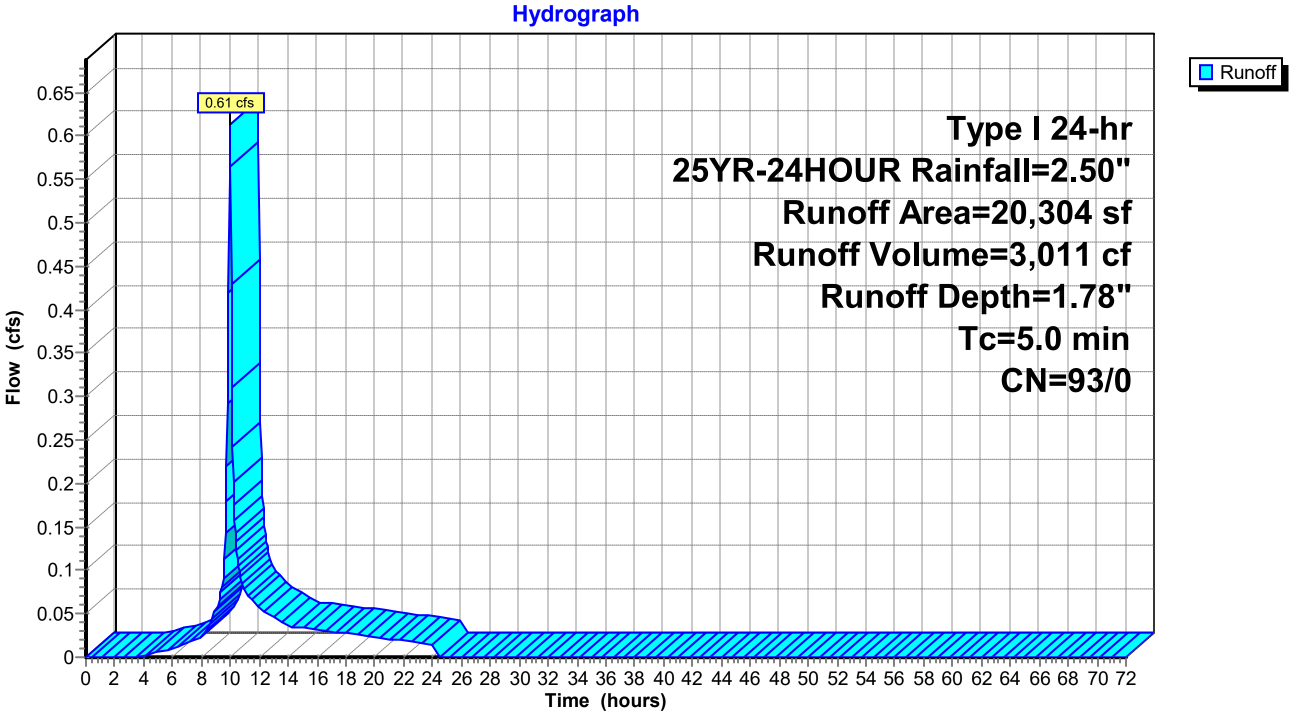
Runoff = 0.61 cfs @ 9.95 hrs, Volume= 3,011 cf, Depth= 1.78"
Routed to Pond 24P : DW1.5

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	20,304	93	Paved roads w/curbs & sewers, HSG A
	20,304	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 5S: G1.5



Summary for Subcatchment 6S: G1.6

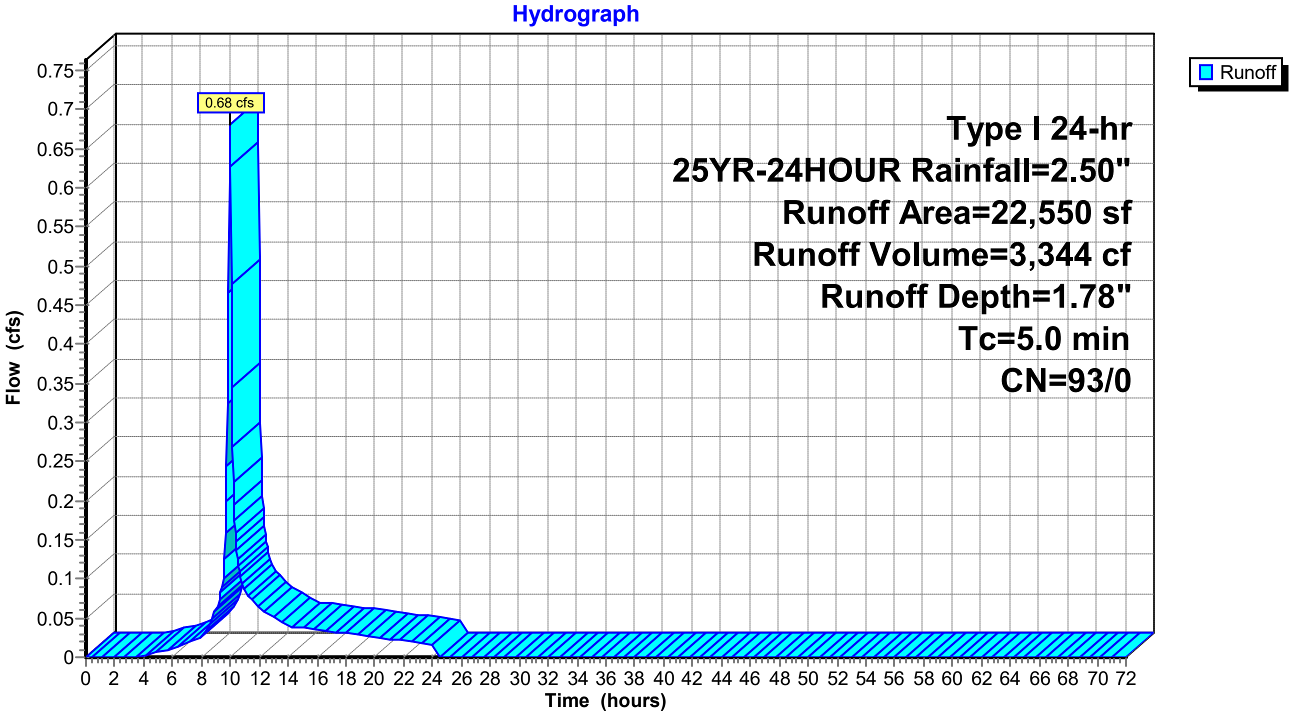
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,344 cf, Depth= 1.78"
Routed to Pond 25P : DW1.6

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,550	93	Paved roads w/curbs & sewers, HSG A
	22,550	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 6S: G1.6



Summary for Subcatchment 10S: G1.7

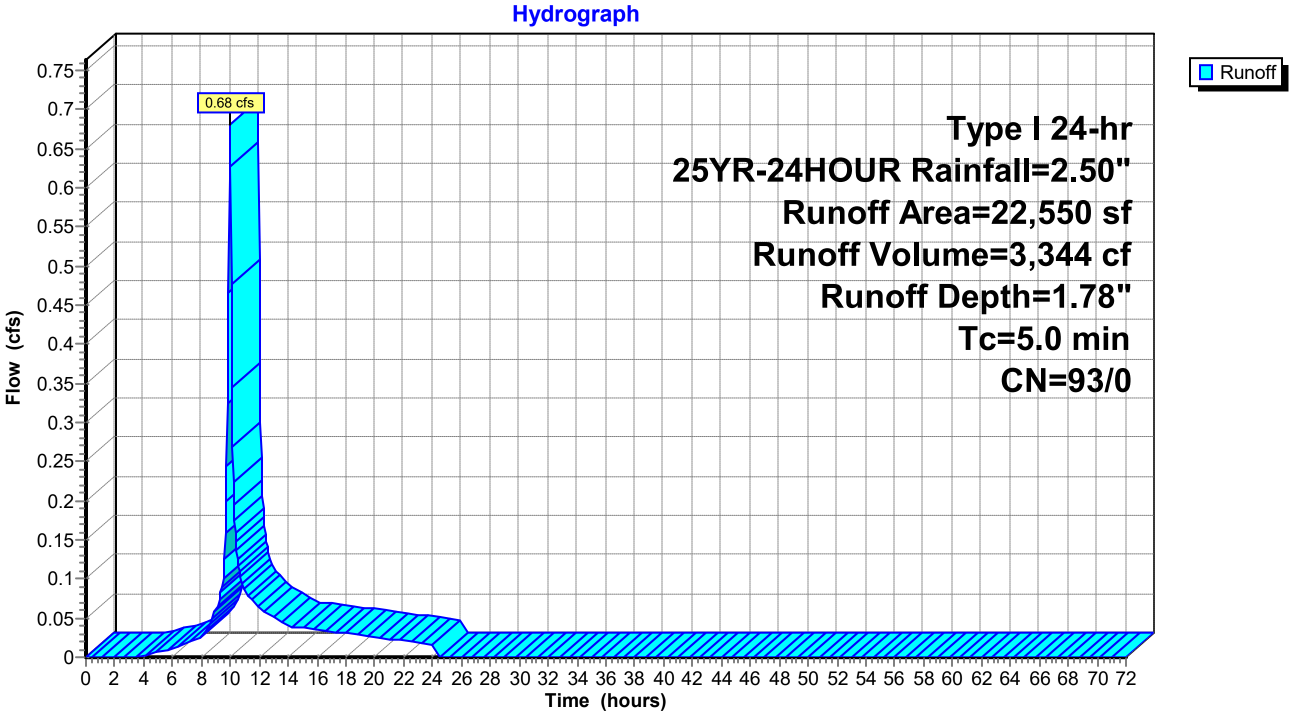
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,344 cf, Depth= 1.78"
Routed to Pond 26P : DW1.7

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,550	93	Paved roads w/curbs & sewers, HSG A
	22,550	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 10S: G1.7



Summary for Subcatchment 11S: G1.8

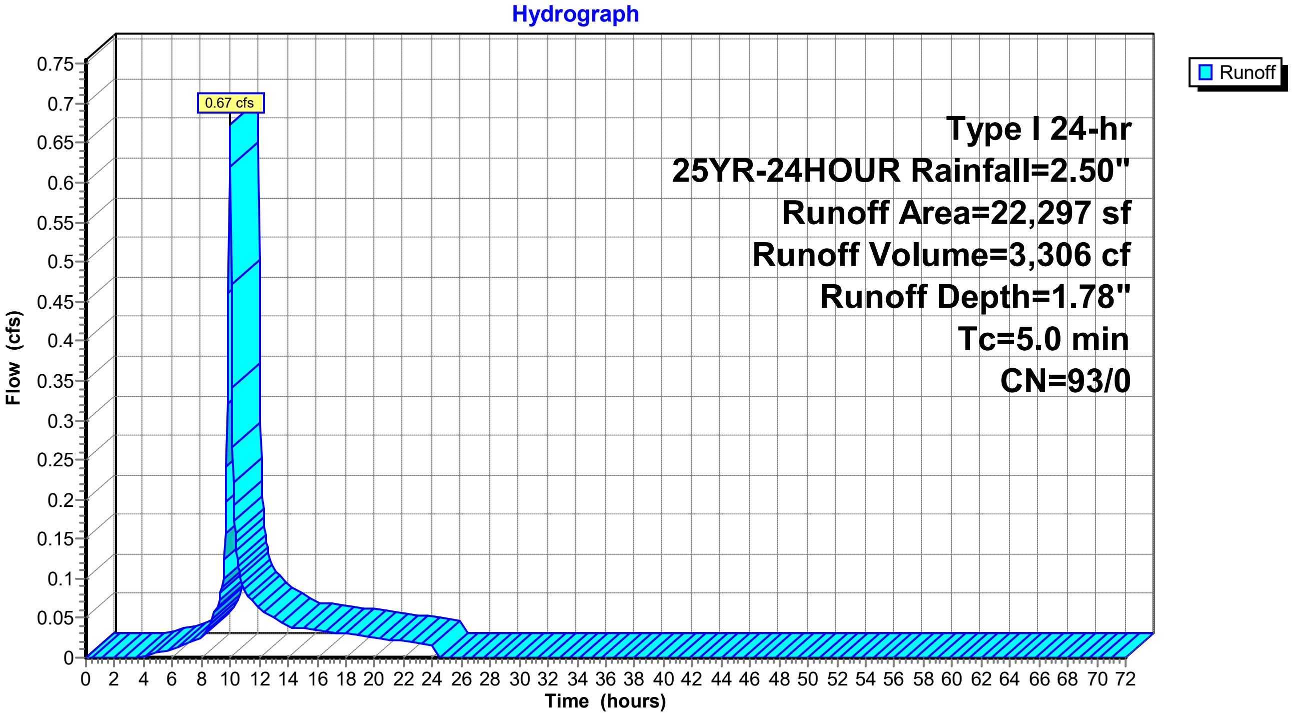
Runoff = 0.67 cfs @ 9.95 hrs, Volume= 3,306 cf, Depth= 1.78"
Routed to Pond 27P : DW1.8

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,297	93	Paved roads w/curbs & sewers, HSG A
	22,297	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 11S: G1.8



Summary for Subcatchment 12S: G1.9

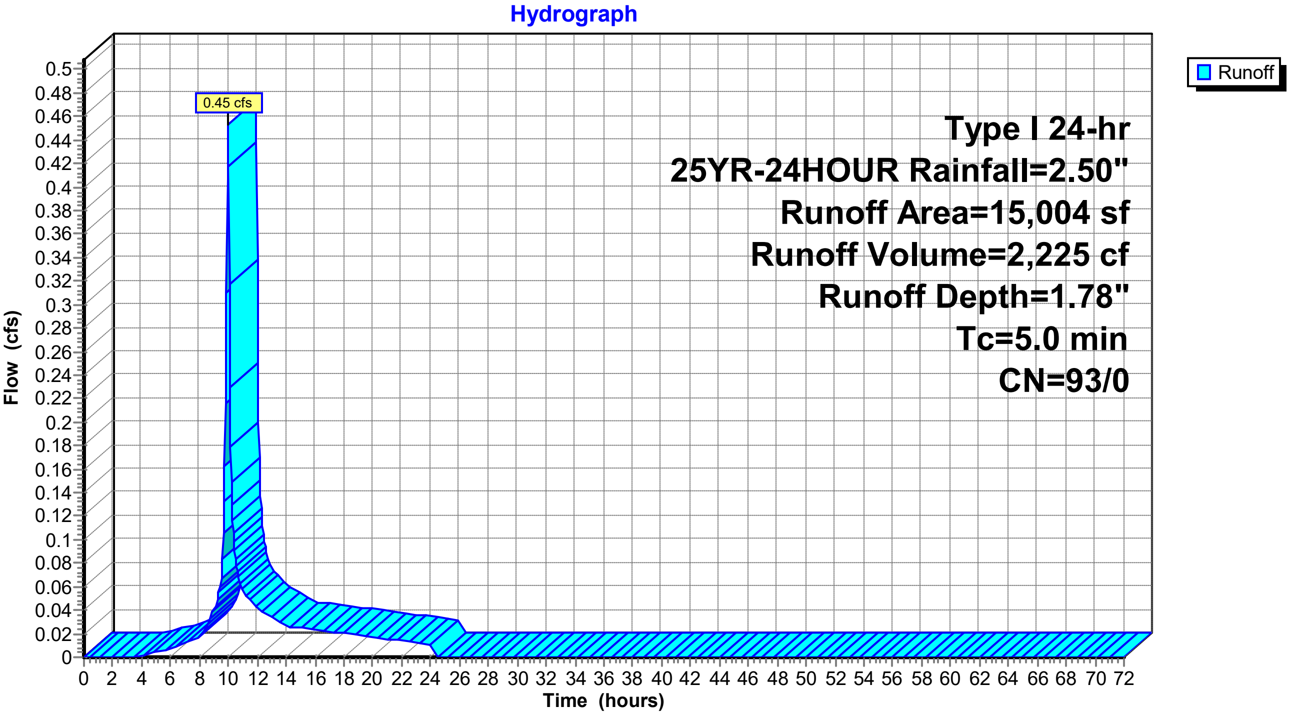
Runoff = 0.45 cfs @ 9.95 hrs, Volume= 2,225 cf, Depth= 1.78"
Routed to Pond 19P : DW1.9

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	15,004	93	Paved roads w/curbs & sewers, HSG A
	15,004	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 12S: G1.9



Summary for Subcatchment 13S: G1.10

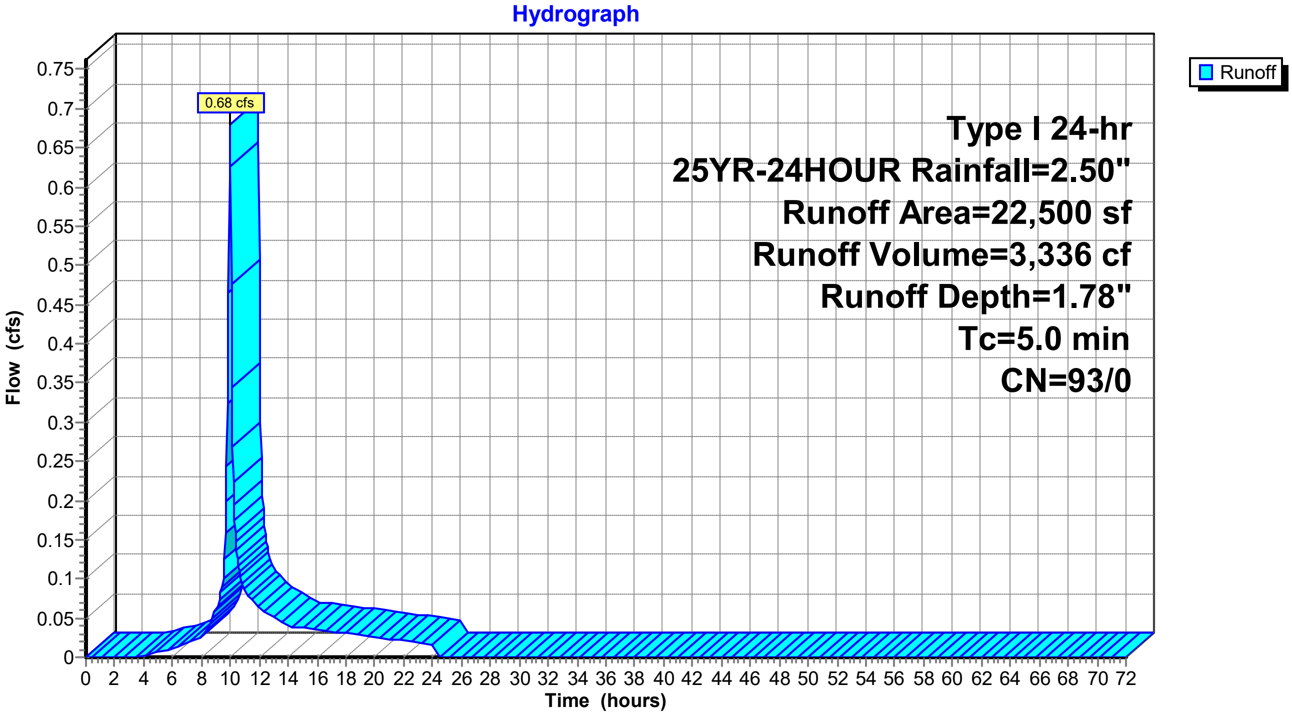
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf, Depth= 1.78"
Routed to Pond 28P : DW1.10

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 13S: G1.10



Summary for Subcatchment 14S: G1.11

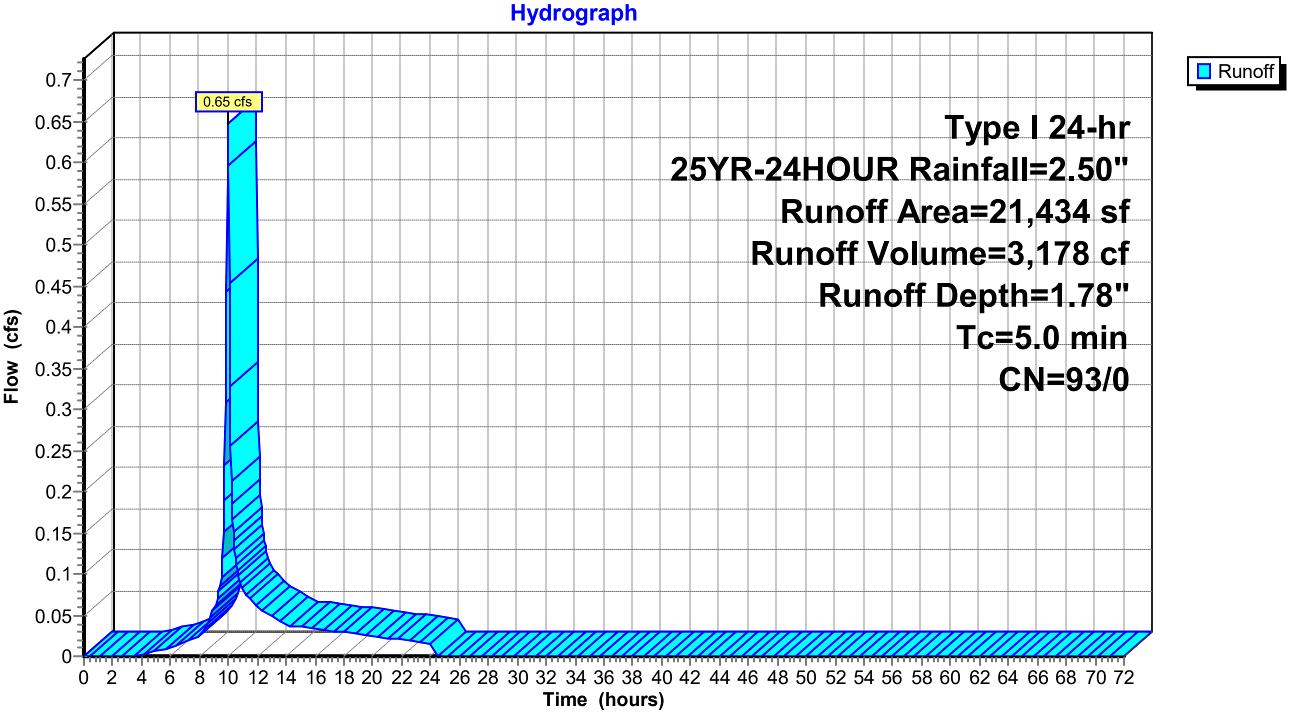
Runoff = 0.65 cfs @ 9.95 hrs, Volume= 3,178 cf, Depth= 1.78"
Routed to Pond 29P : DW1.11

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	21,434	93	Paved roads w/curbs & sewers, HSG A
	21,434	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 14S: G1.11



Summary for Subcatchment 15S: G1.12

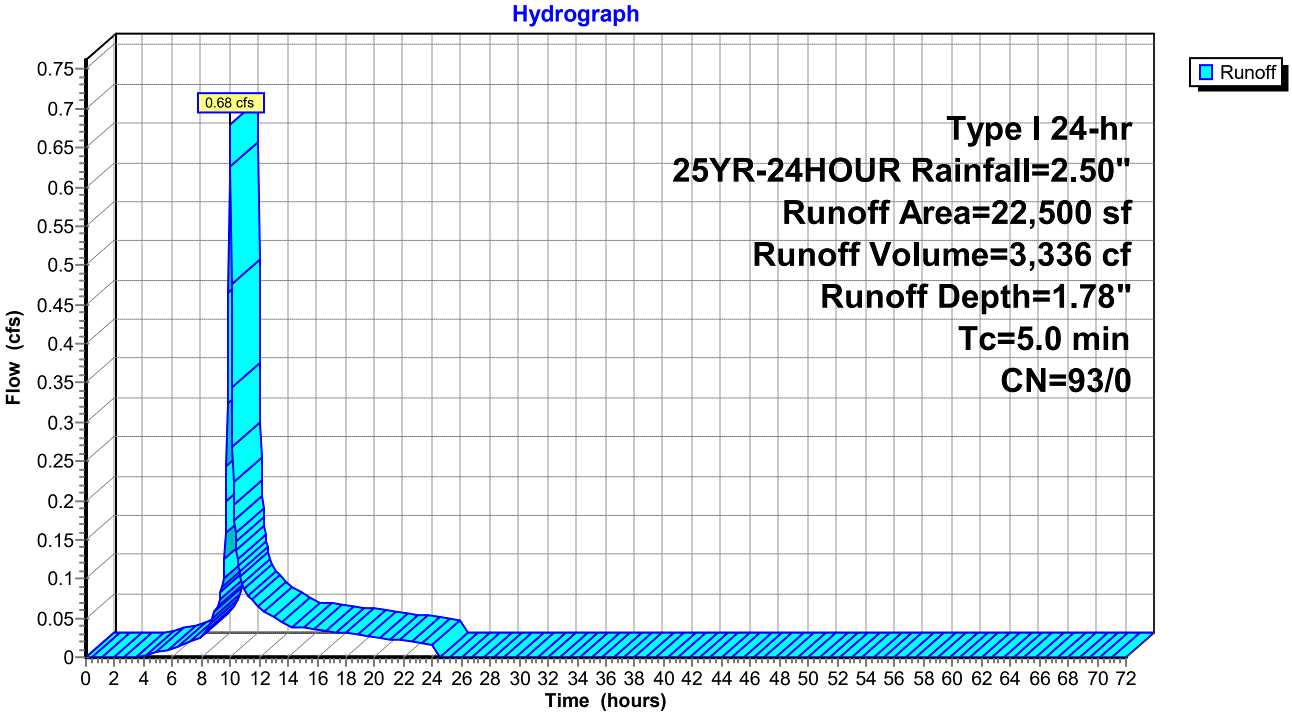
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf, Depth= 1.78"
Routed to Pond 30P : DW1.12

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 15S: G1.12



Summary for Subcatchment 16S: G1.13

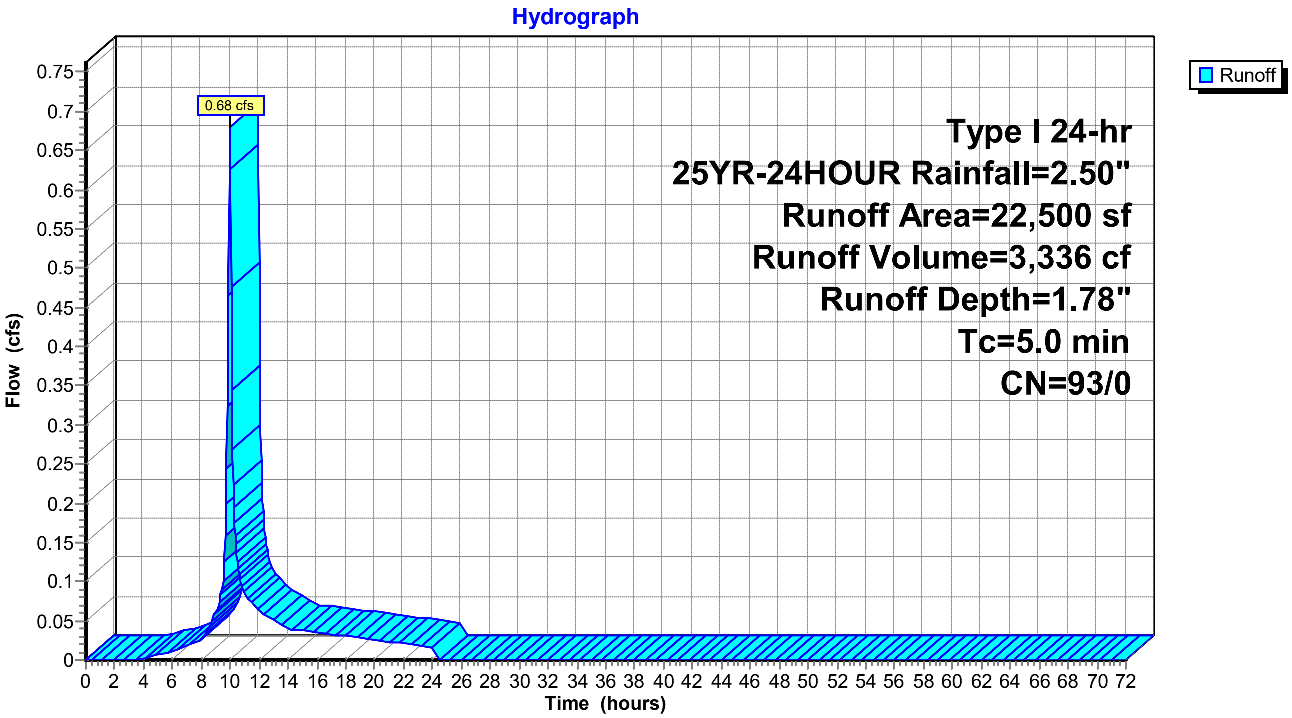
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf, Depth= 1.78"
Routed to Pond 31P : DW1.13

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 16S: G1.13



Summary for Subcatchment 17S: G1.14

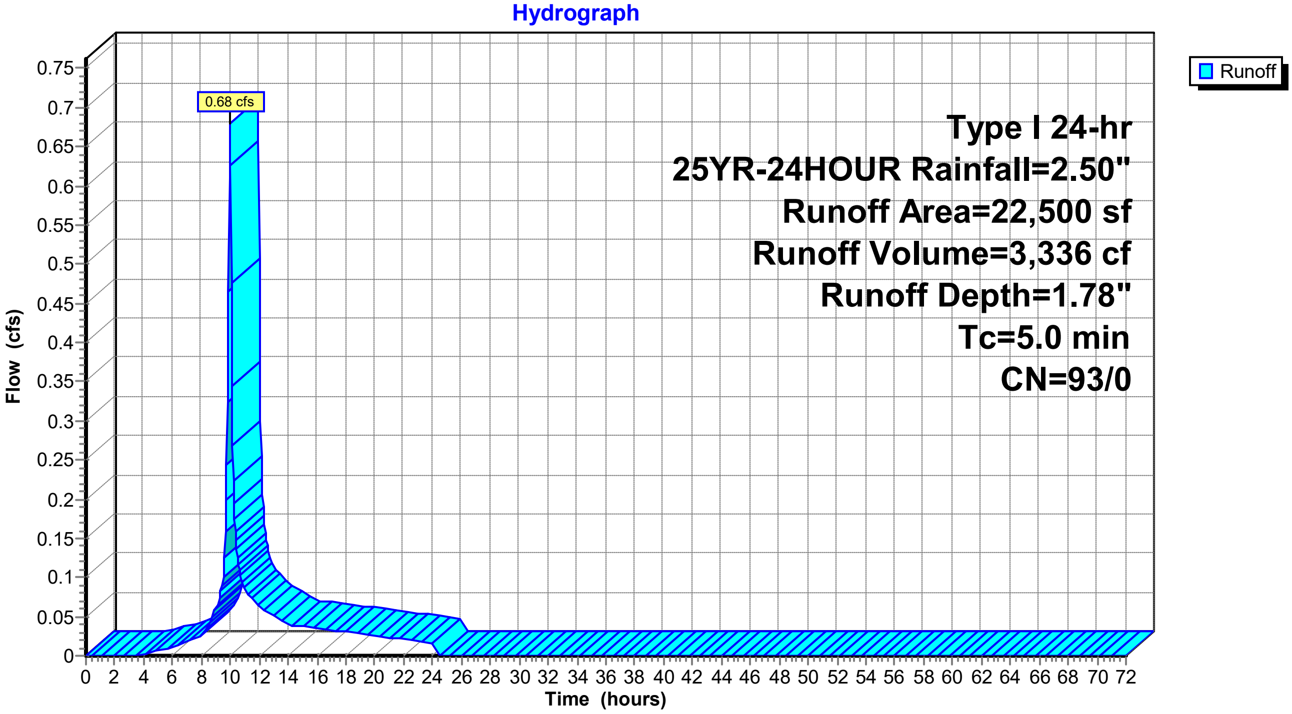
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf, Depth= 1.78"
Routed to Pond 32P : DW1.14

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 17S: G1.14



Summary for Subcatchment 18S: G1.15

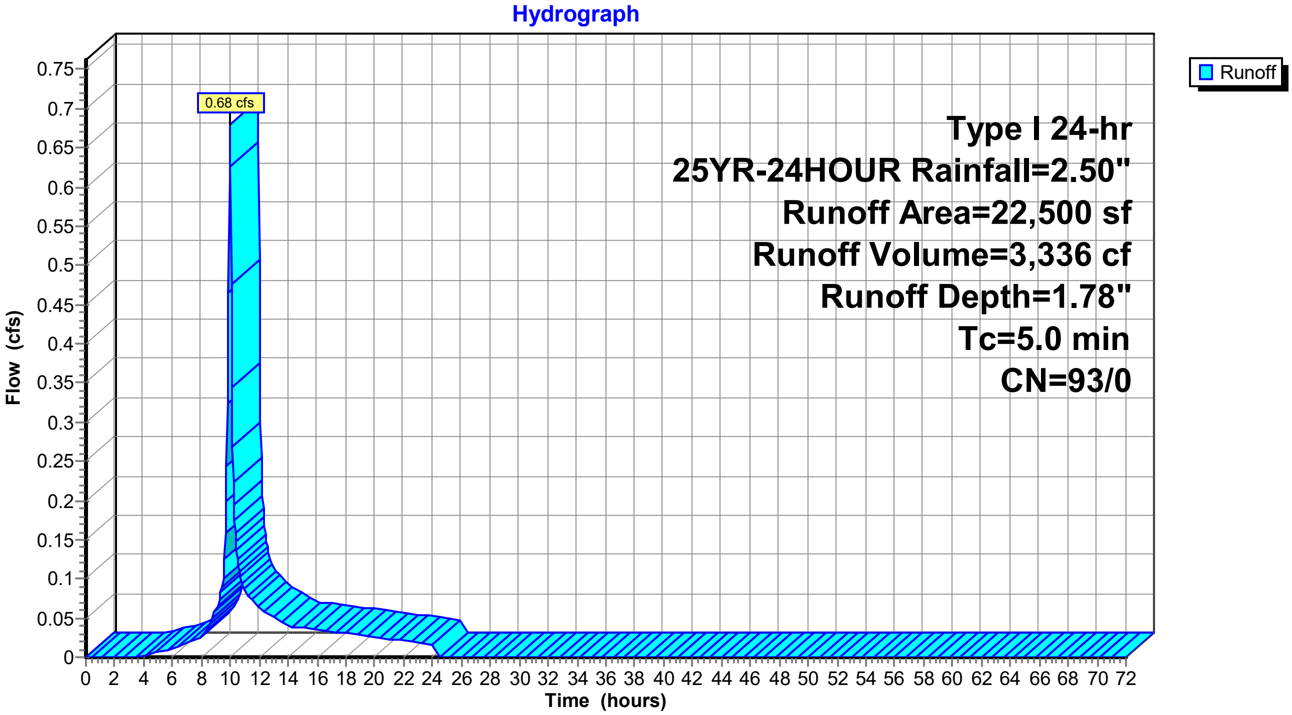
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf, Depth= 1.78"
Routed to Pond 33P : DW1.15

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 18S: G1.15



Summary for Pond 19P: DW1.9

Inflow Area = 15,004 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.45 cfs @ 9.95 hrs, Volume= 2,225 cf
Outflow = 0.08 cfs @ 9.65 hrs, Volume= 2,225 cf, Atten= 82%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.65 hrs, Volume= 2,225 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 4.35' @ 10.50 hrs Surf.Area= 225 sf Storage= 409 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 26.4 min calculated for 2,223 cf (100% of inflow)
Center-of-Mass det. time= 26.4 min (790.7 - 764.3)

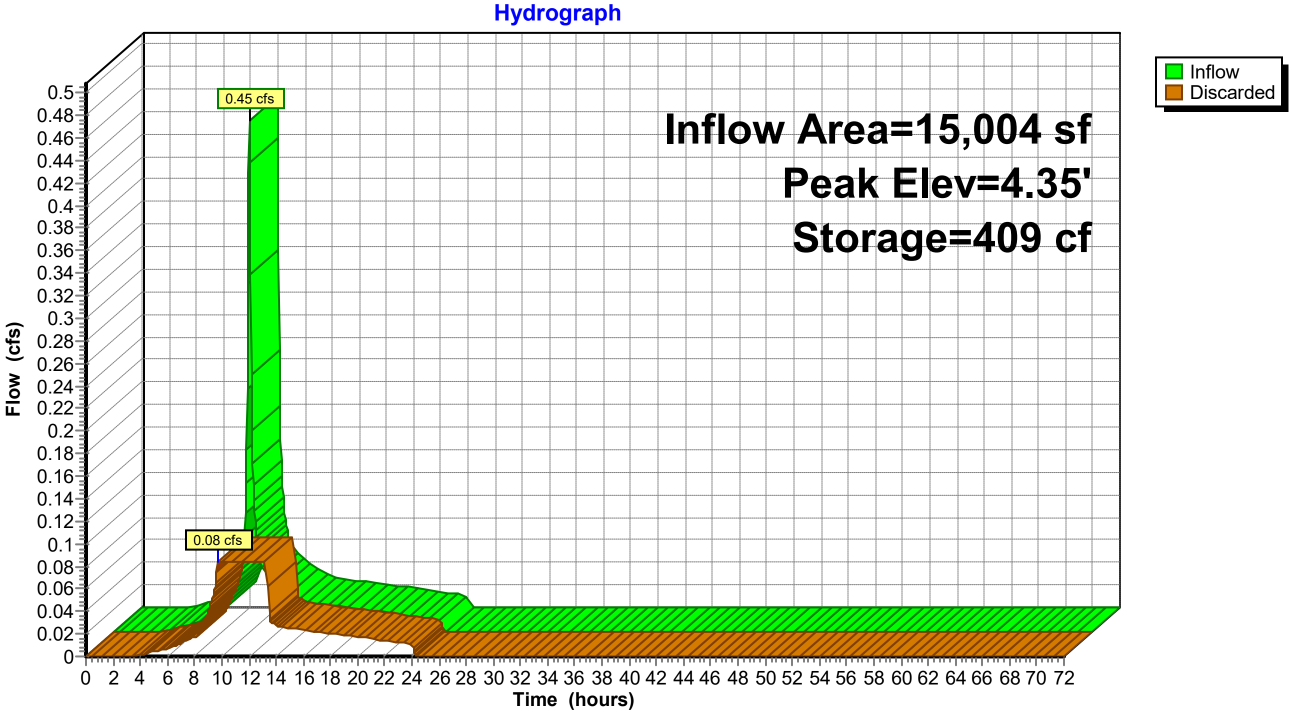
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.65 hrs HW=0.16' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

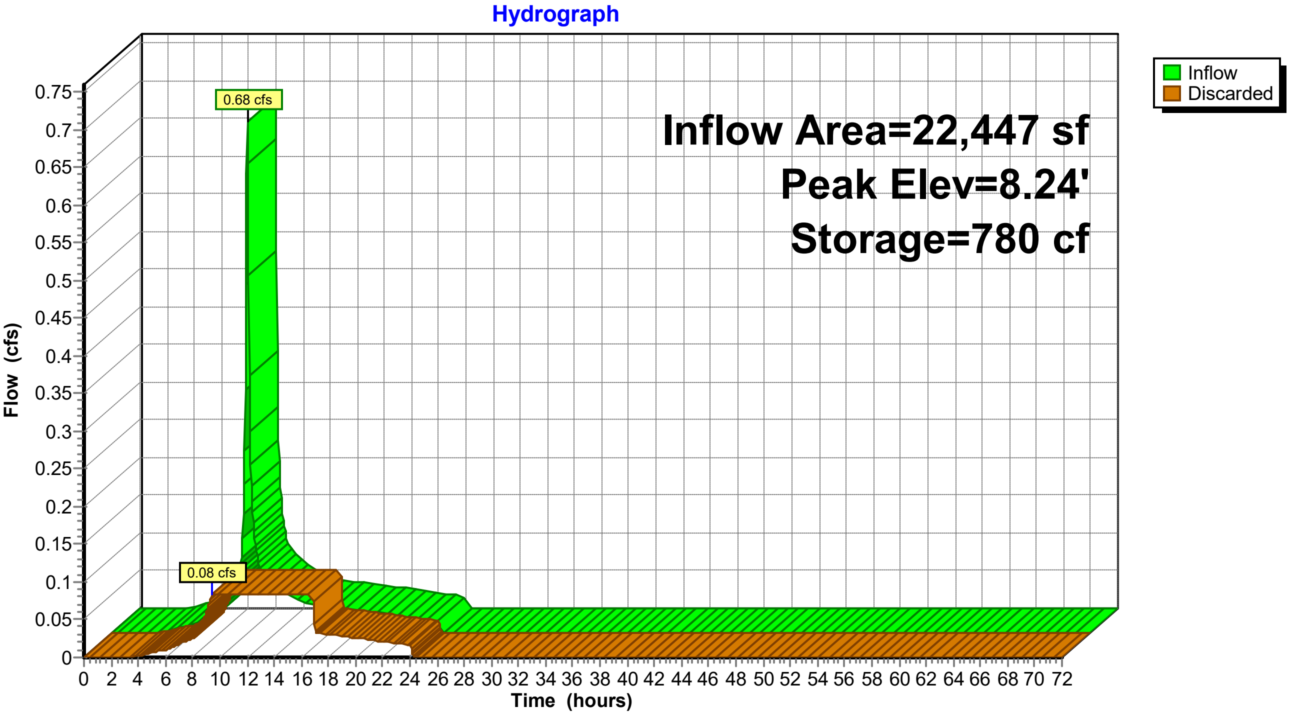
Pond 19P: DW1.9



Summary for Pond 20P: DW1.1

```
Inflow Area =        22,447 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow      =       0.68 cfs @    9.95 hrs,  Volume=            3,329 cf
Outflow     =       0.08 cfs @    9.40 hrs,  Volume=            3,329 cf,  Atten= 88%,  Lag= 0.0 min
Discarded  =        0.08 cfs @    9.40 hrs,  Volume=            3,329 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.24' @ 11.02 hrs   Surf.Area= 225 sf   Storage= 780 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 66.1 min calculated for 3,326 cf (100% of inflow)
Center-of-Mass det. time= 66.1 min ( 830.4 - 764.3 )

Volume        Invert    Avail.Storage   Storage Description
   #1          0.00'          767 cf    DW (Pyramidal) Listed below
                                        2,166 cf Overall - 248 cf Embedded = 1,918 cf  x 40.0% Voids
   #2          1.00'          170 cf    4.00'D x 13.50'H Vertical Cone/Cylinder  Inside #1
                                        248 cf Overall - 5.0" Wall Thickness = 170 cf
                              937 cf    Total Available Storage

 Elevation        Surf.Area         Inc.Store        Cum.Store         Wet.Area
    (feet)           (sq-ft)      (cubic-feet)     (cubic-feet)           (sq-ft)
      0.00               225                 0                0               225
      9.00               225             2,025            2,025               765
      9.50                18                51            2,076               973
     14.50                18                90            2,166             1,058

Device   Routing          Invert   Outlet Devices
   #1    Discarded         0.00'   16.000 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.08 cfs @ 9.40 hrs  HW=0.15'   (Free Discharge)
└─1=Exfiltration  (Exfiltration Controls 0.08 cfs)
```

Pond 20P: DW1.1



Summary for Pond 21P: DW1.2

Inflow Area = 18,682 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.56 cfs @ 9.95 hrs, Volume= 2,770 cf
Outflow = 0.08 cfs @ 9.60 hrs, Volume= 2,770 cf, Atten= 85%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.60 hrs, Volume= 2,770 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 6.15' @ 10.70 hrs Surf.Area= 225 sf Storage= 580 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 43.3 min calculated for 2,768 cf (100% of inflow)
Center-of-Mass det. time= 43.3 min (807.6 - 764.3)

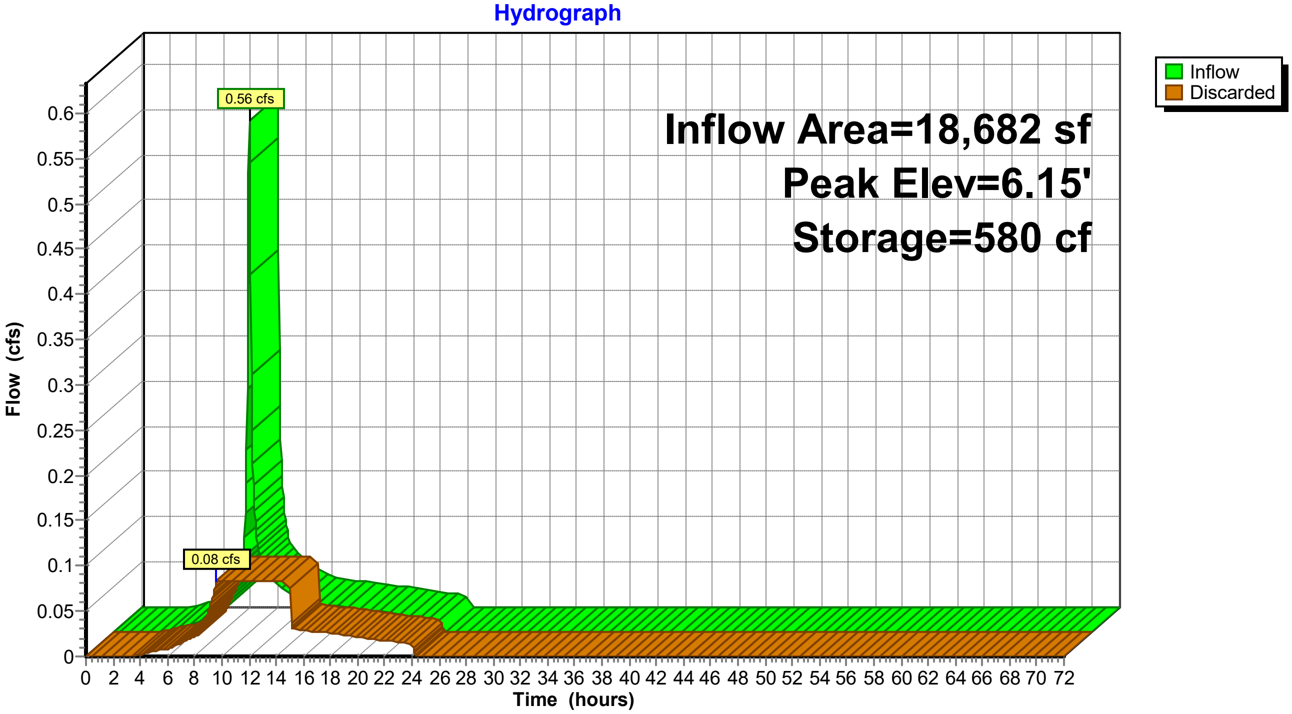
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.60 hrs HW=0.17' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 21P: DW1.2



Summary for Pond 22P: DW1.3

Inflow Area = 16,897 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.51 cfs @ 9.95 hrs, Volume= 2,506 cf
Outflow = 0.08 cfs @ 9.65 hrs, Volume= 2,506 cf, Atten= 84%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.65 hrs, Volume= 2,506 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 5.25' @ 10.58 hrs Surf.Area= 225 sf Storage= 495 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 34.5 min calculated for 2,504 cf (100% of inflow)
Center-of-Mass det. time= 34.5 min (798.8 - 764.3)

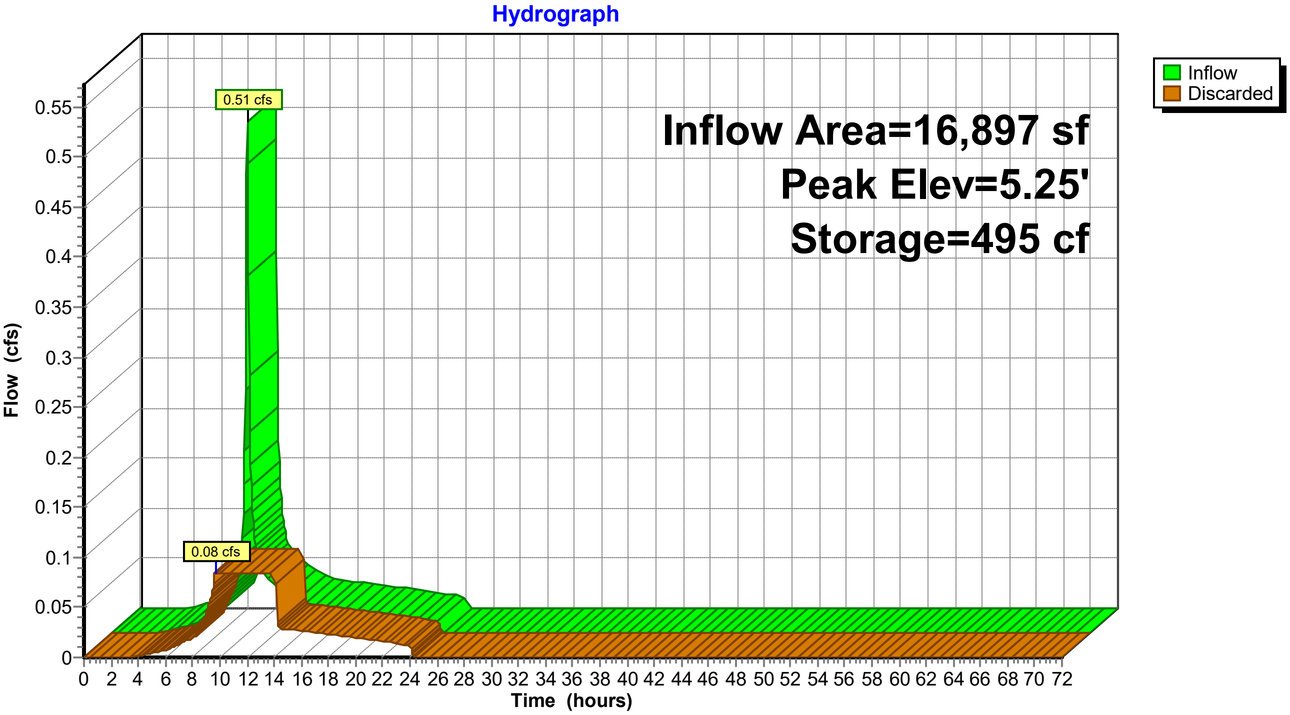
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.65 hrs HW=0.19' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 22P: DW1.3



Summary for Pond 23P: DW1.4

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf
Outflow = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf, Atten= 88%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.27' @ 11.02 hrs Surf.Area= 225 sf Storage= 783 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 66.5 min calculated for 3,334 cf (100% of inflow)
Center-of-Mass det. time= 66.4 min (830.7 - 764.3)

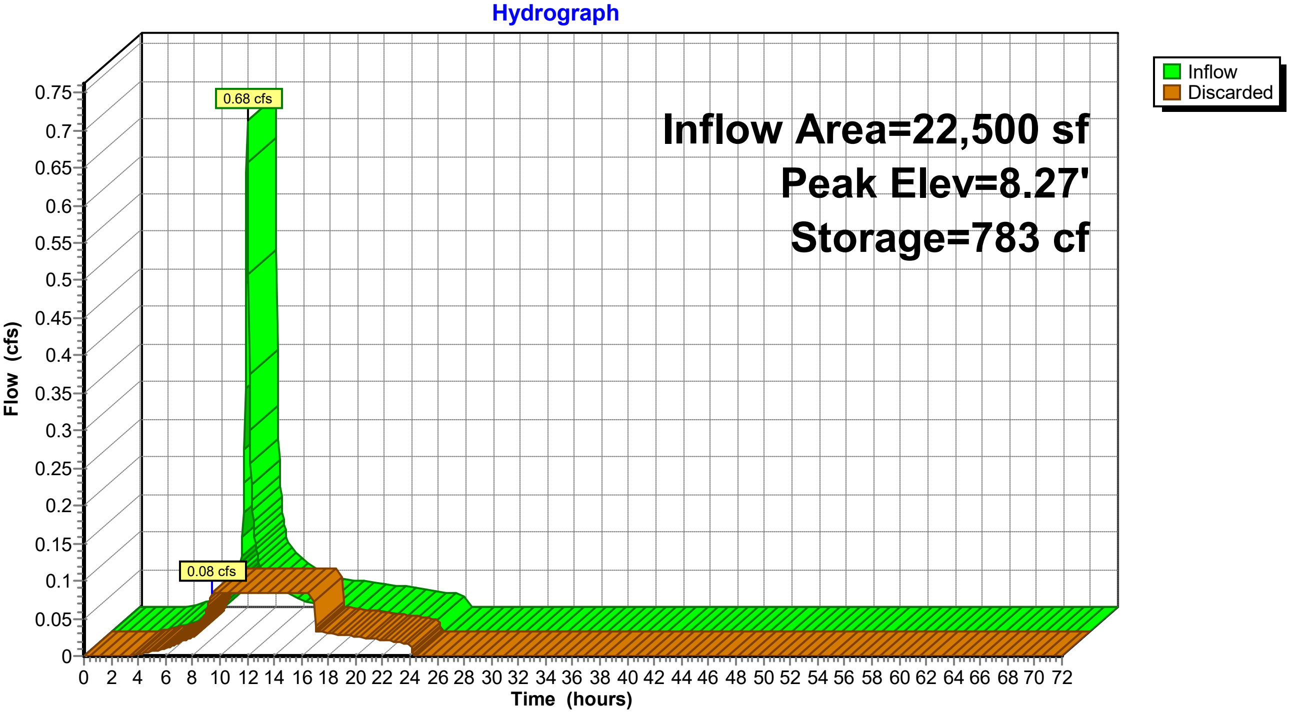
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 23P: DW1.4



Summary for Pond 24P: DW1.5

Inflow Area = 20,304 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.61 cfs @ 9.95 hrs, Volume= 3,011 cf
Outflow = 0.08 cfs @ 9.50 hrs, Volume= 3,011 cf, Atten= 86%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.50 hrs, Volume= 3,011 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 7.01' @ 10.84 hrs Surf.Area= 225 sf Storage= 663 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 52.3 min calculated for 3,009 cf (100% of inflow)
Center-of-Mass det. time= 52.3 min (816.6 - 764.3)

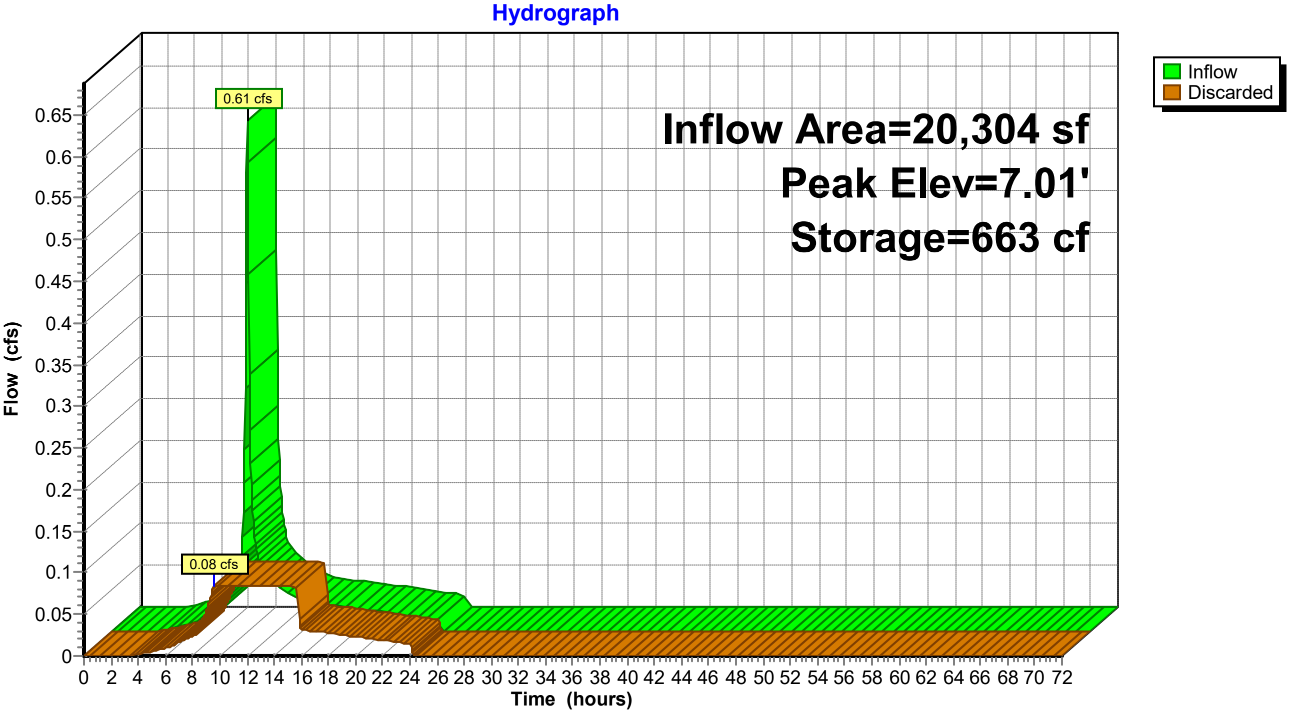
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.50 hrs HW=0.15' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 24P: DW1.5



Summary for Pond 25P: DW1.6

```
Inflow Area =          22,550 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow      =       0.68 cfs @    9.95 hrs,  Volume=             3,344 cf
Outflow     =       0.08 cfs @    9.40 hrs,  Volume=             3,344 cf,  Atten= 88%,  Lag= 0.0 min
Discarded  =        0.08 cfs @    9.40 hrs,  Volume=             3,344 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.30' @ 11.02 hrs Surf.Area= 225 sf Storage= 785 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 66.8 min calculated for 3,341 cf (100% of inflow)
Center-of-Mass det. time= 66.8 min (831.1 - 764.3)

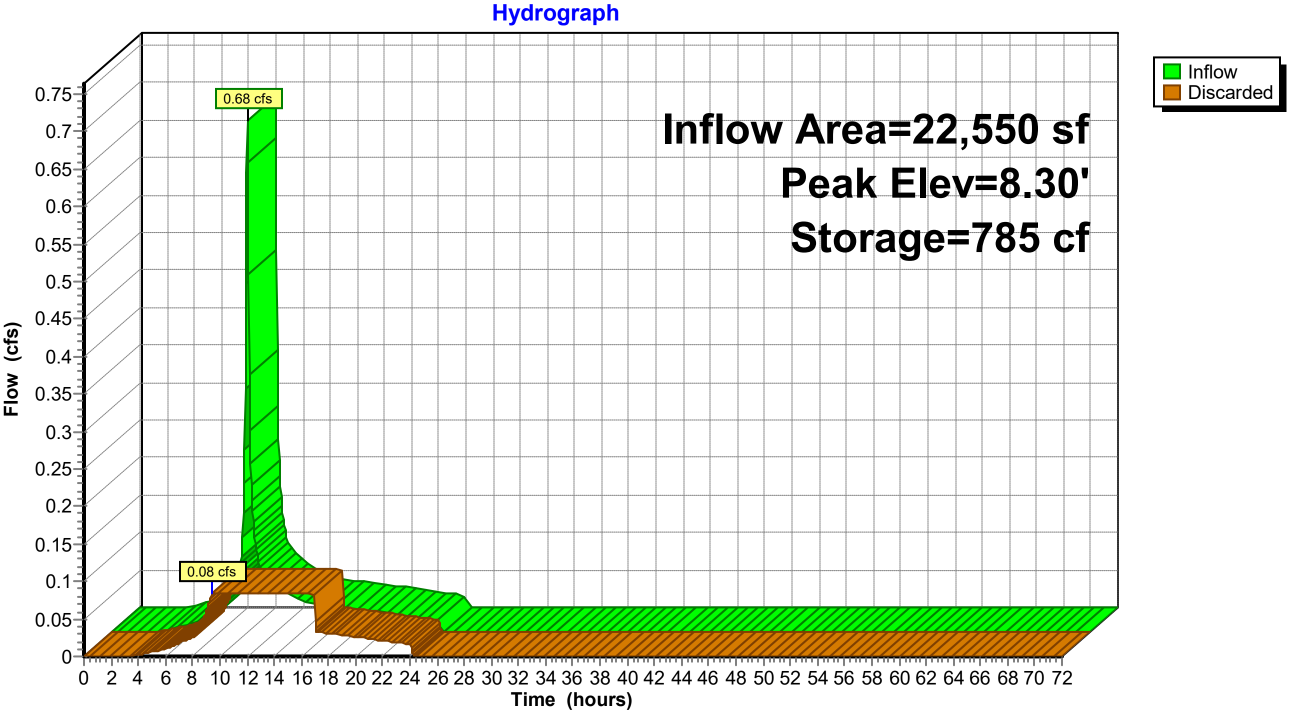
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 25P: DW1.6



Summary for Pond 26P: DW1.7

```
Inflow Area =          22,550 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow       =        0.68 cfs @    9.95 hrs,  Volume=             3,344 cf
Outflow      =        0.08 cfs @    9.40 hrs,  Volume=             3,344 cf,  Atten= 88%,  Lag= 0.0 min
Discarded  =          0.08 cfs @    9.40 hrs,  Volume=             3,344 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.30' @ 11.02 hrs   Surf.Area= 225 sf   Storage= 785 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 66.8 min calculated for 3,341 cf (100% of inflow)
Center-of-Mass det. time= 66.8 min (831.1 - 764.3)

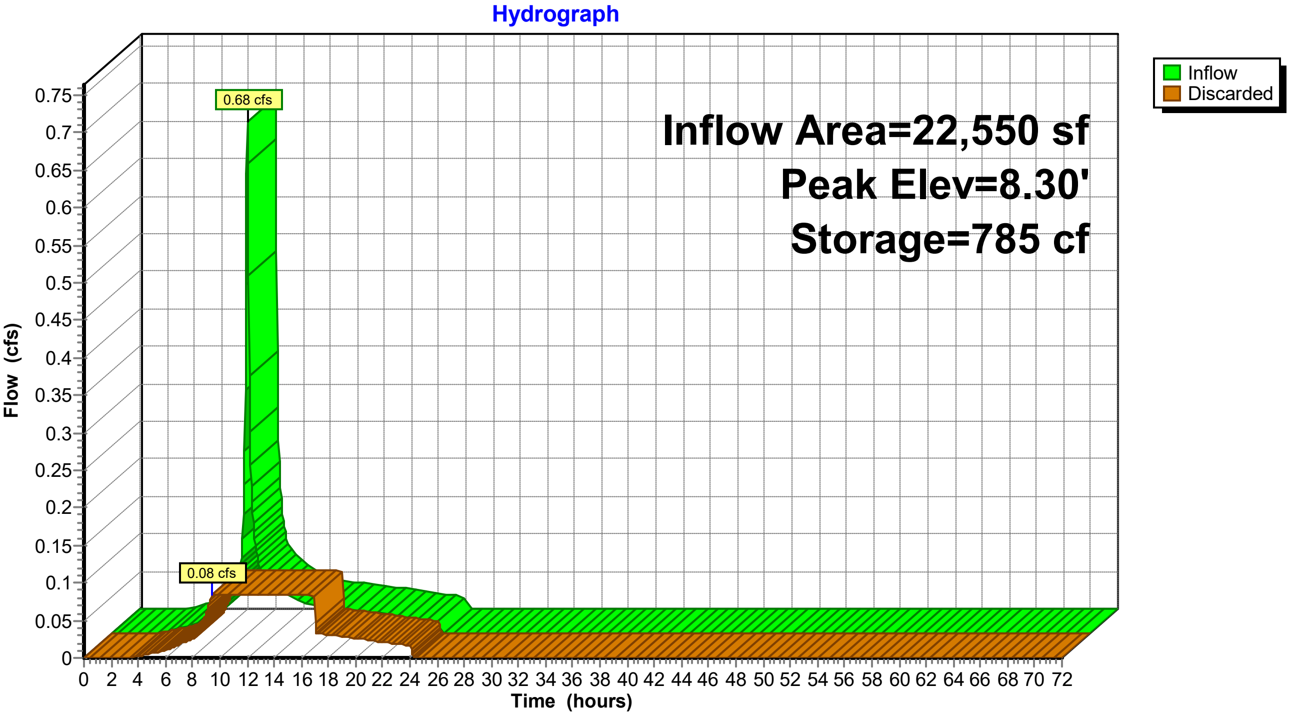
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 26P: DW1.7



Summary for Pond 27P: DW1.8

Inflow Area = 22,297 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.67 cfs @ 9.95 hrs, Volume= 3,306 cf
Outflow = 0.08 cfs @ 9.40 hrs, Volume= 3,306 cf, Atten= 88%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.40 hrs, Volume= 3,306 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.15' @ 11.00 hrs Surf.Area= 225 sf Storage= 771 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 65.1 min calculated for 3,304 cf (100% of inflow)
Center-of-Mass det. time= 65.0 min (829.3 - 764.3)

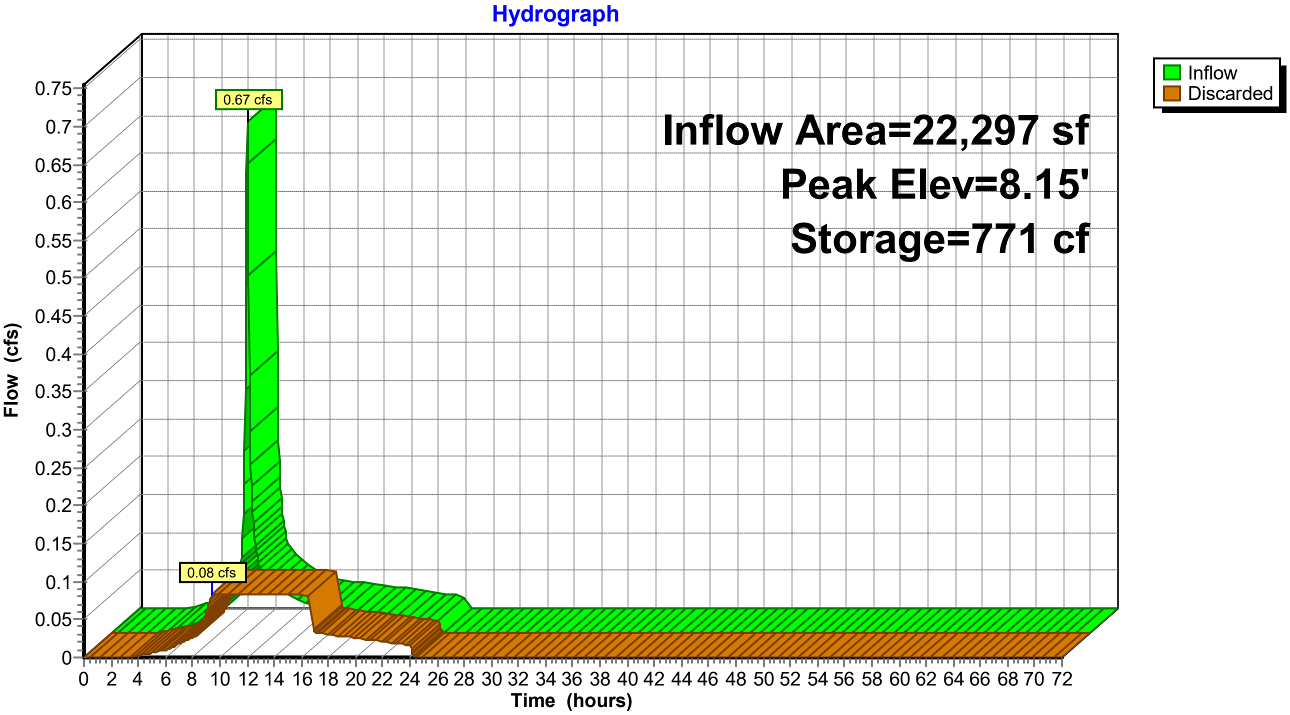
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 27P: DW1.8



Summary for Pond 28P: DW1.10

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf
Outflow = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf, Atten= 88%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.27' @ 11.02 hrs Surf.Area= 225 sf Storage= 783 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 66.5 min calculated for 3,334 cf (100% of inflow)
Center-of-Mass det. time= 66.4 min (830.7 - 764.3)

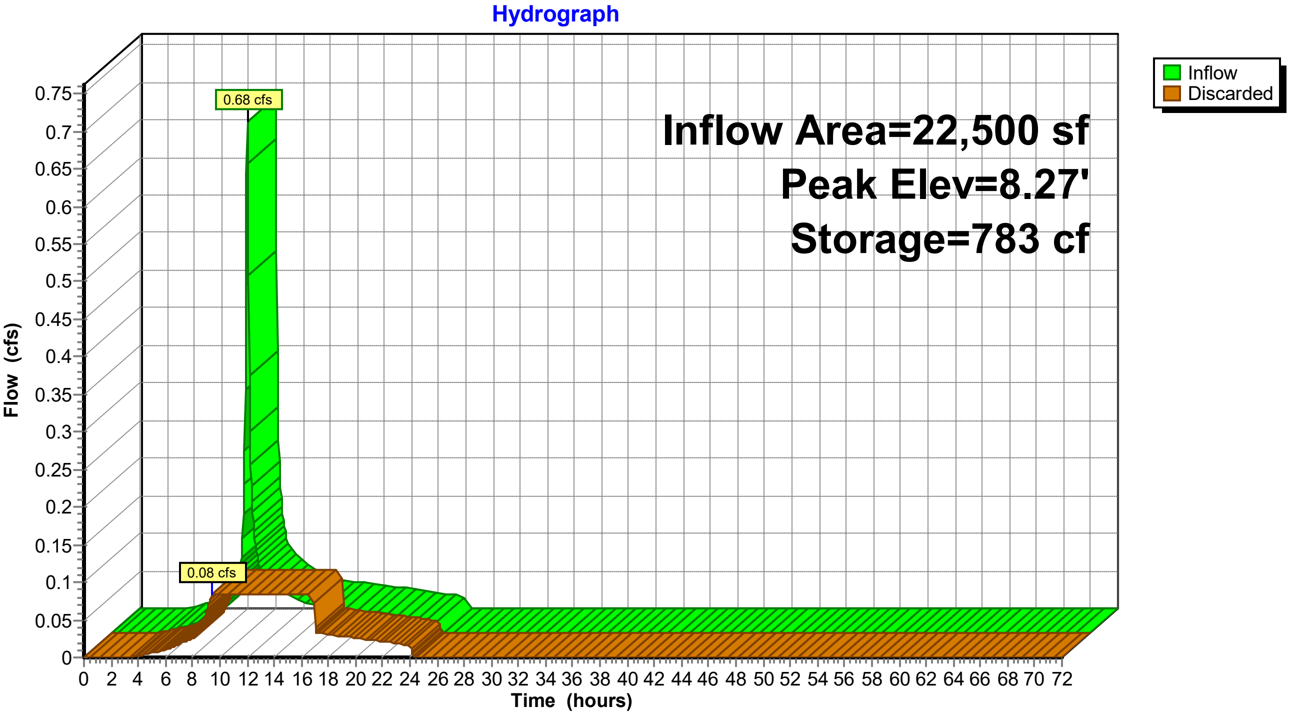
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
⬑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 28P: DW1.10



Summary for Pond 29P: DW1.11

Inflow Area = 21,434 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.65 cfs @ 9.95 hrs, Volume= 3,178 cf
Outflow = 0.08 cfs @ 9.45 hrs, Volume= 3,178 cf, Atten= 87%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.45 hrs, Volume= 3,178 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 7.65' @ 10.93 hrs Surf.Area= 225 sf Storage= 723 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 59.3 min calculated for 3,176 cf (100% of inflow)
Center-of-Mass det. time= 59.3 min (823.6 - 764.3)

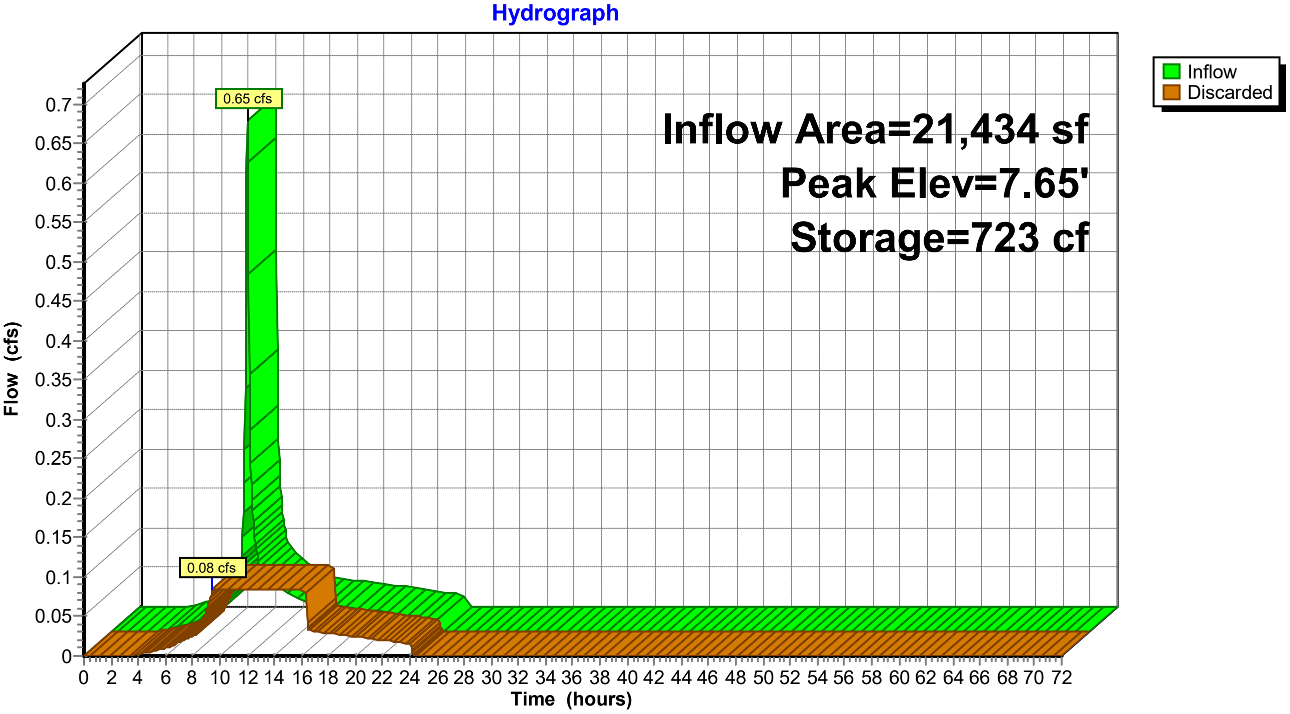
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.45 hrs HW=0.15' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 29P: DW1.11



Summary for Pond 30P: DW1.12

```
Inflow Area =        22,500 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow      =      0.68 cfs @    9.95 hrs,  Volume=          3,336 cf
Outflow     =      0.08 cfs @    9.40 hrs,  Volume=          3,336 cf,  Atten= 88%,  Lag= 0.0 min
Discarded  =       0.08 cfs @    9.40 hrs,  Volume=          3,336 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.27' @ 11.02 hrs Surf.Area= 225 sf Storage= 783 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 66.5 min calculated for 3,334 cf (100% of inflow)
Center-of-Mass det. time= 66.4 min (830.7 - 764.3)

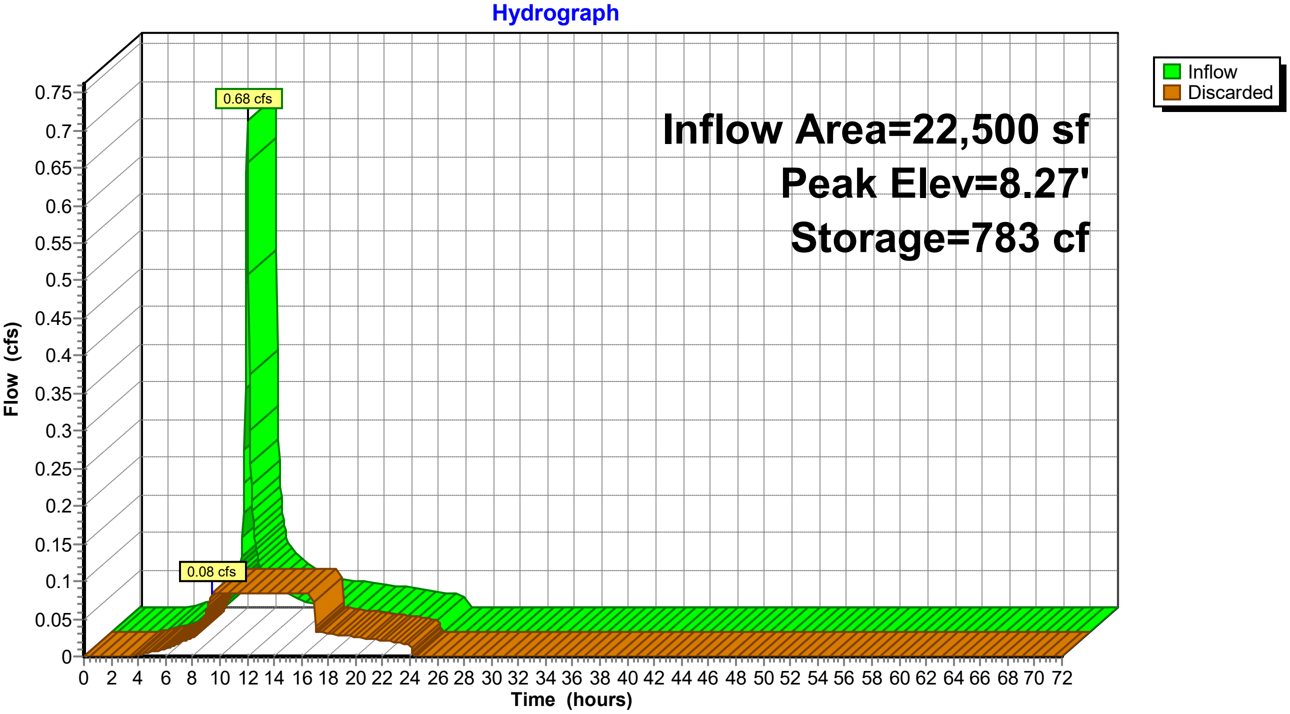
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
└—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 30P: DW1.12



Summary for Pond 31P: DW1.13

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf
Outflow = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf, Atten= 88%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.27' @ 11.02 hrs Surf.Area= 225 sf Storage= 783 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 66.5 min calculated for 3,334 cf (100% of inflow)
Center-of-Mass det. time= 66.4 min (830.7 - 764.3)

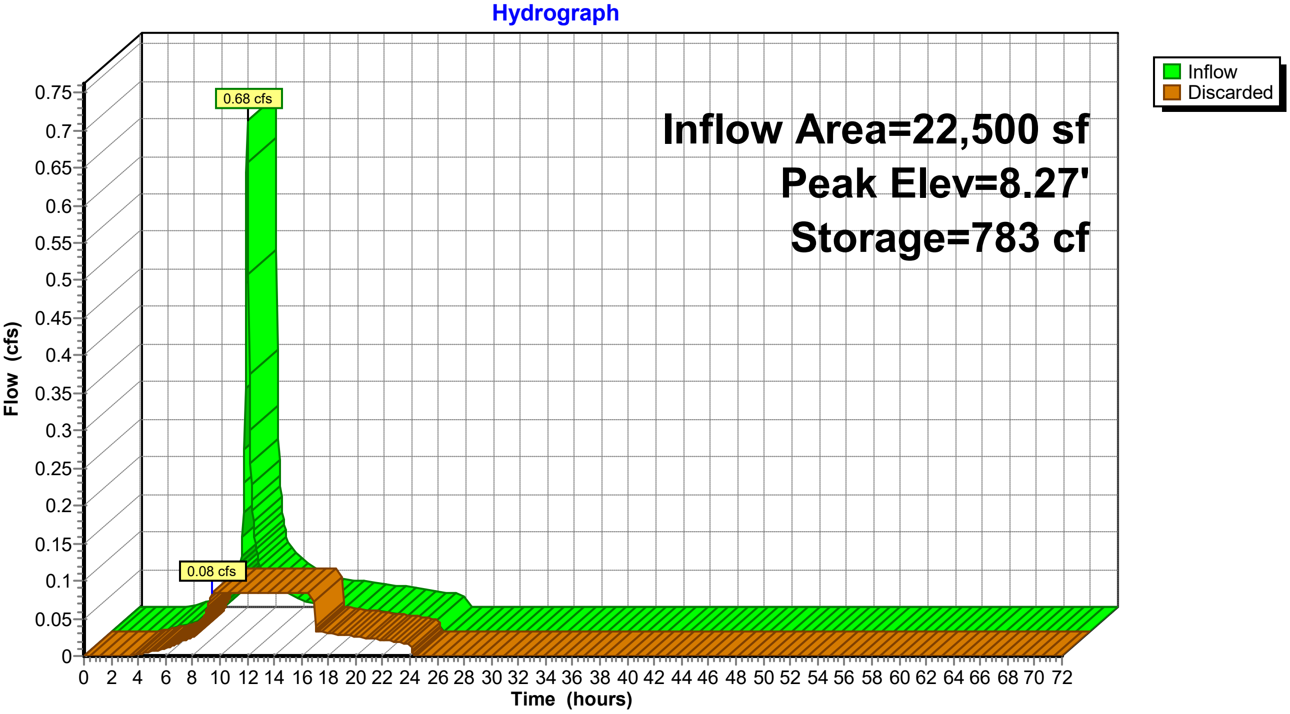
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 31P: DW1.13



Summary for Pond 32P: DW1.14

```
Inflow Area =          22,500 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow      =        0.68 cfs @    9.95 hrs,  Volume=             3,336 cf
Outflow     =        0.08 cfs @    9.40 hrs,  Volume=             3,336 cf,  Atten= 88%,  Lag= 0.0 min
Discarded  =         0.08 cfs @    9.40 hrs,  Volume=             3,336 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.27' @ 11.02 hrs Surf.Area= 225 sf Storage= 783 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 66.5 min calculated for 3,334 cf (100% of inflow)
Center-of-Mass det. time= 66.4 min (830.7 - 764.3)

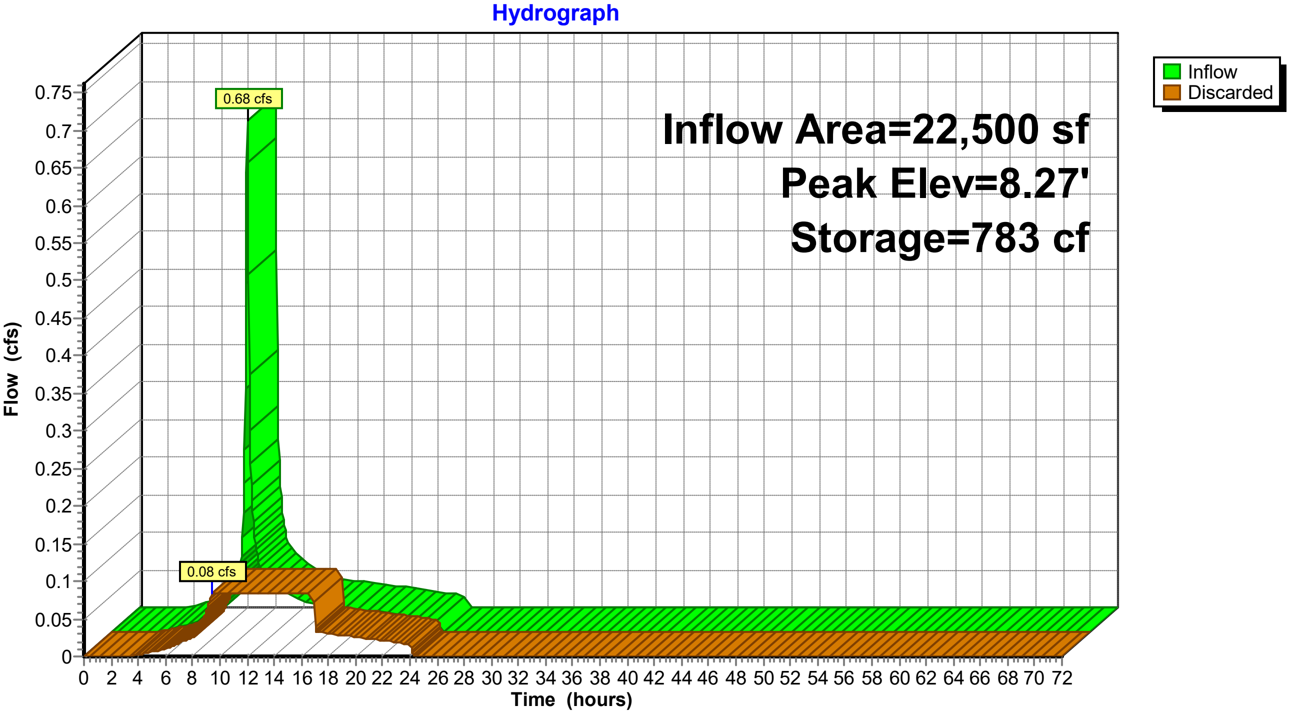
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 32P: DW1.14



Summary for Pond 33P: DW1.15

```
Inflow Area =          22,500 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow      =       0.68 cfs @    9.95 hrs,  Volume=             3,336 cf
Outflow     =       0.08 cfs @    9.40 hrs,  Volume=             3,336 cf,  Atten= 88%,  Lag= 0.0 min
Discarded  =        0.08 cfs @    9.40 hrs,  Volume=             3,336 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.27' @ 11.02 hrs   Surf.Area= 225 sf   Storage= 783 cf
Flood Elev= 9.00'   Surf.Area= 225 sf   Storage= 852 cf

Plug-Flow detention time= 66.5 min calculated for 3,334 cf (100% of inflow)
Center-of-Mass det. time= 66.4 min (830.7 - 764.3)

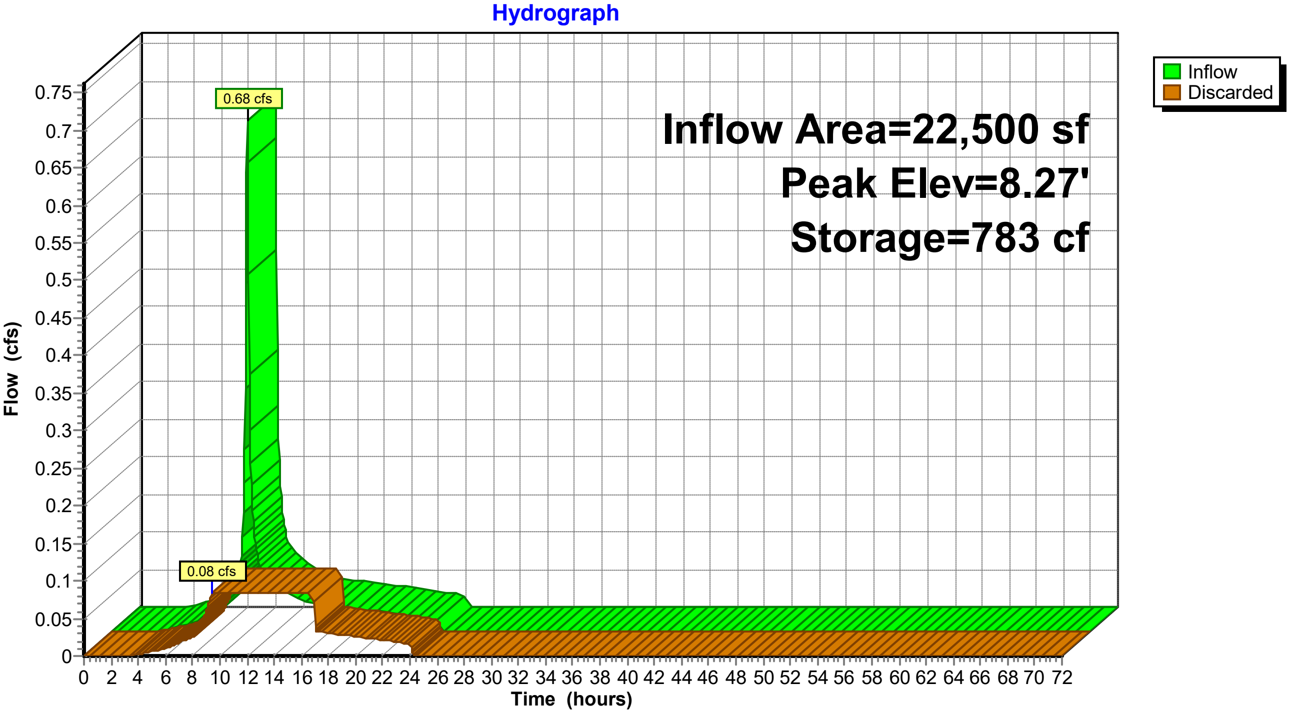
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 33P: DW1.15



Summary for Pond 69P: DW2.1

```
Inflow Area =          7,700 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow      =      0.23 cfs @    9.95 hrs,  Volume=            1,142 cf
Outflow     =      0.08 cfs @    9.80 hrs,  Volume=            1,142 cf,  Atten= 64%,  Lag= 0.0 min
Discarded  =       0.08 cfs @    9.80 hrs,  Volume=            1,142 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 1.37' @ 10.18 hrs Surf.Area= 225 sf Storage= 125 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 6.7 min calculated for 1,141 cf (100% of inflow)
Center-of-Mass det. time= 6.7 min (771.0 - 764.3)

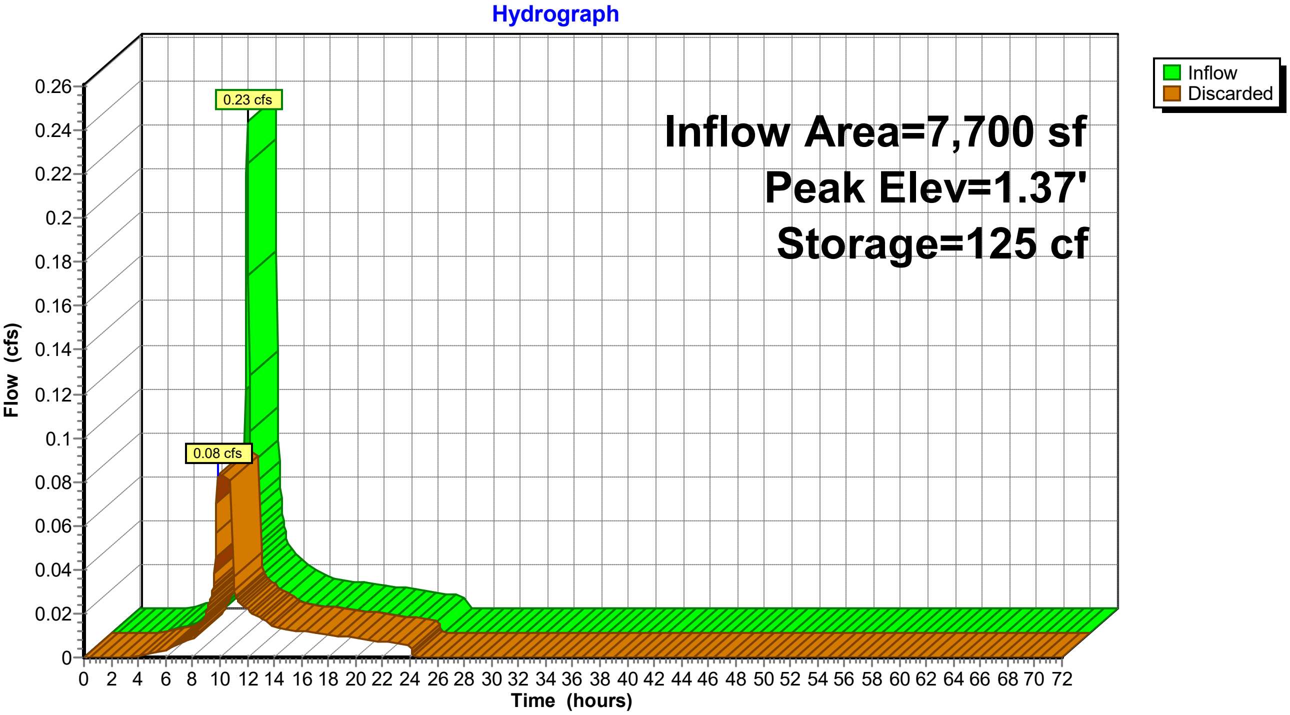
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.80 hrs HW=0.16' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 69P: DW2.1



Summary for Pond 70P: DW2.4

Inflow Area = 17,300 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.52 cfs @ 9.95 hrs, Volume= 2,565 cf
Outflow = 0.08 cfs @ 9.60 hrs, Volume= 2,565 cf, Atten= 84%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.60 hrs, Volume= 2,565 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 5.45' @ 10.61 hrs Surf.Area= 225 sf Storage= 514 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 36.4 min calculated for 2,564 cf (100% of inflow)
Center-of-Mass det. time= 36.4 min (800.7 - 764.3)

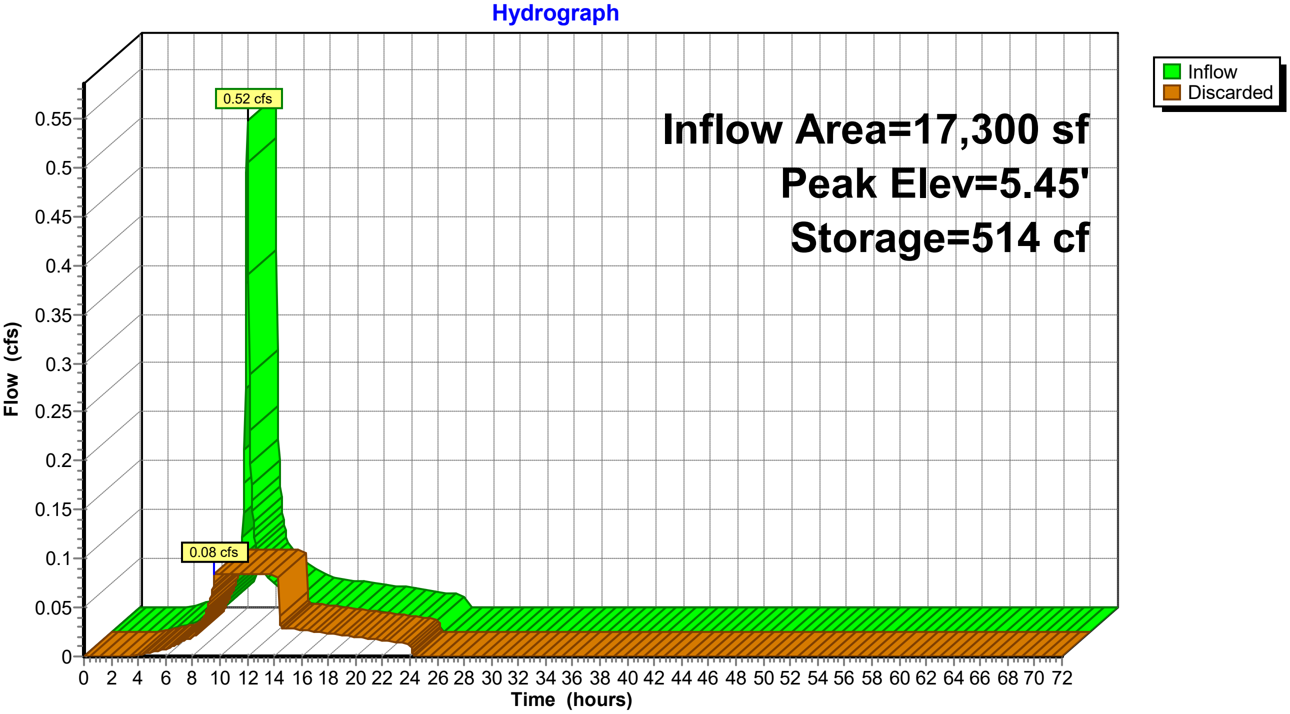
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.60 hrs HW=0.15' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 70P: DW2.4



Summary for Subcatchment 71S: F2.2

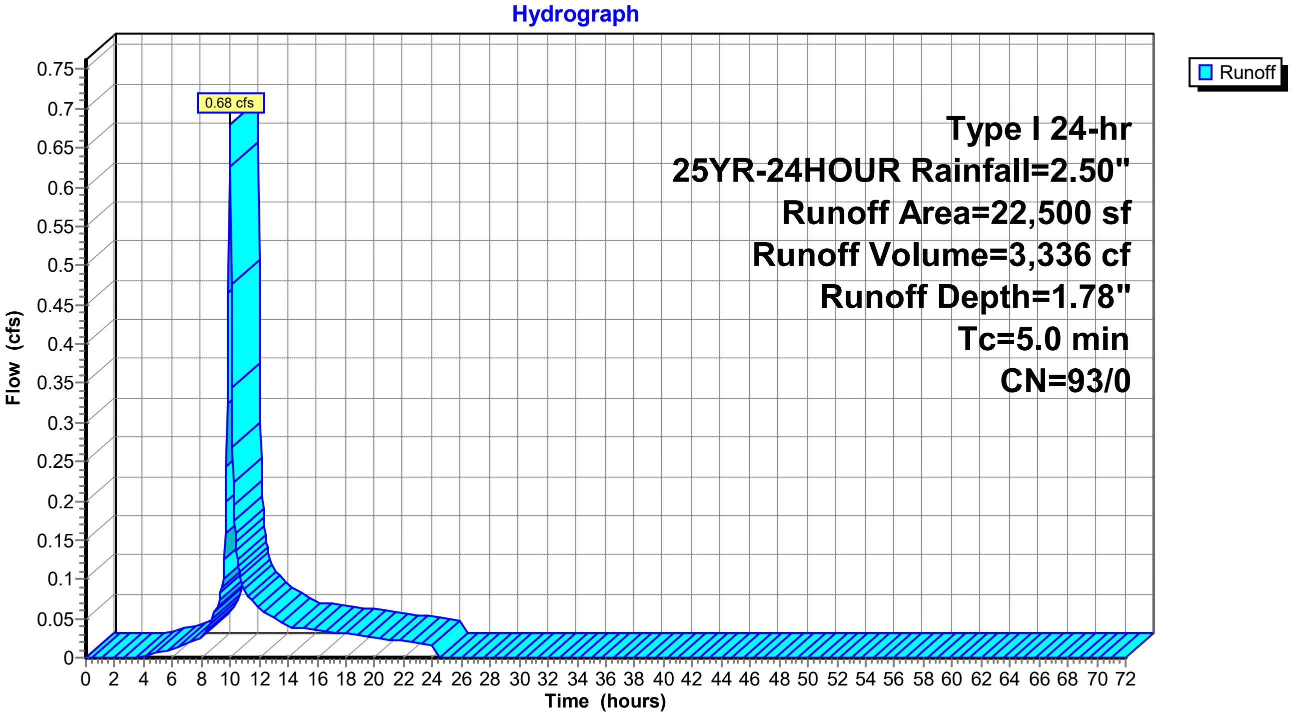
Runoff = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf, Depth= 1.78"
Routed to Pond 74P : DW2.2

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 71S: F2.2



Summary for Subcatchment 72S: F2.3

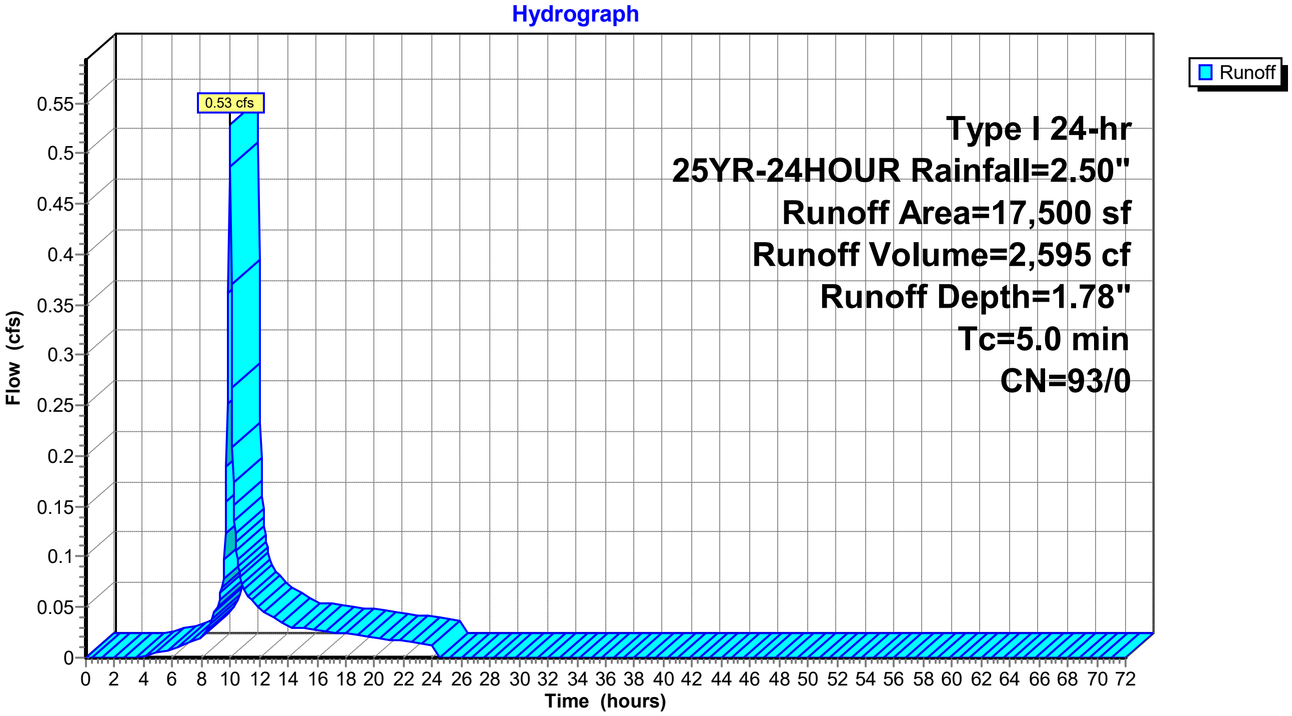
Runoff = 0.53 cfs @ 9.95 hrs, Volume= 2,595 cf, Depth= 1.78"
Routed to Pond 75P : DW2.3

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	17,500	93	Paved roads w/curbs & sewers, HSG A
	17,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 72S: F2.3



Summary for Subcatchment 73S: F2.4

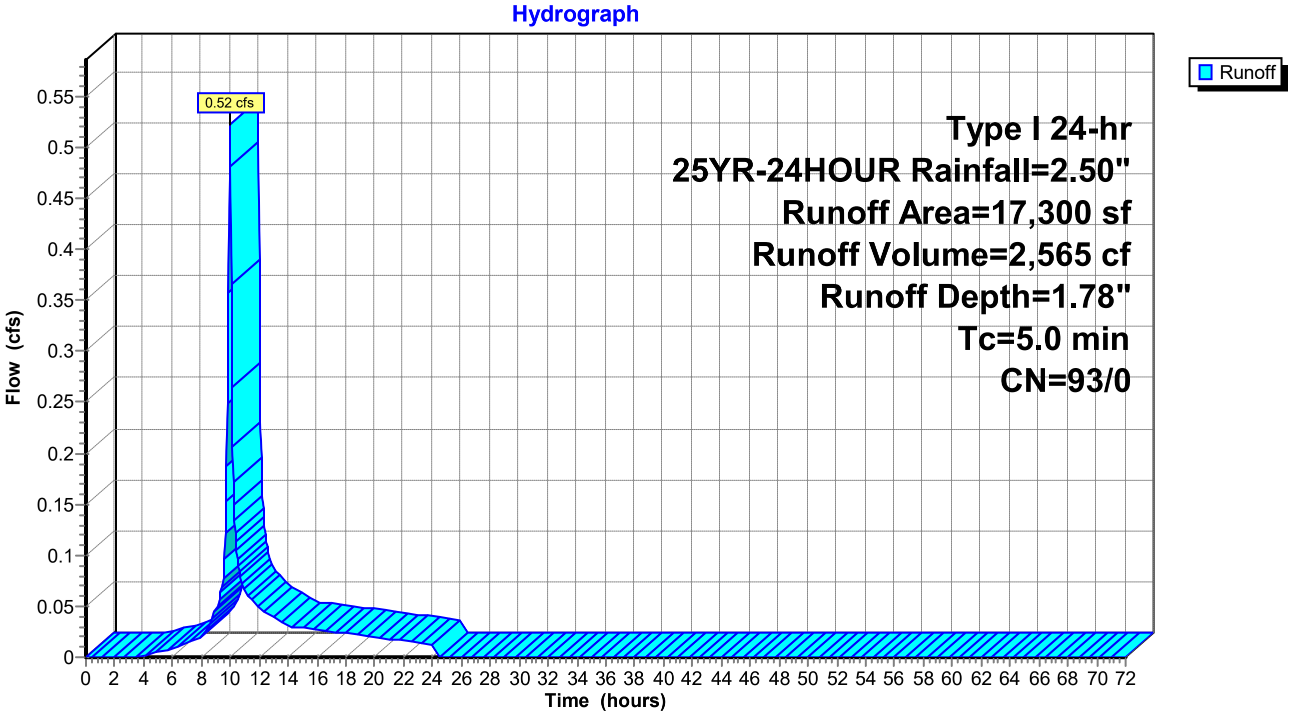
Runoff = 0.52 cfs @ 9.95 hrs, Volume= 2,565 cf, Depth= 1.78"
Routed to Pond 70P : DW2.4

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	17,300	93	Paved roads w/curbs & sewers, HSG A
	17,300	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 73S: F2.4



Summary for Pond 74P: DW2.2

```
Inflow Area =          22,500 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow      =        0.68 cfs @    9.95 hrs,  Volume=            3,336 cf
Outflow     =        0.08 cfs @    9.40 hrs,  Volume=            3,336 cf,  Atten= 88%,  Lag= 0.0 min
Discarded  =         0.08 cfs @    9.40 hrs,  Volume=            3,336 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.27' @ 11.02 hrs Surf.Area= 225 sf Storage= 783 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 66.5 min calculated for 3,334 cf (100% of inflow)
Center-of-Mass det. time= 66.4 min (830.7 - 764.3)

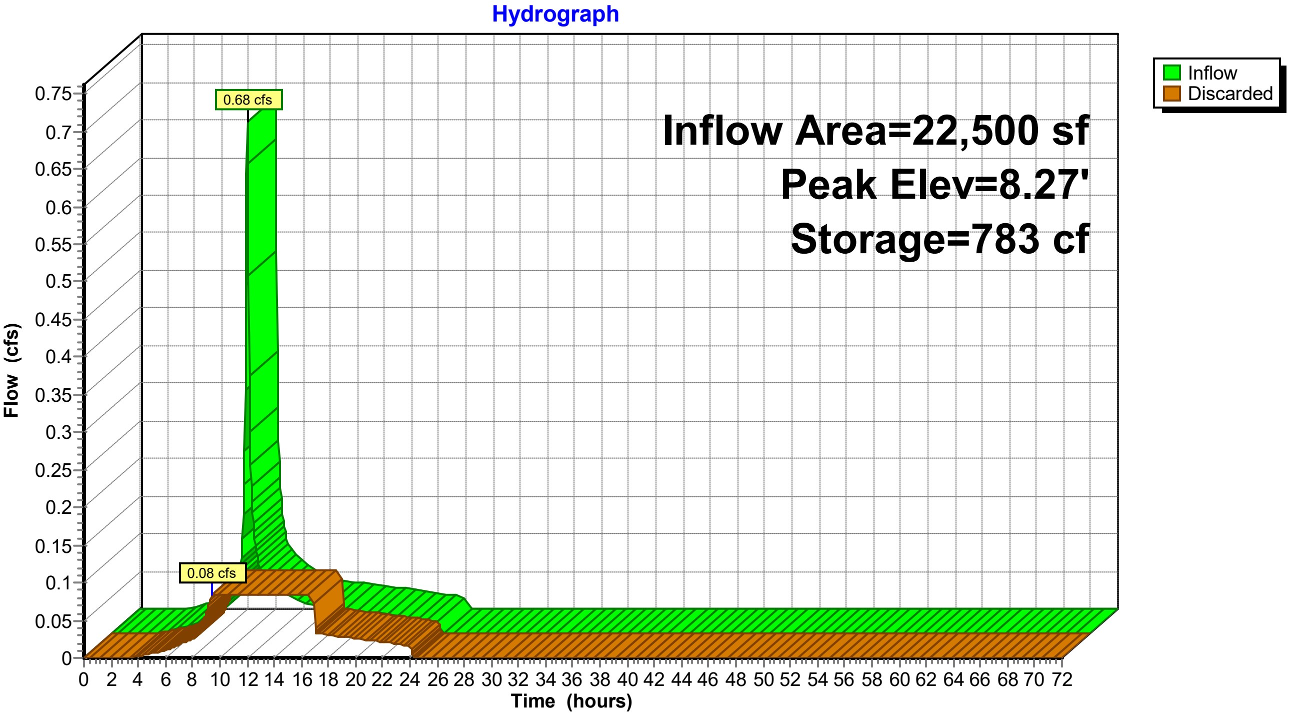
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 74P: DW2.2



Summary for Pond 75P: DW2.3

```
Inflow Area =         17,500 sf,   0.00% Impervious,  Inflow Depth =   1.78"    for  25YR-24HOUR event
Inflow      =      0.53 cfs @    9.95 hrs,  Volume=             2,595 cf
Outflow     =      0.08 cfs @    9.60 hrs,  Volume=             2,595 cf,  Atten= 84%,  Lag= 0.0 min
Discarded  =       0.08 cfs @    9.60 hrs,  Volume=             2,595 cf
```

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 5.55' @ 10.62 hrs Surf.Area= 225 sf Storage= 523 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 37.4 min calculated for 2,593 cf (100% of inflow)
Center-of-Mass det. time= 37.3 min (801.6 - 764.3)

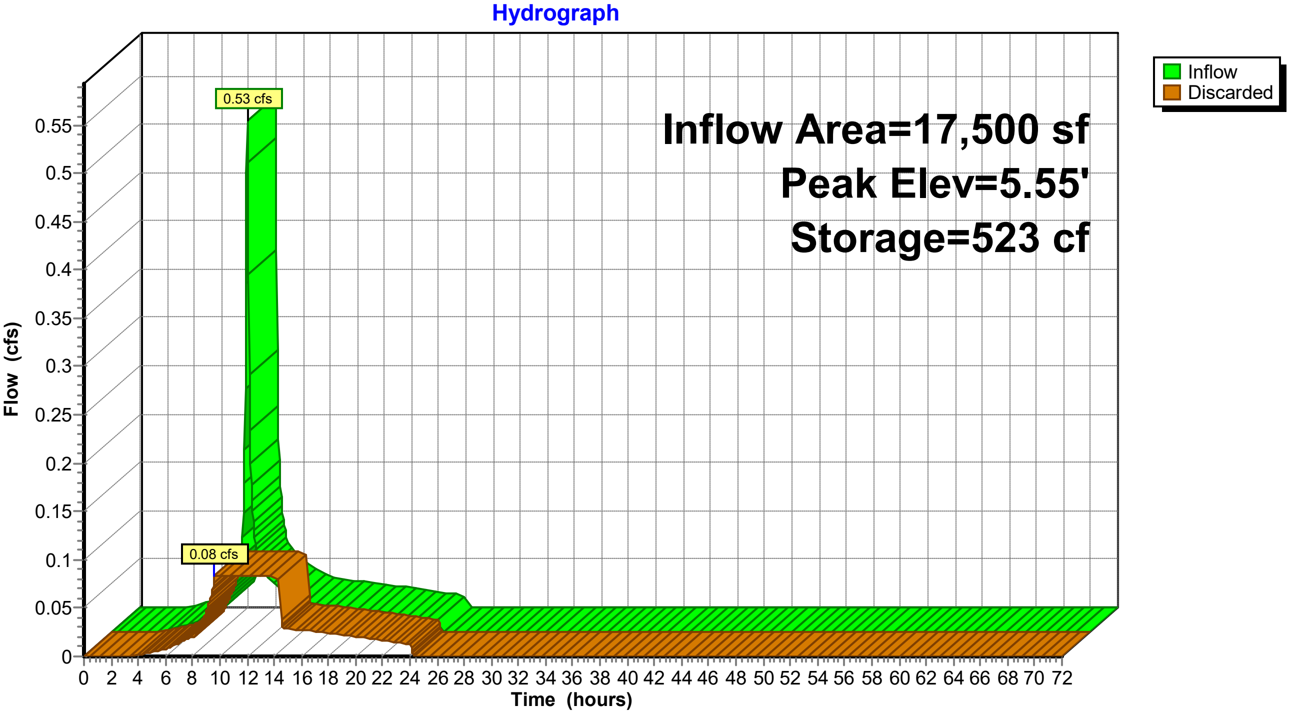
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.60 hrs HW=0.15' (Free Discharge)
└—**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 75P: DW2.3



Summary for Pond 78P: DW2.5

Inflow Area = 22,500 sf, 0.00% Impervious, Inflow Depth = 1.78" for 25YR-24HOUR event
Inflow = 0.68 cfs @ 9.95 hrs, Volume= 3,336 cf
Outflow = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf, Atten= 88%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.40 hrs, Volume= 3,336 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 8.27' @ 11.02 hrs Surf.Area= 225 sf Storage= 783 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 66.5 min calculated for 3,334 cf (100% of inflow)
Center-of-Mass det. time= 66.4 min (830.7 - 764.3)

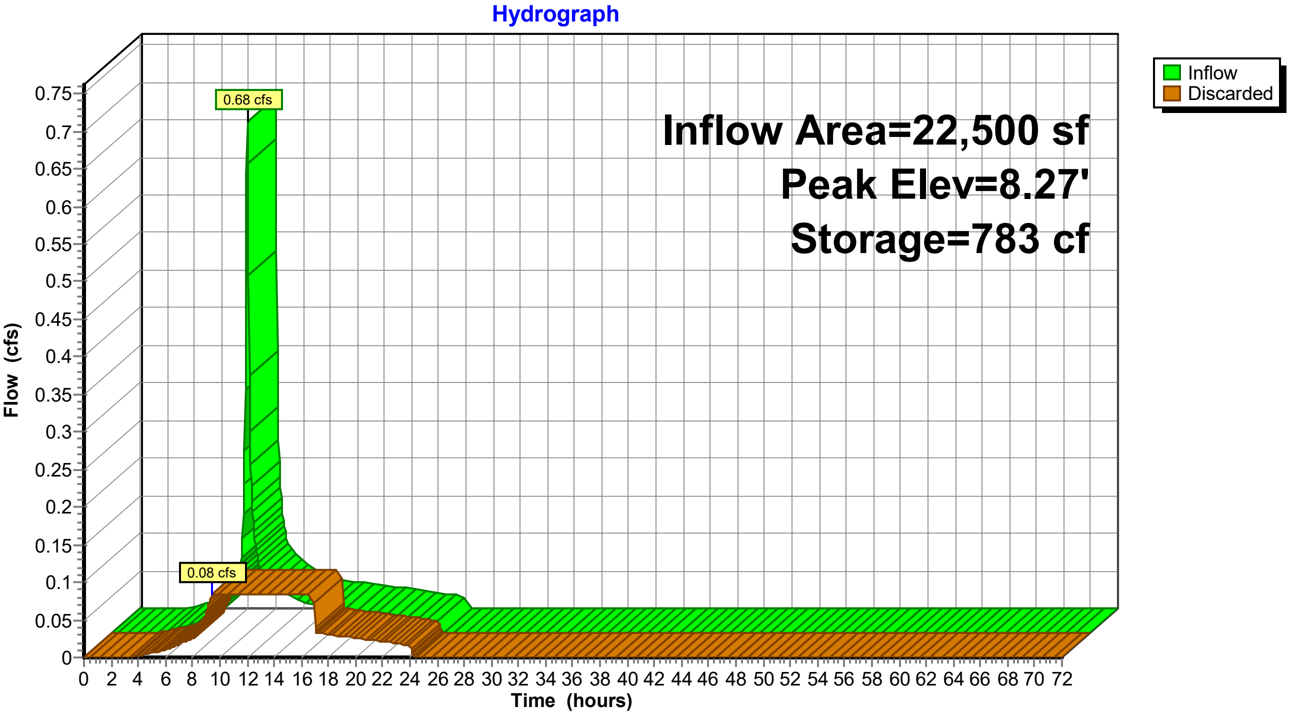
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 78P: DW2.5



Summary for Subcatchment F2.1: F2.1

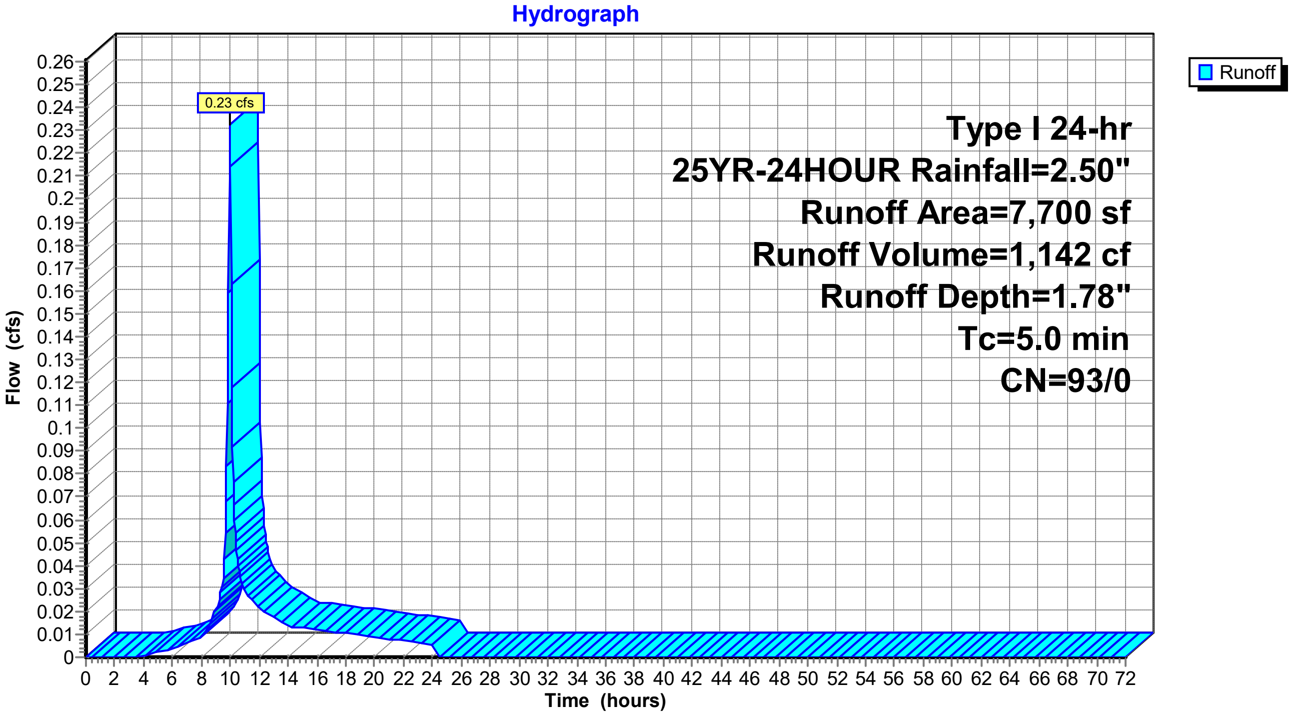
Runoff = 0.23 cfs @ 9.95 hrs, Volume= 1,142 cf, Depth= 1.78"
Routed to Pond 69P : DW2.1

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	7,700	93	Paved roads w/curbs & sewers, HSG A
	7,700	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment F2.1: F2.1



Summary for Subcatchment F2.5: F2.5

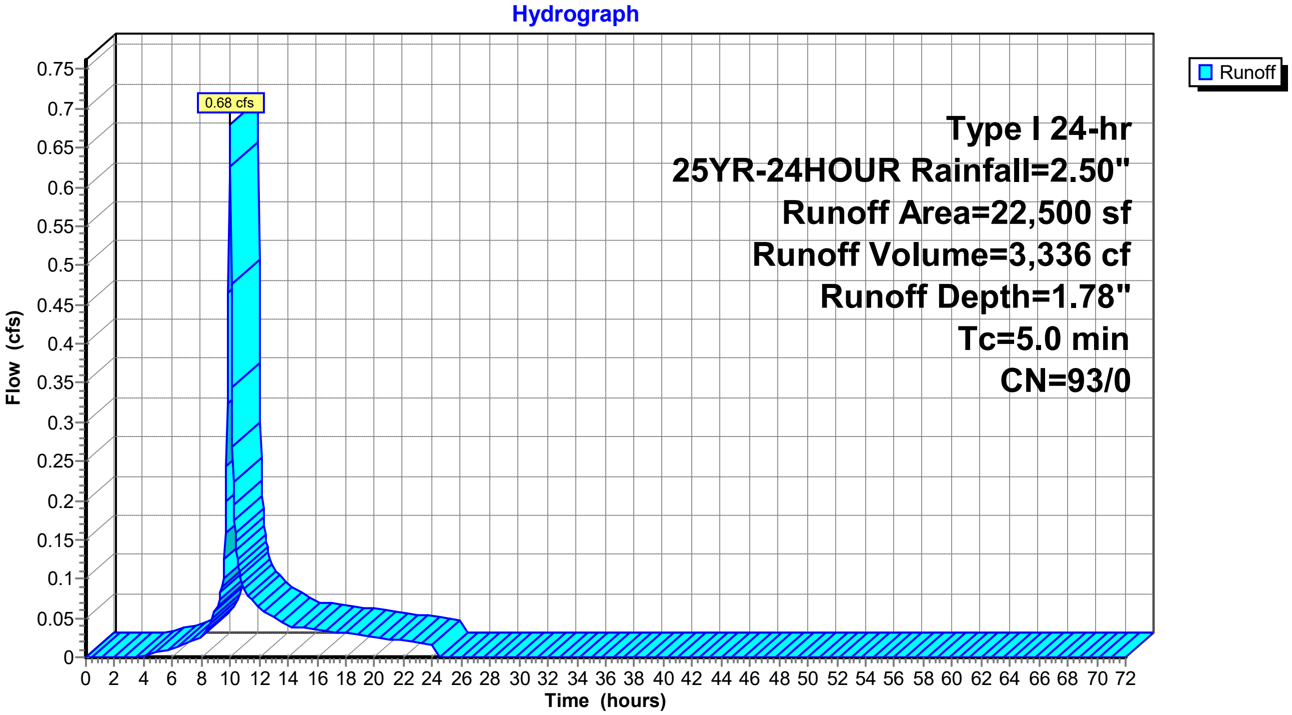
```
Runoff      =        0.68 cfs @    9.95 hrs,  Volume=            3,336 cf,  Depth=  1.78"
    Routed to Pond 78P : DW2.5
```

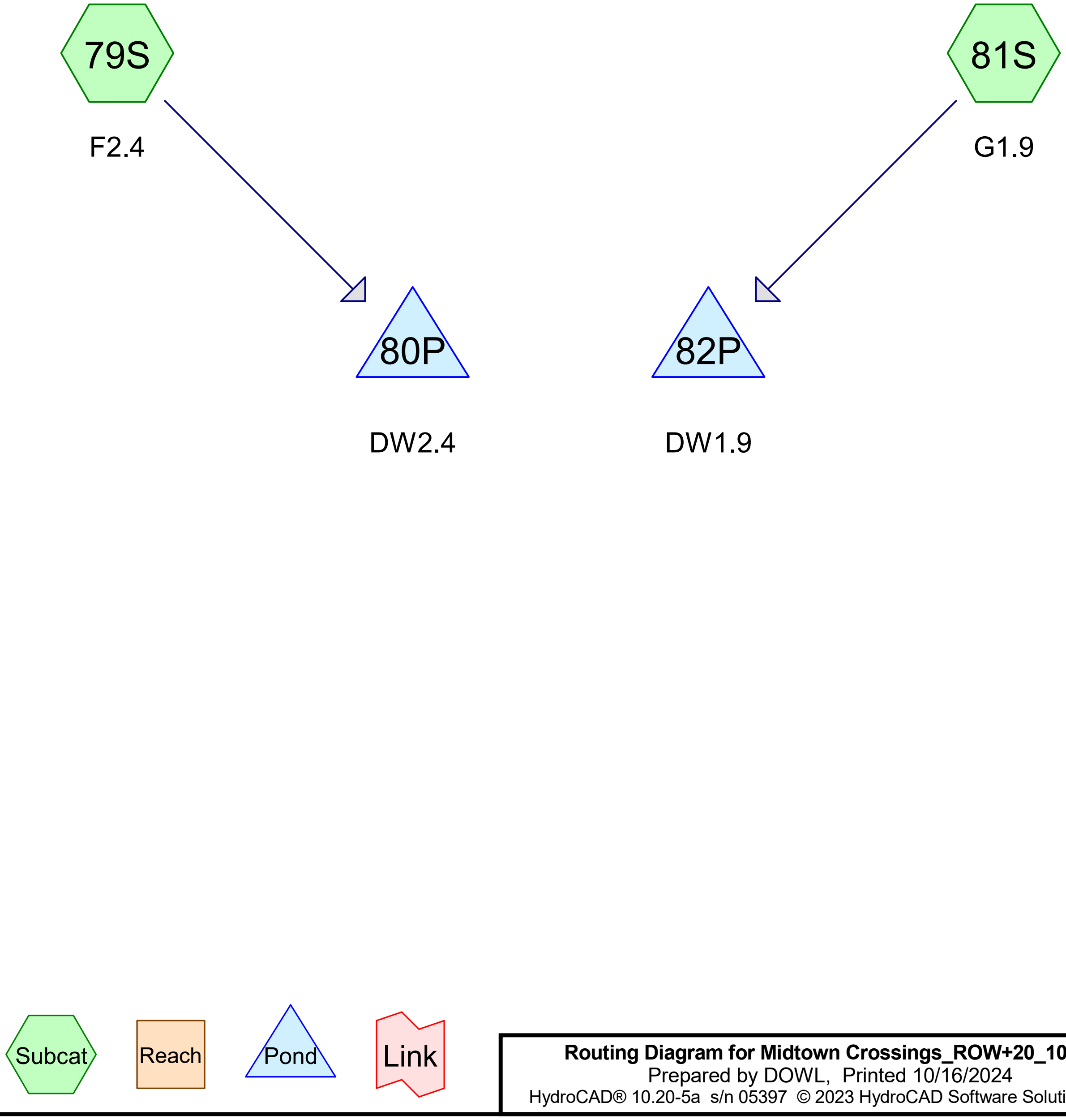
Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 25YR-24HOUR Rainfall=2.50"

	Area (sf)	CN	Description
*	22,500	93	Paved roads w/curbs & sewers, HSG A
	22,500	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment F2.5: F2.5





Routing Diagram for Midtown Crossings_ROW+20_100yr
Prepared by DOWL, Printed 10/16/2024
HydroCAD® 10.20-5a s/n 05397 © 2023 HydroCAD Software Solutions LLC

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	100YR-24HOUR	Type I 24-hr		Default	24.00	1	3.00	2

Summary for Subcatchment 79S: F2.4

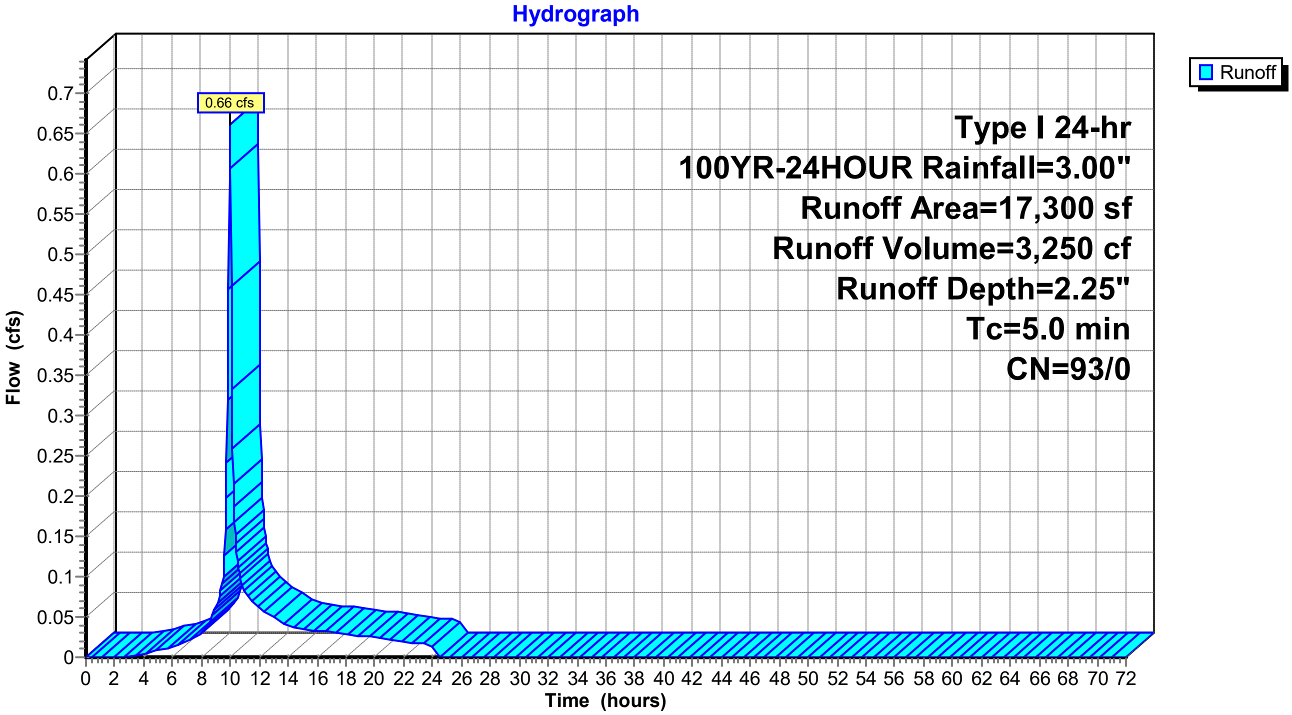
```
Runoff      =          0.66 cfs @    9.95 hrs,  Volume=           3,250 cf,  Depth=  2.25"
    Routed to Pond 80P : DW2.4
```

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

	Area (sf)	CN	Description
*	17,300	93	Paved roads w/curbs & sewers, HSG A
	17,300	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 79S: F2.4



Summary for Pond 80P: DW2.4

Inflow Area = 17,300 sf, 0.00% Impervious, Inflow Depth = 2.25" for 100YR-24HOUR event
Inflow = 0.66 cfs @ 9.95 hrs, Volume= 3,250 cf
Outflow = 0.08 cfs @ 9.40 hrs, Volume= 3,250 cf, Atten= 87%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.40 hrs, Volume= 3,250 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 7.91' @ 10.93 hrs Surf.Area= 225 sf Storage= 748 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= 60.9 min calculated for 3,247 cf (100% of inflow)
Center-of-Mass det. time= 60.9 min (815.7 - 754.8)

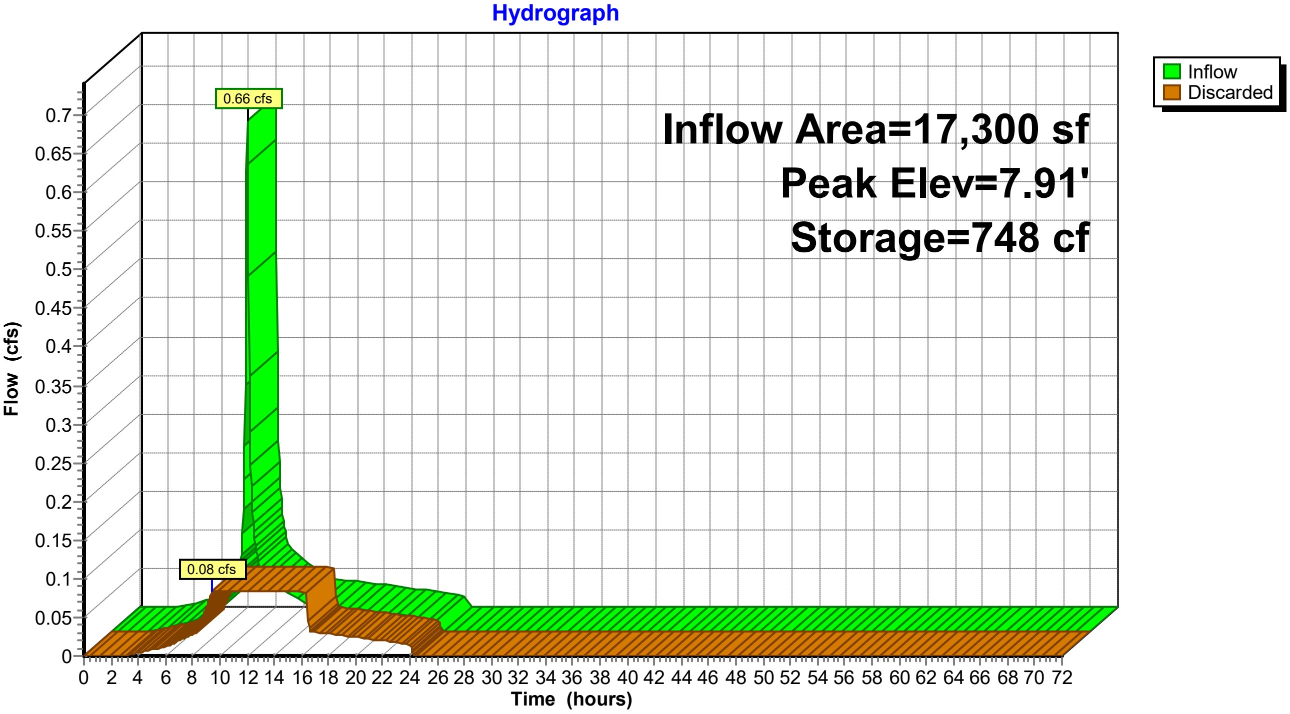
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.40 hrs HW=0.15' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 80P: DW2.4



Summary for Subcatchment 81S: G1.9

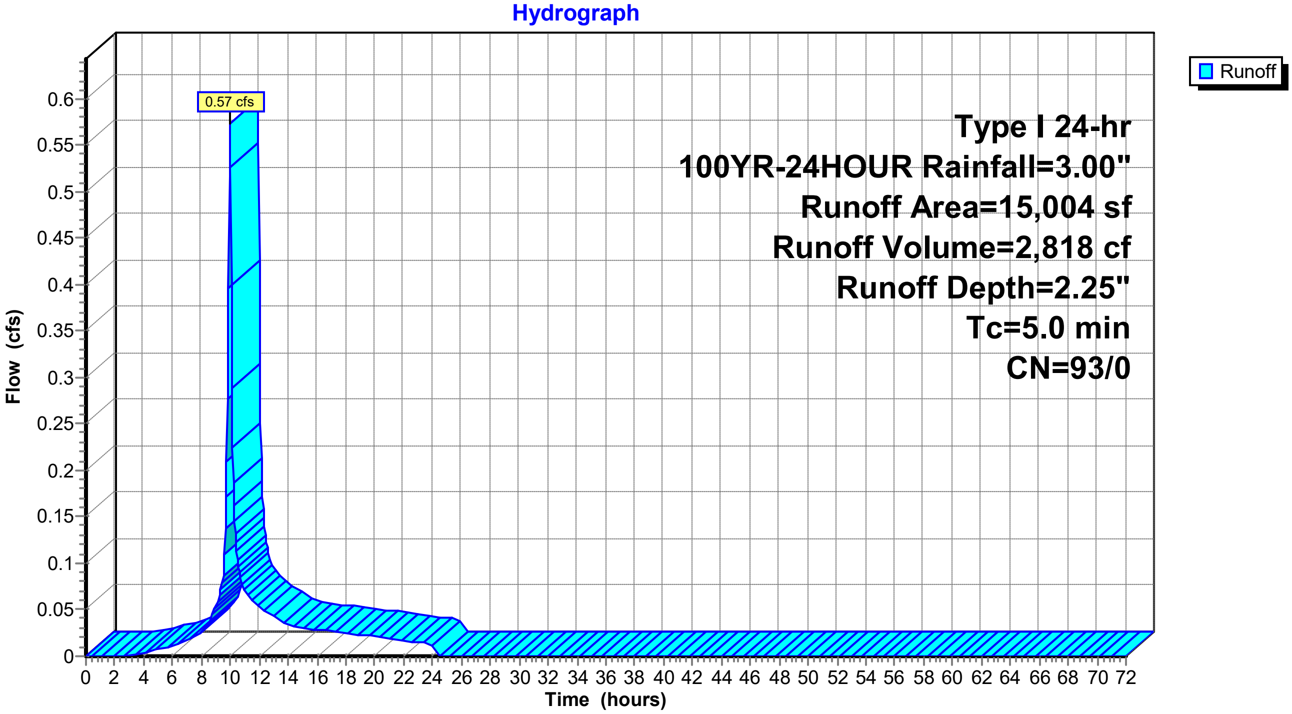
Runoff = 0.57 cfs @ 9.95 hrs, Volume= 2,818 cf, Depth= 2.25"
Routed to Pond 82P : DW1.9

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type I 24-hr 100YR-24HOUR Rainfall=3.00"

	Area (sf)	CN	Description
*	15,004	93	Paved roads w/curbs & sewers, HSG A
	15,004	93	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 81S: G1.9



Summary for Pond 82P: DW1.9

Inflow Area = 15,004 sf, 0.00% Impervious, Inflow Depth = 2.25" for 100YR-24HOUR event
Inflow = 0.57 cfs @ 9.95 hrs, Volume= 2,818 cf
Outflow = 0.08 cfs @ 9.55 hrs, Volume= 2,818 cf, Atten= 85%, Lag= 0.0 min
Discarded = 0.08 cfs @ 9.55 hrs, Volume= 2,818 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 6.31' @ 10.69 hrs Surf.Area= 225 sf Storage= 595 cf
Flood Elev= 9.00' Surf.Area= 225 sf Storage= 852 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 43.9 min (798.8 - 754.8)

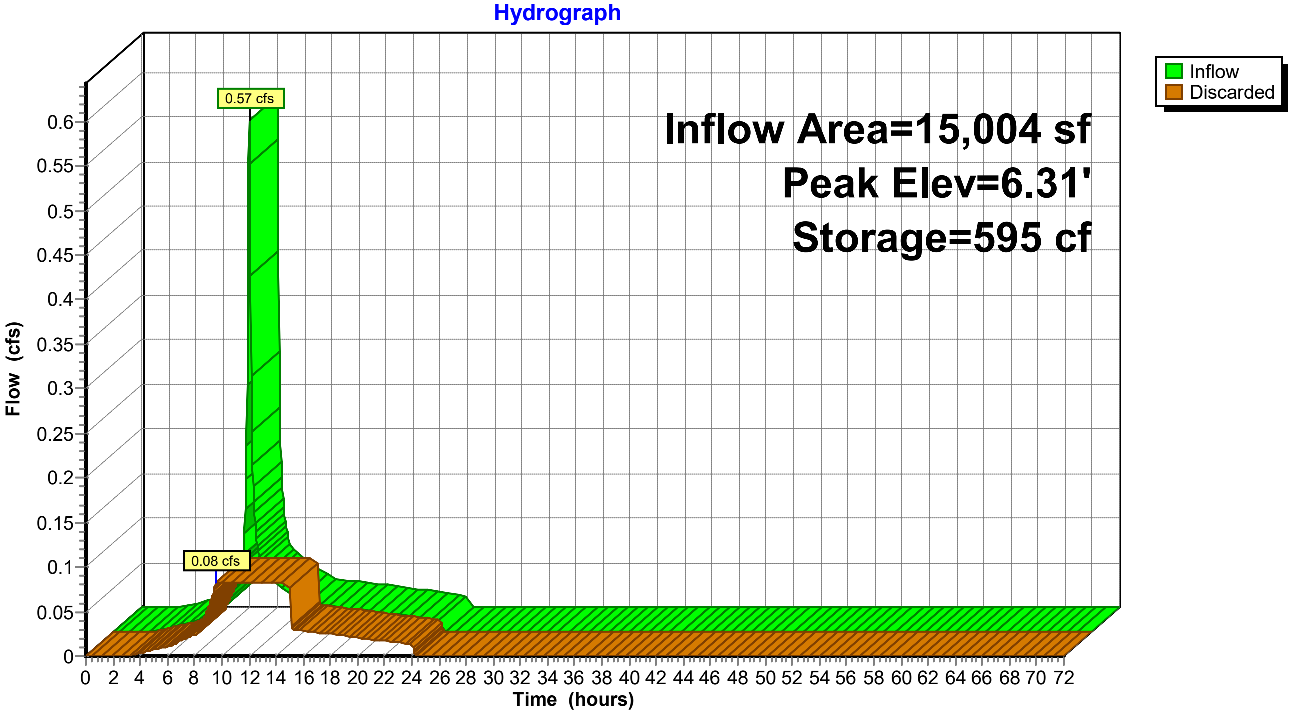
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	767 cf	**DW (Pyramidal)** Listed below 2,166 cf Overall - 248 cf Embedded = 1,918 cf x 40.0% Voids
#2	1.00'	170 cf	**4.00'D x 13.50'H Vertical Cone/Cylinder** Inside #1 248 cf Overall - 5.0" Wall Thickness = 170 cf
		937 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
0.00	225	0	0	225
9.00	225	2,025	2,025	765
9.50	18	51	2,076	973
14.50	18	90	2,166	1,058

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**16.000 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.08 cfs @ 9.55 hrs HW=0.15' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Pond 82P: DW1.9



APPENDIX 4: HWA INFILTRATION TESTING

HWA
CIVIL ENGINEERING | SURVEYING | PLANNING

62930 O. B. Riley Road, Suite 100
Bend, Oregon 97703
(541)389-9351 Fax: (541)388-5416

DRYWELL OBSERVATION REPORT

PROJECT: MIDTOWN
JOB NO.
DATE: 2-22-24 TIME: 7:45 TO 8:30
WEATHER: CLEAR TEMP MAX: 40 °F MIN: 30° °F
PRECIPITATION: 0 GROUND CONDITIONS: SATURATED

EQUIPMENT USED: 3 4,000 GAL WATER TRUCKS

NOTE:

PARTICIPANTS: HWA / K&E

1 **DRYWELL # TA-1 DDW003417:**
DEPTH TO BOTTOM OF DW:
INV IN:
TEST VOLUME: **1,337 CF / 10,000 Gallons**
INITIAL METER READING:
FINAL METER READING:
START TIME: 7:46
END TIME:

DEPTH TO WATER AT END OF TEST:
AFTER 5 MIN: 2'
10 MIN:
15 MIN: -4^{4}
20 MIN:
25 MIN:
30 MIN: -4^{9}
45 -5^{3}
1hr -5^{3}

GENERAL NOTES:

Time	Meter Reading	Depth	Required Test Volume: 7,750 Gal. / 1,036 CF
7:46			
8:05	(1) 4,000 TRUCK	FULL	GOING BACK INTO FIRST CATCHBASIN
8:06			
8:23	(2) 4000 TRUCK	BACKING UP INTO SECOND CATCHBASIN	BARELY DROP DOWN SMOOTHLY
8:24			
8:30	3 2,000 TRUCK		

PREPARED BY: ~~Sean Williams, PE~~ JARED KAPP

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Bend, Oregon 97703
(541)389-9351 Fax: (541)388-5416

DRYWELL OBSERVATION REPORT

PROJECT: MID TOWN
JOB NO.
DATE: 2-22-24
TIME: 12:40 TO 1:40
WEATHER: SUNNY
TEMP MAX: 46° °F
MIN: °F
PRECIPITATION: 0
GROUND CONDITIONS: SATURATED

EQUIPMENT USED: 3 4,000 GAL TRUCKS

NOTE:

PARTICIPANTS: HWA / K&E

DRILL HOLE
4 **DRYWELL # TA-1 DDH009616:**
DEPTH TO BOTTOM OF DW:
INV IN:
TEST VOLUME: **1,337 CF / 10,000 Gallons**
INITIAL METER READING:
FINAL METER READING:
START TIME:
END TIME:

DEPTH TO WATER AT END OF TEST:
AFTER 5 MIN:
10 MIN:
15 MIN:
20 MIN:
25 MIN:
30 MIN:

GENERAL NOTES:

Time	Meter Reading	Depth	Required Test Volume: 7,750 Gal. / 1,036 CF
12:39	4000 GAL TRUCK		
1:02		FINISHED	
1:07	4,000 GAL TRUCK		
1:40	FINISHED		PUT 6 IN YESTERDAY'S @ Hour

PREPARED BY: ~~Sean Williams, PE~~ JARED KAPP

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Bend, Oregon 97703
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DRYWELL OBSERVATION REPORT

PROJECT: Midtown
JOB NO.
DATE: 2/21/23 TIME: 8:51 am TO
WEATHER: overcast
TEMP MAX: 37 °F MIN: °F
PRECIPITATION:
GROUND CONDITIONS:

EQUIPMENT USED:

NOTE:

PARTICIPANTS: HWA / K&E

DRYWELL # ~~TA-1~~ DD4001724 (3)
DEPTH TO BOTTOM OF DW:
INV IN:
TEST VOLUME: **1,337 CF / 10,000 Gallons**
INITIAL METER READING:
FINAL METER READING:
START TIME:
END TIME:

DEPTH TO WATER AT END OF TEST:
AFTER 5 MIN:
10 MIN:
15 MIN:
20 MIN:
25 MIN:
30 MIN:

GENERAL NOTES:

Required Test Volume: 7,750 Gal. 10K ~~1,036~~ 1337 CF

Time	Meter Reading	Depth	
8:51	0"	–	
9:08	7"		Had to start adjusting flow rate
9:25	~2/3 x 4K		so it didn't overtop
10:02	4000 gal		Truck fill
Pause.			
10:39	0"	–	Start again

PREPARED BY: Sean Williams, PE

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Bend, Oregon 97703
(541)389-9351 Fax: (541)388-5416

DRYWELL OBSERVATION REPORT

PROJECT: Midtown
JOB NO. ______ DATE: 2/21/24 TIME: 12:13 TO 1:43
WEATHER: ______ TEMP MAX: ______ °F MIN: ______ °F
PRECIPITATION: ______ GROUND CONDITIONS: ______

EQUIPMENT USED: (2)

NOTE:

PARTICIPANTS: HWA / K&E

DRYWELL # TA-1 DDH009.616 (4)
DEPTH TO BOTTOM OF DW:
INV IN:
TEST VOLUME: **1,337 CF / 10,000 Gallons**
INITIAL METER READING:
FINAL METER READING:
START TIME: 12:13
END TIME: 1:13

DEPTH TO WATER AT END OF TEST:
AFTER 5 MIN:
10 MIN:
15 MIN:
20 MIN:
25 MIN:
30 MIN:

GENERAL NOTES:

Truck	Time	Meter Reading	Depth	Total	Required Test Volume: ~~7,750 Gal. / 1,036 CF~~
01	12:13 - 1:13	4,000 gal		~ 4,000	Will re-do test when testing materials improve

PREPARED BY: Sean Williams, PE

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Bend, Oregon 97703
(541)389-9351 Fax: (541)388-5416

DRYWELL OBSERVATION REPORT

PROJECT: MIDTOWN
JOB NO.
DATE:
TIME: 11:40 TO 12:40
WEATHER: SUNNY
TEMP MAX: 46 °F
MIN: °F /
PRECIPITATION: 0
GROUND CONDITIONS: SATURATED

EQUIPMENT USED: 3 4,000 GAL TRUCKS

NOTE:

PARTICIPANTS: HWA / K&E

DRILLHOLE
5 **DRYWELL # TA-1 DCB001726:**
DEPTH TO BOTTOM OF DW:
INV IN:
TEST VOLUME: **1,337 CF / 10,000 Gallons**
INITIAL METER READING:
FINAL METER READING:
START TIME:
END TIME:

DEPTH TO WATER AT END OF TEST:
AFTER 5 MIN:
10 MIN:
15 MIN:
20 MIN:
25 MIN:
30 MIN:

GENERAL NOTES:

Time	Meter Reading	Depth	Required Test Volume: 7,750 Gal. / 1,036 CF
11:40	(1) 2,000 GAL TRUCK		
11:50		FINISHED	
11:52	(2) 4,000 GAL TRUCK		
12:10		FINISHED	
12:12	(3) 4,000 GAL TRUCK		
12:36		FINISHED	

PREPARED BY: ~~Sean Williams, PE~~ JARED KAPP

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DRYWELL OBSERVATION REPORT

PROJECT: MID TOWN
JOB NO. ______ DATE: ______ TIME: 10:26 TO 11:19
WEATHER: SUNNY TEMP MAX: 44 °F MIN: ______ °F
PRECIPITATION: 0 GROUND CONDITIONS: SATURATED

EQUIPMENT USED: 3 - 4,000 GAL TRUCKS

NOTE:

PARTICIPANTS: HWA / K&E

6 **DRYWELL # TA-1 DDH010033:**
DEPTH TO BOTTOM OF DW:
INV IN:
TEST VOLUME: **1,337 CF / 10,000 Gallons**
INITIAL METER READING:
FINAL METER READING:
START TIME:
END TIME:

DEPTH TO WATER AT END OF TEST:
AFTER 5 MIN:
10 MIN:
15 MIN:
20 MIN:
25 MIN:
30 MIN:

GENERAL NOTES:

Required Test Volume: 7,750 Gal. / 1,036 CF

Time	Meter Reading	Depth
10:26	(1) 4,000 GAL TRUCK	
10:46		FINISHED
10:48	(2) 4,000 GAL TRUCK	
11:08		FINISHED
11:19	(3) 2,000 GAL	FINISHED

PREPARED BY: ~~Sean Williams, PE~~ JARED KAPP

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DRYWELL OBSERVATION REPORT

PROJECT: MID TOWN
JOB NO. ______ DATE: 2-22-24 TIME: 8:45 TO 10:30
WEATHER: SUNNY TEMP MAX: 44 °F MIN: ______ °F
PRECIPITATION: 0 GROUND CONDITIONS: SATURATED

EQUIPMENT USED: (3) 4,000 GAL TRUCKS

NOTE:

PARTICIPANTS: HWA / K&E

DRILL HOLE CONNECTED TO DRILL HOLE ACROSS STREET

DRILLHOLE'S DDH009614

9+7 **DRYWELL # TA-1** DDH009551:

DEPTH TO BOTTOM OF DW:
INV IN:
TEST VOLUME: **1,337 CF / 10,000 Gallons**
INITIAL METER READING:
FINAL METER READING:
START TIME:
END TIME:

DEPTH TO WATER AT END OF TEST:
AFTER 5 MIN:
10 MIN:
15 MIN:
20 MIN:
25 MIN:
30 MIN:

GENERAL NOTES:

Time	Meter Reading	Depth	Required Test Volume: 7,750 Gal. / 1,036 CF
8:48			
9:10	(1) 4000 TRUCK	FINISHED *	
9:11			
9:25	(2) 4,000 TRUCK	FINISHED *	
9:23	(1) 4,000 TRUCK	STARTED	
9:40	(3) "	FINISHED *	
9:42	(1) "	STARTED	
10:02	(4) "	FINISHED *	
10:06	1 "	STARTING	
10:23	(5) "	FINISHED *	

PREPARED BY: ~~Sean Williams, PE~~ JARED KAPP

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Bend, Oregon 97703
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DRYWELL OBSERVATION REPORT

PROJECT: MIDTOWN
JOB NO.
DATE: 2-22-24
TIME: 8:30 TO 8:50
WEATHER: SUNNY
TEMP MAX: 44 °F
MIN: °F
PRECIPITATION: 0
GROUND CONDITIONS:

EQUIPMENT USED: 3 4,000 GAL TRUCKS

NOTE:

PARTICIPANTS: HWA / K&E

8 **DRYWELL # TA-1** ODW00 7539:

DEPTH TO BOTTOM OF DW:
INV IN:
TEST VOLUME: **1,337 CF / 10,000 Gallons**
INITIAL METER READING:
FINAL METER READING:
START TIME:
END TIME:

DEPTH TO WATER AT END OF TEST:
AFTER 5 MIN: -2^{0}
10 MIN:
15 MIN: -4^{0}
20 MIN:
25 MIN:
30 MIN: 5^{3}
1 hr 6^{5}
1:30 6^{9}

GENERAL NOTES:

Required Test Volume: 7,750 Gal. / 1,036 CF

Time	Meter Reading	Depth
8:35	1600	
8:45	FAIL FILLED BACK UP & OUT OF CATCHBASIN'S	

PREPARED BY: ~~Sean Williams, PE~~ JARED KAPP

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DRYWELL OBSERVATION REPORT

PROJECT:
JOB NO. DATE: TIME: TO
WEATHER: TEMP MAX: °F MIN: °F
PRECIPITATION: GROUND CONDITIONS:

EQUIPMENT USED:

NOTE:

PARTICIPANTS: HWA / K&E

DRYWELL # TA-1 DDW 010686 (10):
DEPTH TO BOTTOM OF DW:
INV IN:
TEST VOLUME: **1,337 CF / 10,000 Gallons**
INITIAL METER READING:
FINAL METER READING:
START TIME:
END TIME:

DEPTH TO WATER AT END OF TEST: 5.1'
AFTER 5 MIN: 5.6'
10 MIN: 6.0'
15 MIN: 6.3'
20 MIN: 6.5'
25 MIN: 6.7'
30 MIN: 6.9'

GENERAL NOTES:

Required Test Volume: 7,750 Gal. / 1,036 CF

Time	Meter Reading		Depth Total	
1:15 - 1:39	4,000	~	4,000	
1:39 - 2:15	2,000	~	6,000	* Dry well

PREPARED BY: Sean Williams, PE

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Bend, Oregon 97703
(541)389-9351 Fax: (541)388-5416

DRYWELL OBSERVATION REPORT

PROJECT: MID TOWN
JOB NO.
DATE: 2-22-24
TIME: 1:45 TO 2:50
WEATHER: SUNNY
TEMP MAX: 49° °F
MIN: °F
PRECIPITATION: 0
GROUND CONDITIONS: SATURATED

EQUIPMENT USED: 3 4,000G. TRUCKS

NOTE:

PARTICIPANTS: HWA / K&E

1) **DRYWELL # TA-1** DD1100 950':
DEPTH TO BOTTOM OF DW:
INV IN:
TEST VOLUME: **1,337 CF / 10,000 Gallons**
INITIAL METER READING:
FINAL METER READING:
START TIME:
END TIME:

DEPTH TO WATER AT END OF TEST:
AFTER 5 MIN:
10 MIN:
15 MIN:
20 MIN:
25 MIN:
30 MIN:

GENERAL NOTES:

Required Test Volume: 7,750 Gal. / 1,036 CF

Time	Meter Reading	Depth
1:30	(1) 4,000 GAL TRUCK	
2:13		FINISHED
2:25	(1) 4000 GAL TRUCK	
2:33		
2:35	(1) 2000 GAL TRUCK	
2:47		FINISHED

PREPARED BY: ~~Sean Williams, PE~~ JARED MAPP

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Bend, Oregon 97703
(541)389-9351 Fax: (541)388-5416

DRYWELL OBSERVATION REPORT

PROJECT: Midtown
JOB NO. DATE: TIME: TO
WEATHER: TEMP MAX: °F MIN: °F
PRECIPITATION: GROUND CONDITIONS:

EQUIPMENT USED: (2) 4,000 gal water trucks

NOTE:

PARTICIPANTS: HWA / K&E

DRYWELL # TA-1 DD #009504 : (11)
DEPTH TO BOTTOM OF DW:
INV IN:
TEST VOLUME: **1,337 CF / 10,000 Gallons**
INITIAL METER READING:
FINAL METER READING:
START TIME:
END TIME:

DEPTH TO WATER AT END OF TEST:
AFTER 5 MIN:
10 MIN:
15 MIN:
20 MIN:
25 MIN:
30 MIN:

GENERAL NOTES:

Required Test Volume: 7,750 Gal. / 1,036 CF

Time	Meter Reading	Depth	
2:29 - 2:59	4,000	~ 4,000	
3:00 - 3:25	4,000	~ 8,000	* Test ended due to testing conditions. Not able to get 10,000 gallons

PREPARED BY: Sean Williams, PE

Appendix B:

CIP & Tool Kit Fact Sheets

Dove Lane Drainage Improvement

Capital Improvement Project Fact Sheet

CITY OF BEND

Location	**SE Dove Ln & Skyline View Dr**		
ID	**PP-1**	*Rank*	**10**

Problem Summary

Stormwater runoff from the right-of-way (ROW) and neighboring properties causes recurring undesirable overland flow at a low point along SE Dove Lane near Skyline View Road. A property owner had installed a sump pump on private property to mitigate flooding impacts on private structures, but the pump is overwhelmed during heavy rain events. To improve drainage, the City of Bend installed a trench filled with crushed basalt drain rock in 2013. While the trench mitigated runoff from smaller storm events, larger storms continue to cause flooding impacts on the west side of SE Dove Lane.

The project is located on formerly unincorporated Deschutes County land and does not currently have sufficient stormwater infrastructure. Roads in the area do not have curbs or gutters to direct runoff.

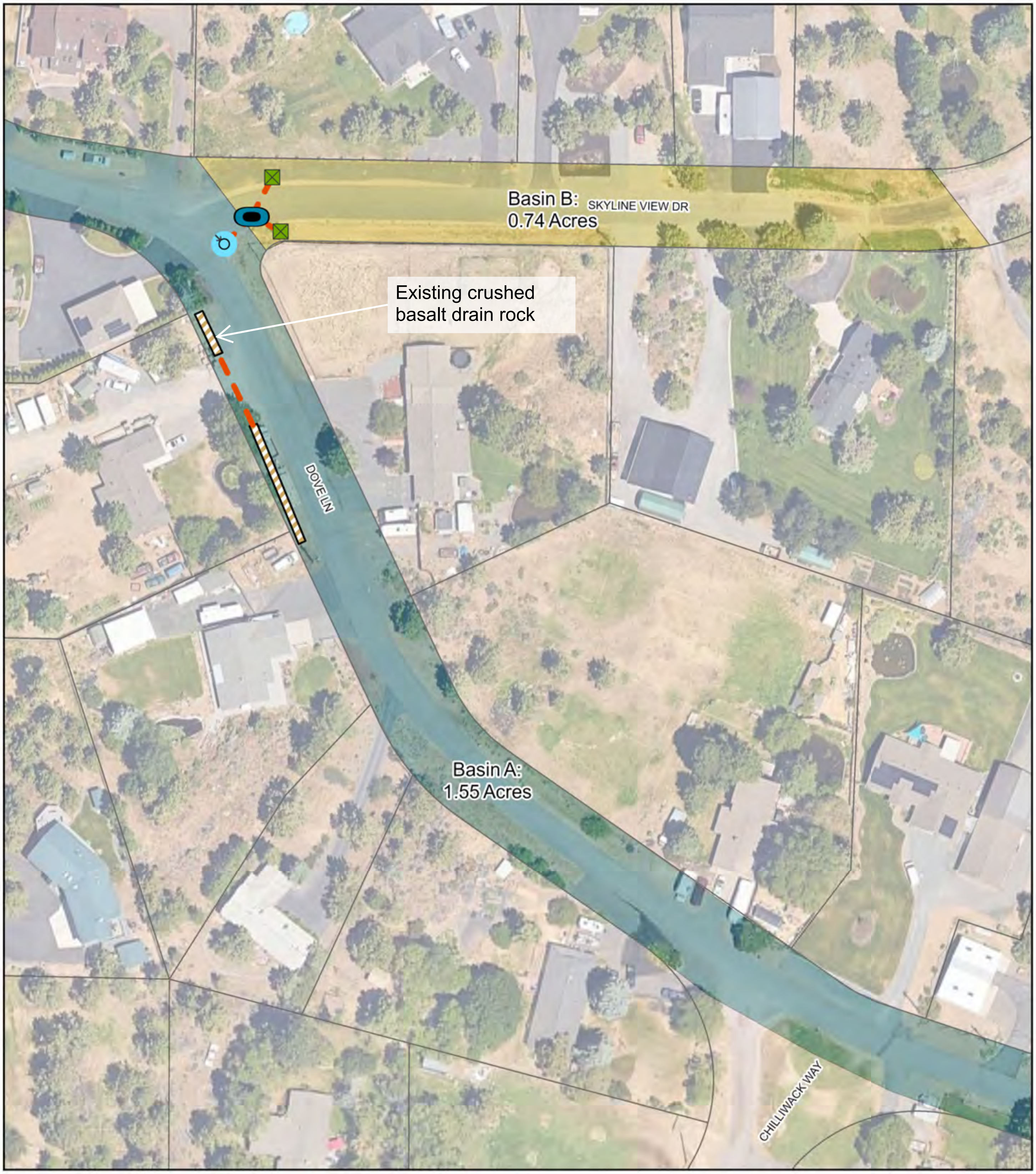
Project Description

This project proposes two strategies to improve drainage. Basin areas follow the existing ROW and assume 70% of the area is impervious for drainage calculations. Basin A on SE Dove Ln is estimated to drain 1.55 acres and Basin B on Skyline View Dr is estimated to drain 0.74 acres.

To improve drainage in front of properties impacted by flooding during storm events, two connected infiltration trenches will be installed on the west side of SE Dove Ln. These trenches will occupy 735 square feet along the ROW and will not extend into the roadway. The trenches will be connected by a 12-inch diameter storm sewer pipe underneath the existing driveway. The infiltration trenches allow for parking over top.

To improve drainage in the neighborhood, a drywell will be installed at the intersection of SE Dove Lane and Skyline View Drive. Preceding the drywell, a pre-treatment facility for a drainage area up to one acre will protect the drywell from sediment and spills and improve water quality of the runoff. Stormwater will enter this system through two new ditch inlets and 12-inch diameter storm sewer pipe.

See Design and Implementation Considerations and Constraints on page 4 for more information about data needs, site constraints, and alternative solutions to be considered during final design.



BEND STORMWATER MASTER PLAN

Proposed Improvements

- ● Drywell
- ⬬ Pre-treatment
- ☒ Catch Basin
- – – Storm Sewer Pipe
- ▨ Infiltration Trench

0 50 100 150 Feet

PP-1: Dove Lane Drainage Improvements

8/12/2025 - O:\PROJECT\20300\20359\04 CAD\GIS\APRX\Bend CIP Figures\20359 Bend SMP CIP Figures\20359 Bend SMP CIP Figures - JAJ.aprx

Cost Estimate*				
Construction	**Qty**	**Unit**	**Price**	**Amount**
Stormwater Tool Kit				
Infiltration Trench	735	SF	$30.00	$22,050.00
Pre-Treatment, for small drainage basin (less than 1 ac.)	1	EA	$12,000.00	$12,000.00
Storm Sewer Pipe, 12-in diam.	150	LF	$180.00	$27,000.00
Drywell	1	EA	$32,000.00	$32,000.00
Ditch Inlet	2	EA	$3,500.00	$7,000.00
Other Construction Costs (Rounded)				
Mobilization	10	%	of Const.	$30,000.00
Erosion and Sediment Control	2	%	of Const.	$6,000.00
Traffic Control	4	%	of Const.	$12,000.00
Construction Contingency	50	%	of Const.	$149,000.00
			Total Construction	**$297,050.00**
Other Costs (Rounded)	**Qty**	**Unit**	**Price**	**Amount**
Engineering	20	%	of Const.	$59,000.00
Administration	10	%	of Const.	$30,000.00
Basic Permitting	1	EA	$3,000.00	$3,000.00
			Total Other Costs	**$92,000.00**
Total Project Cost (Rounded)				**$390,000**

**Class V planning level cost estimate. Costs are in 2025 dollars. Escalate unit prices for quantity items when budgeting for implementation.*

Design and Implementation Considerations and Constraints

Data Collection

Surveying is needed at this project location to determine exact locations of the ROW and private property lines and utilities. The previous infiltration trench installation was limited by utility conflicts in the driveway.

Drainage basins of the ROW are estimates only and will require delineation prior to final design.

Constraints

The area does not have existing stormwater infrastructure, so all improvements will be standalone solutions. Because there is an existing driveway in the location of the proposed infiltration trench, the trench will be split, with trenches north and south of the driveway.

While parking is allowable on top of infiltration trenches, heavy equipment or vehicles will compress the trench, significantly reducing effectiveness of this solution. Trenches at this location should be designed to accommodate heavy loads.

Alternatives

The amount of ROW may be too small for the proposed infiltration trenches. If a survey of the project area determines that there is not enough room, alternatives will need to be considered.

Coordination

Due to past work in the area that was not sufficient for large storm events, coordination with impacted property owners is needed.

Photos of Project Area

SE Dove Ln looking southeast

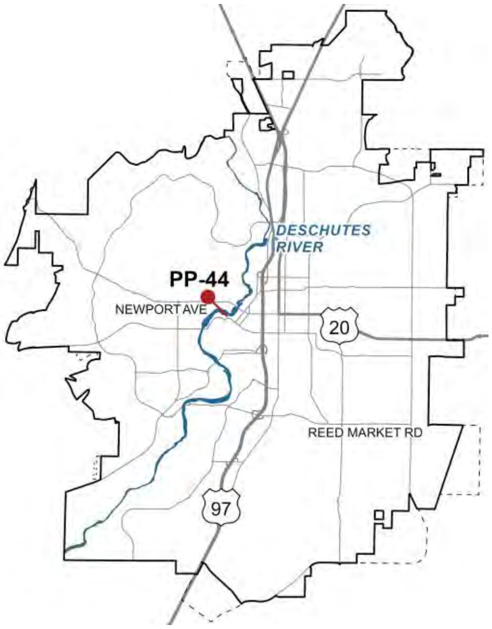
SE Dove Ln and Skyline View Dr looking northwest

Drake Park Stormwater Quality Improvements

Capital Improvement Project Fact Sheet

CITY OF BEND

Location	**NW Riverside Blvd & NW Broadway St**		
ID	**PP-44**	*Rank*	**3**



Problem Summary

Outfall 018 has been identified as a priority basin for a stormwater retrofit project to protect water quality in the Deschutes River. It drains 24 acres of downtown and Old Bend, discharging into the river at Drake Park. Winter sanding material and other debris is known to collect at intersections and block inlets in the vicinity. The stormwater flow path between NW Louisiana Ave and Outfall 018 is not well understood.

Maintenance access to a drillhole located 80 feet upstream of Outfall 018 in the park is restricted because there is no hard-surface access road to it, and the City lacks an easement with Bend Park and Recreation District (BPRD). The park's heavy use limits placement of new stormwater facilities in it.

The stormwater pipe underneath NW Franklin Ave also lacks adequate maintenance access. No manholes are present in a ¼-mile segment, and the only catch basin is located under an outdoor eatery platform in the parking lane. The exact pipe alignment is unknown.

Project Description

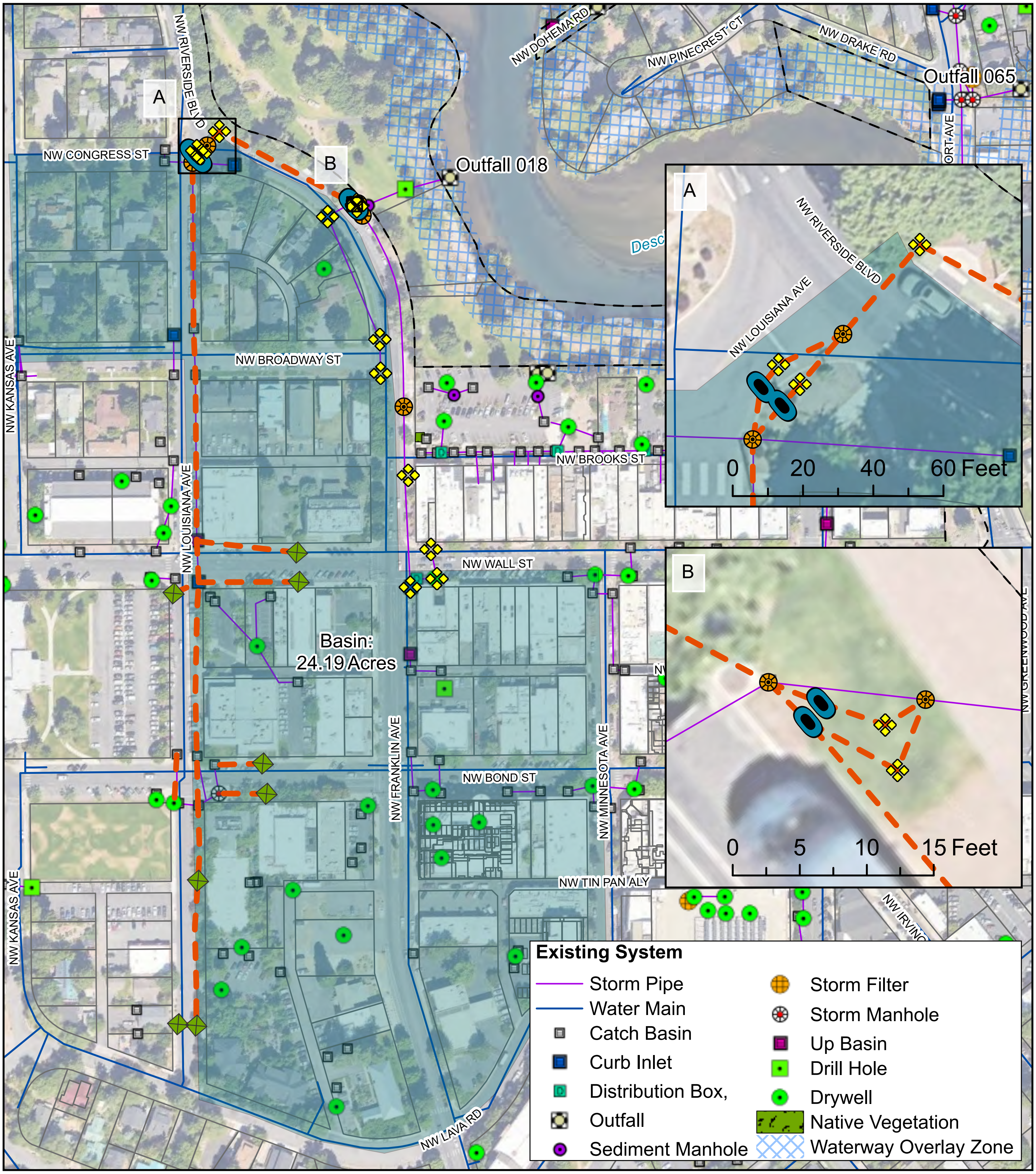
To improve water quality in the stormwater system, a set of proprietary filter systems is proposed to serve an estimated 18.6 acres of impervious surfaces. A total of 309 filter cartridges would be needed to meet Bend's treatment requirements using the water quality design storm. Due to limited space, the project proposes seven catch-basin-style proprietary filter systems and four proprietary treatment vaults in two locations, for a total of 119 filter cartridges.

The four vault-style proprietary filter systems with 28 cartridges each are proposed in the right-of-way (ROW) on NW Riverside Blvd. Each one will be preceded by a pre-treatment facility to protect it from spills and sediment accumulation.

The western set of vaults ('A' on the site map) will serve the existing system that drains NW Louisiana Ave. To reduce gutter flows that may contribute to blocked inlets, the Louisiana pipe system is proposed to be replaced and extended two blocks to the southeast. The recommendation includes 12-inch diameter storm sewer pipe and new catch basins. Half-block pipe extensions on Wall and Bond Streets will convey runoff southwest to Louisiana. Vault 'A' will connect to vault 'B' with new storm sewer pipe. Because the flow path between NW Louisiana Ave and the outfall is not well understood, this concept will need further evaluation in design.

The eastern set of vaults ('B') will serve the existing system that drains NW Franklin Ave. Upstream of this facility, seven catch-basin style proprietary filter systems may be installed in the ROW to increase treatment capacity of the system. A new manhole on the existing pipe near the City parking lot at NW Brooks St is proposed to improve maintenance access.

See Design and Implementation Considerations and Constraints on page 4 for more information about data needs, site constraints, and alternative solutions to be considered during final design.



BEND STORMWATER MASTER PLAN

Proposed Improvements

◆	Proprietary Filter System	☒	Catch Basin	‒ ‒	Storm Sewer Pipe
⬭	Pre-treatment	●	Manhole		

0 125 250 375 Feet

PP-44: Drake Park Stormwater Quality Improvements

7/7/2025 - O:\PROJECT\20300\20359\04 CAD\GIS\APRX\Bend CIP Figures\20359 Bend SMP CIP Figures\20359 Bend SMP CIP Figures - MJB.aprx

Cost Estimate*

Construction	Qty	Unit	Price	Amount
Stormwater Tool Kit				
Pre-Treatment, for large drainage basin (5-15 ac.)	4	EA	$43,500.00	$174,000.00
Storm Sewer Pipe, 12-in diam.	2700	LF	$180.00	$486,000.00
Proprietary Filter System, Catch-basin style	8	EA	$11,500.00	$92,000.00
Proprietary Filter System, Vault-style	4	EA	$100,500.00	$402,000.00
Catch Basin	8	EA	$3,500.00	$28,000.00
Manhole	6	EA	$10,000.00	$60,000.00
Other Construction Costs (Rounded)				
Mobilization	10	%	of Const.	$318,000.00
Erosion and Sediment Control	2	%	of Const.	$64,000.00
Traffic Control	4	%	of Const.	$127,000.00
Construction Contingency	45	%	of Const.	$1,432,000.00
			Total Construction	**$3,183,000.00**
Other Costs (Rounded)	**Qty**	**Unit**	**Price**	**Amount**
Engineering	20	%	of Const.	$637,000.00
Administration	10	%	of Const.	$318,000.00
Basic Permitting	1	EA	$3,000.00	$3,000.00
			Total Other Costs	**$958,000.00**
Total Project Cost (Rounded)				**$4,140,000**

** Class V planning level cost estimate. Costs are in 2025 dollars. Escalate unit prices for quantity items when budgeting for implementation.*

Design and Implementation Considerations and Constraints

Data Collection

Survey is required to locate boundaries of the ROW and BPRD land. Exact basin delineations will be required prior to final design. There is no apparent outfall for the stormwater system on NW Louisiana Ave; the existing system should be surveyed to determine how runoff flows in the current conditions. The pipe under NW Franklin Ave should be surveyed to find the alignment and invert elevations.

Verifying the performance of UICs preceding the outfall is recommended before embarking on design to assess volume of stormwater discharged from Outfall 018.

The drainage basin was taken from the City's Outfall Drainage Basin delineations, provided to Otak in 2024. The area served was assumed to be 90% impervious, applied to the full drainage basin, minus an assumed 12,000 sf for each existing underground injection control within the basin. Actual impervious area will need detailed calculations or measurements.

Constraints

Due to the limited ROW and existing land uses in the area, aboveground solutions are likely not possible for this project location. The project area is likely to have extensive utility conflicts.

Proximity to Drake Park significantly impacts the sizing and locations of the vault-style proprietary filter systems closest to Outfall 018. This is a high-traffic location and maintenance of these facilities may require special considerations from maintenance staff.

Alternatives

The piped connection between vault systems 'A' and 'B' may not be needed. Existing location of storm sewer pipes in this location is unclear and will need investigation.

The area is highly urbanized and lacks consistent stormwater infrastructure. The number of filter cartridges needed was calculated using basin-wide assumptions of imperviousness and flow rates. The final design will need to consider microcontours and precise drainage basins to determine sizes of vaults and number and locations of catch-basin style proprietary filter systems.

Stormwater captured by catch-basin-style proprietary filter systems may be routed to drywells for infiltration in lieu of connecting to treatment vaults in inset 'B'.

Coordination

Outfall 018 is located under Drake Park. All new facilities will be located in the ROW outside of the park. Coordination with BPRD will be needed for any work adjacent to the park. Work inside the park will be avoided. The area is popular with pedestrians, bicyclists, and drivers. Vault locations and selection of inlet, lid, and cover styles will require coordination with City traffic engineering to avoid impacts to safety.

Photos of Project Area

Storm facility access in Drake Park

NW Riverside Blvd looking west from NW Franklin & NW Broadway

Storm facility access on NW Franklin

Downtown Pedestrian Safety Drainage Improvements Program

Capital Improvement Project Fact Sheet

Location	**Downtown Bend**		
ID	**PP-42**	*Rank*	**2**

Problem Summary

Downtown Bend is a popular location for pedestrians. Several downtown intersections experience drainage problems near pedestrian crossings. Ponded water impacts pedestrian circulation and can be hazardous in frozen conditions. These challenges have a variety of causes that are typically localized to a half-block or less. Through both observation and public complaints, City staff have documented three of these locations, which include failed UICs, poor drainage to inlets after the installation of ADA ramps, and inlets not located in low spots. More locations of localized ponding may exist beyond what has been documented.

In addition to pedestrian impacts, flooding occurs due to failed UICs. Water remains in the failed UICs year-round and stormwater that cannot enter the facility routinely damages the exterior of properties on NW Wall St.

Overall, the aging downtown drainage system requires comprehensive upgrades for pedestrian safety and protection of property.

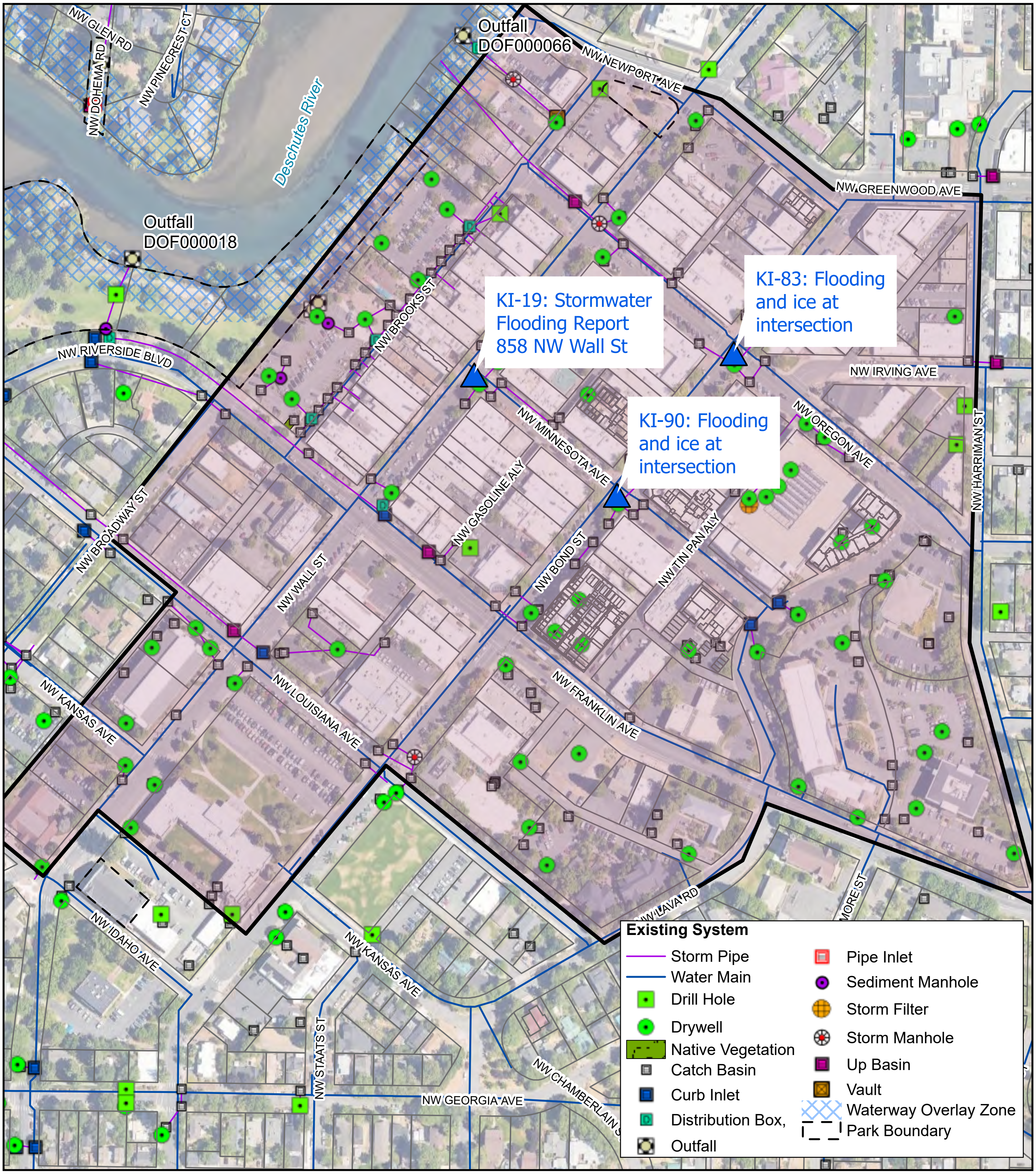
Project Description

To evaluate extent of the localized drainage needs in downtown Bend, the project recommendation begins with a study to identify and map ponding locations. The study area encompasses approximately 16 square blocks from NW Newport Ave to NW Louisiana and from NW Broadway St to NW Lava Rd and NW Harriman St. It includes a portion of the project site for the Drake Park Stormwater Outfall 018 and Pipe Access Project, PP-44, which is also recommended in the Bend Stormwater Master Plan. The initial study is a walking survey conducted twice: once after a moderate rainstorm to document ponding and once during a freeze that follows a rainstorm to document frozen ponds at intersections. In addition to documenting locations, the initial study should include observations of both severity and potential causes at each location, which might include pavement slope away from inlet and/or lack of inlet at low point, curb height, pavement condition (e.g. potholes), and failed or under-capacity UICs.

A desktop evaluation will then group locations by problem type, develop conceptual solutions for each type, and prioritize locations by severity. We recommend prioritizing the locations that freeze first.

The cost estimate assumes the walking survey will be conducted by City staff and will identify six locations that need a simple drainage solution. It assumes two different solution types as follows: 1) improving drainage to existing inlets by patching asphalt and replacing curb and gutter so that runoff drains properly to existing inlets, and 2) installing new drywells in locations where stormwater infrastructure is either lacking or existing UICs have failed. The proposed implementation plan is to group solutions by type into two phases and to prepare simple designs in-house.

See Design and Implementation Considerations and Constraints on page 4 for more information about data needs, site constraints, and alternative solutions to be considered during final design.



BEND STORMWATER MASTER PLAN

Proposed Improvements

▭ Study Area - Downtown Bend

▲ Downtown Pedestrian Safety Known Issues

N

0 140 280 420 Feet

PP-42: Downtown Pedestrian Safety Drainage Improvements Program

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Cost Estimate*				
Construction	**Qty**	**Unit**	**Price**	**Amount**
Stormwater Tool Kit				
Pre-Treatment, for small drainage basin (less than 1 ac.)	3	EA	$12,000.00	$36,000.00
Storm Sewer Pipe, 12-in diam.	180	LF	$180.00	$32,400.00
Drywell	3	EA	$32,000.00	$96,000.00
Surface Restoration (Asphalt Patch)	59	SY	$100.00	$5,900.00
Curb & Gutter	105	LF	$70.00	$7,350.00
Catch Basin	6	EA	$3,500.00	$21,000.00
Other Construction Costs (Rounded)				
Mobilization	10	%	of Const.	$58,000.00
Erosion and Sediment Control	2	%	of Const.	$12,000.00
Traffic Control	4	%	of Const.	$23,000.00
Construction Contingency	50	%	of Const.	$291,000.00
			Total Construction	**$582,650.00**
Other Costs (Rounded)	**Qty**	**Unit**	**Price**	**Amount**
Walking Study	1	EA	$10,000.00	$10,000.00
Engineering	20	%	of Const.	$117,000.00
Administration	10	%	of Const.	$58,000.00
Basic Permitting	2	EA	$3,000.00	$6,000.00
			Total Other Costs	**$191,000.00**
Total Project Cost (Rounded)				**$770,000**

**Class V planning level cost estimate. Costs are in 2025 dollars. Escalate unit prices for quantity items when budgeting for implementation*

Design and Implementation Considerations and Constraints

Data Collection	Survey is required at each location of a proposed solution to identify inlet elevations and pipe invert elevations.
Constraints	Downtown Bend is a popular area with heavy traffic and street parking which can impact siting of proposed improvements. Pavement condition varies across the study area and may impact surface restoration area. Conflicts with underground utilities are expected for any underground work associated with this project.
Alternatives	Stormwater trees may be an alternative to additional drywells in the study area and can be incorporated into plans for street redesigns.
Coordination	The Drake Park Stormwater Outfall 018 Retrofit and Pipe Access Project proposes stormwater improvements on NW Franklin Ave and NW Louisiana Ave within the study area of this project. Coordination with the two projects is needed to avoid disruptions to either project. City of Bend or the Downtown Bend Business Association may be considering development of plans for downtown improvements such as festival streets, street trees, and other streetscape improvements. The six solutions for this study area could be packaged with the implementation of those plans, if they come to fruition. Coordination with the City's Accessibility Program to maintain accessibility of sidewalks and crosswalks for people with disabilities is recommended. In addition, coordinating with the Engineering and Infrastructure Planning Department to improve drainage design with future ADA ramp installation is encouraged.

Photos of Project Area

Catch basin next to ponding in crosswalk at NW Oregon & NW Bond

Ponding on ADA Ramp at NW Oregon & NW Wall

Ponding on road and crosswalk at NW Wall & NW Greenwood

Riverfront Street Stormwater Improvements

Capital Improvement Project Fact Sheet

CITY OF BEND

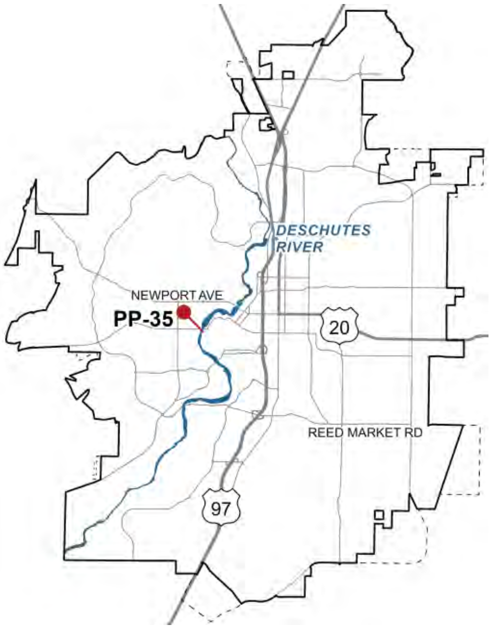
Location	**NW Riverfront St & NW Hixon Ave**		
ID	**PP-35**	*Rank*	**1**

Problem Summary

Outfall 128 has been identified as a priority for a stormwater retrofit project to protect water quality in the Deschutes River. The outfall drains a riverfront neighborhood and runs under a private residence without an easement.

The neighborhood experiences localized flooding on NW Riverfront St near Hixon St during high water, or about half of each year, because the outfall pipe becomes submerged in the river. The stormwater system therefore backs up and sometimes floods local roads and one home. Maintenance efforts, such as digging around the outfall during low river levels, have been unsuccessful. A 2023 inspection revealed that the pipe under NW Riverfront St. is corroded and the section under the residence remains in fair condition.

Outfall 022, while not a priority for a water quality retrofit, is located three blocks north of Outfall 128 and may have capacity to accept more flow. Outfall 022 serves NW Tumalo Ave and is located under Drake Park.



Project Description

To provide additional system capacity to reduce flooding, a storm pipe will be constructed under NW Riverfront St from NW Mueller Ave north to NW Tumalo Ave. The new pipe will intersect the existing storm pipe under NW Hixon Ave and allow flows to split, either by flowing west to the river in the Outfall 128 pipe or by continuing north in the new pipe to its connection with the Outfall 022 storm system. If storm system flooding is caused by river backwater, the additional pipe capacity may act as temporary underground storage, reducing surface ponding. Pipe condition will be evaluated and damaged pipe segments will be replaced or lined.

To provide water quality treatment for Outfall 128, catch-basin-style Proprietary Filter Systems will be installed at catch basins on both the exiting pipe system under NW Hixon Ave and on the new pipe under NW Riverfront St. The outfall basin is approximately 1.4 acres of impervious surface. Approximately 12 filter cartridges may fit in the pipe system.

To ensure access to Outfall 128, the City will work to negotiate an easement with the property owner. To ensure access to Outfall 022, the City will work to negotiate an intergovernmental agreement with Bend Park and Recreation District (BPRD). An agreement may cover Outfall 022 individually or may provide universal access for the City to outfall pipes, stormwater pipes, City UICs, and other City stormwater infrastructure on BPRD parks.

See Design and Implementation Considerations and Constraints on page 4 for more information about data needs, site constraints, and alternative solutions to be considered during final design.

BEND STORMWATER MASTER PLAN

Proposed Improvements

- ◆ Proprietary Filter System
- ● Manhole
- ▬ ▬ Storm Sewer Pipe

0 50 100 150 Feet

PP-35: Riverfront Street Stormwater Improvements

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Cost Estimate*				
Construction	**Qty**	**Unit**	**Price**	**Amount**
Stormwater Tool Kit				
Storm Sewer Pipe, 12-in diam.	640	LF	$180.00	$115,200.00
Drywell	1	EA	$32,000.00	$32,000.00
Proprietary Filter System, Catch Basin-style	12	EA	$11,500.00	$138,000.00
Manhole	1	EA	$10,000.00	$10,000.00
Other Construction Costs (Rounded)				
Mobilization	10	%	of Const.	$67,000.00
Erosion and Sediment Control	2	%	of Const.	$13,000.00
Traffic Control	4	%	of Const.	$27,000.00
Construction Contingency	40	%	of Const.	$268,000.00
			Total Construction	**$670,200.00**
Other Costs (Rounded)	**Qty**	**Unit**	**Price**	**Amount**
Engineering	20	%	of Const.	$134,000.00
Administration	10	%	of Const.	$67,000.00
Basic Permitting	1	EA	$3,000.00	$3,000.00
Permitting in WOZ	1	EA	$3,000.00	$3,000.00
Easement Acquisition	540.00	SF	$9.00	$4,860.00
			Total Other Costs	**$211,860.00**
Total Project Cost (Rounded)				**$880,000**

** Class V planning level cost estimate. Costs are in 2025 dollars. Escalate unit prices for quantity items when budgeting for implementation.*

Design and Implementation Considerations and Constraints

Data Collection

Topography appears flat and existing infrastructure appears shallow. Request survey data from project 1TRVF Riverfront Improvements and determine how much additional survey is needed to evaluate feasibility of the proposed alternative.

Constraints

To treat Outfall 128 to the city's treatment standard using the 1-inch design storm, 25 filter cartridges would be needed. This design provides for 12 cartridges due to site constraints.

ROW width is limited on NW Riverfront. The filter catch basin at the end of NW Hixon will be in the travel lane of NW Riverfront and fitted with a traffic-rated access cover.

Shallow pipe depth at the western terminus of NW Hixon Ave may prevent the use of any below-ground Proprietary Filter System. The two filter cartridges shown at this location may not be feasible and will need to be evaluated in design.

Alternatives

Flat topography and shallow infrastructure will inform the proprietary filter system selection in final design. Different brands and models require different minimum elevation change (also known as "drop") to function.

Permeable pavement may also be considered in the project area to provide infiltration capacity and reduce the amount of impermeable surfaces in the ROW.

Stormwater Planters on NW Riverside Blvd between NW Mueller Ave and NW Tumalo Ave may be considered if Proprietary Filter Systems are determined infeasible for the project site, but this location has limited treatment potential for Outfall 128.

Adding a water quality retrofit to Outfall 022 with a vault-style Proprietary Filter System of 28 filter cartridges and a sedimentation manhole would add approximately $118,000 to the Stormwater Tool Kit Construction costs.

Coordination

Outfall 022 is located under Drake Park. All new facilities will be located in the ROW outside of the park. Coordination with BPRD will be needed for any potential work within and adjacent to the park.

1TRVF Riverfront Improvements is a transportation capital project that will redesign Riverfront Street at the location of this project. Coordination is needed for synergy between projects.

Photos of Project Area

NW Riverside looking east down NW Hixon

NW Hixon looking north down NW Riverside

Catch basin at SE corner of NW Riverside and NW Hixon

Campbell Road Drainage Improvements

Capital Improvement Project Fact Sheet

CITY OF BEND

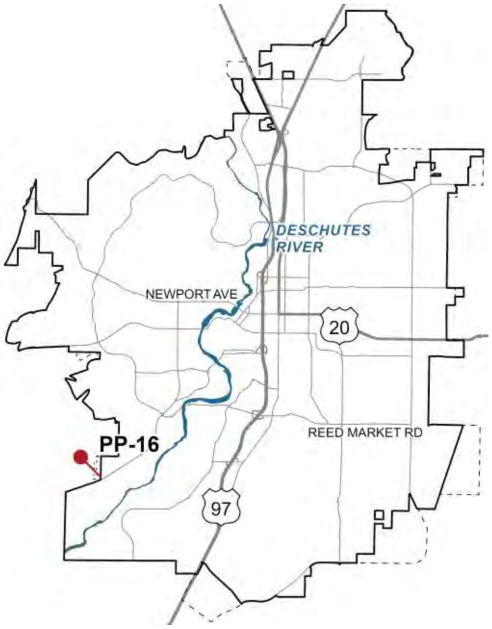
Location	**W Campbell Rd & SW Swarens Ave**		
ID	**PP-16**	*Rank*	**12**

Problem Summary

Existing stormwater infrastructure at W Campbell Rd and SW Swarens Ave is insufficient. During large rain events, stormwater flows overland and deposits debris and sediment in the right-of-way (ROW) at the bottom of the slope. The maintenance needs on SW Century Dr from upstream runoff are significant, and ponding impacts road safety.

This location collects stormwater runoff from drainage basins that include both impervious urban surfaces and natural undeveloped landcover. The landowners in these basins include Deschutes County, Bend Park and Recreation District (BPRD), private owners, and the City of Bend. A portion of the site is on unincorporated land within Bends Urban Growth Boundary (UGB).

The western portion of W Campbell Rd is maintained by the City, but it is outside of the City limits.



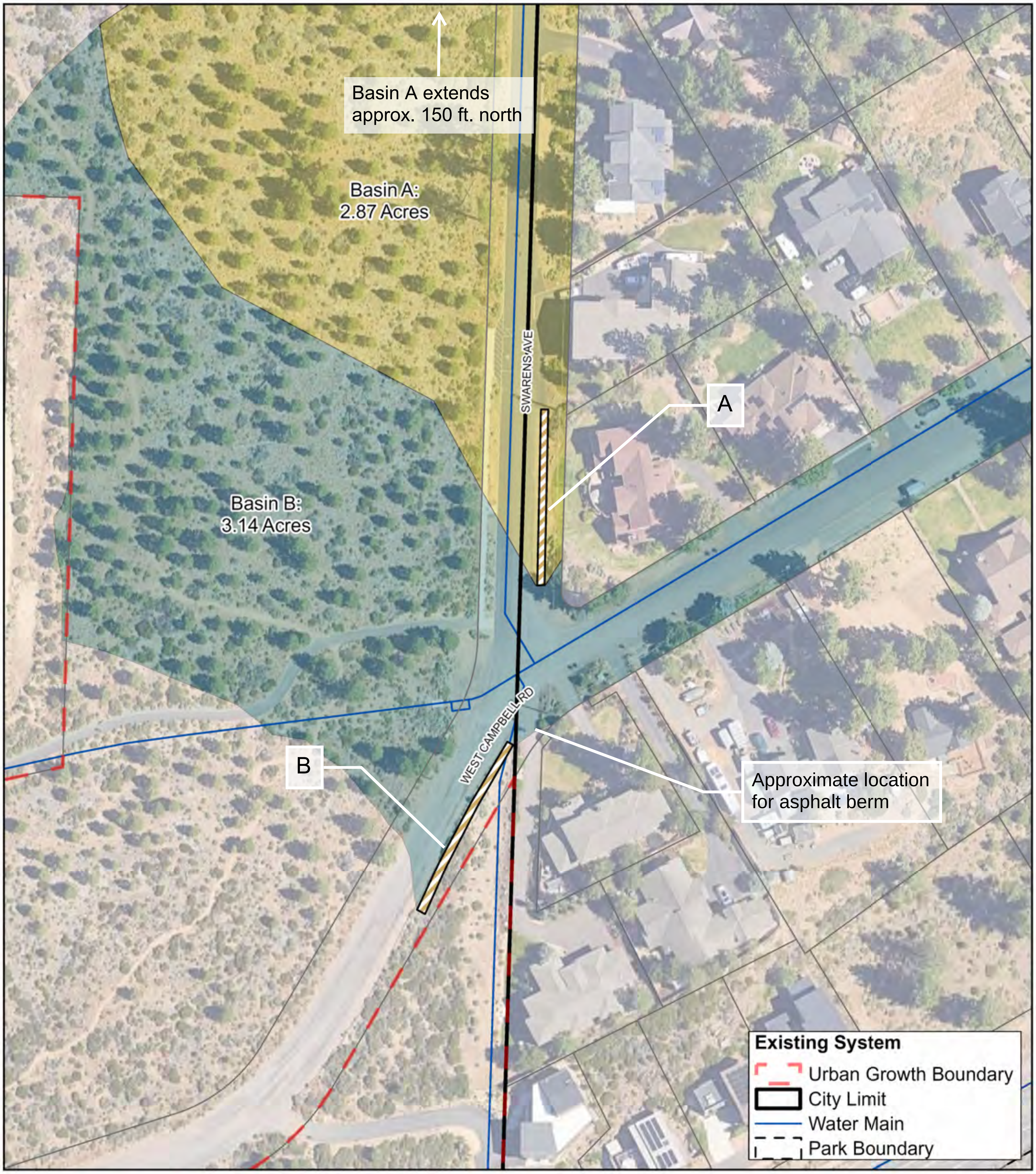
Project Description

To improve drainage in the area, two infiltration trenches are proposed. These trenches will drain an area that includes impervious surfaces in the ROW and undeveloped landcover. The total area of the infiltration trenches is 1,476 square-feet. Parking is allowable on top of the infiltration trenches.

The infiltration trench north of W Campbell Rd (‘A’ on map figure) will be approximately 680 square-feet in area and installed on the east side of SW Swarens Ave. This facility will drain 2.87 acres of urban and natural runoff.

The southern infiltration trench (‘B’) will be approximately 800 square-feet in area and installed on the east side of the road. This facility will drain 3.14 acres of urban and natural runoff. The proposed location of this infiltration trench is outside of current city limits but is within Bend’s unincorporated UGB. Coordination with Deschutes County may be needed for the City to build this infrastructure project. An asphalt berm will be installed on the southern edge of W Campbell Rd in front of driveways to redirect runoff into the southern infiltration trench.

See Design and Implementation Considerations and Constraints on page 4 for more information about data needs, site constraints, and alternative solutions to be considered during final design.



BEND STORMWATER MASTER PLAN

Proposed Improvements

▨ Infiltration Trench

N

0 50 100 150 Feet

PP-16: Campbell Road Drainage Improvements

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Cost Estimate*

Construction	Qty	Unit	Price	Amount
Stormwater Tool Kit				
Infiltration Trench	1500	SF	$30.00	$45,000.00
Asphalt Berm	60	SF	$15.00	$900.00
Other Construction Costs (Rounded)				
Mobilization	10	%	of Const.	$10,000.00
Erosion and Sediment Control	2	%	of Const.	$2,000.00
Traffic Control	4	%	of Const.	$4,000.00
Construction Contingency	40	%	of Const.	$42,000.00
			Total Construction	**$103,900.00**
Other Costs (Rounded)	**Qty**	**Unit**	**Price**	**Amount**
Engineering	20	%	of Const.	$21,000.00
Administration	5	%	of Const.	$5,000.00
Basic Permitting	1	EA	$3,000.00	$3,000.00
			Total Other Costs	**$29,000.00**
Total Project Cost (Rounded)				**$130,000**

**Class V planning level cost estimate. Costs are in 2025 dollars. Escalate unit prices for quantity items when budgeting for implementation.*

Design and Implementation Considerations and Constraints

Data Collection	Survey is required to establish ROW and City boundaries and identify utilities for potential conflicts. A geotechnical analysis is recommended for soil drainage conditions. The project location is within an area of generally poor infiltration capacity.
Constraints	Proximity to city limits constrains where facilities can be built without intergovernmental coordination and agreements. W Campbell Rd west of NW Swarens Ave is unimproved and is within the UGB area. Future development and ROW improvements may alter the effectiveness of the infiltration trench south of W Campbell Rd. Plans for annexation may lengthen the time needed to complete the infiltration trench south of W Campbell Rd.
Alternatives	Possible alternatives include replacing the infiltration trenches with a swale or ditch with ditch inlets connected to a drywell.
Coordination	Because the proposed location of the southern infiltration trench is outside of current city limits but within the UGB of the City, Coordination with Deschutes County is required due to proximity to city limits and origin of runoff appears to be from unincorporated county lands.

Photos of Project Area

End of W Campbell Rd at city limits looking southwest

W Campbell Rd & SW Swarens Ave looking northeast

Stormwater runoff downslope from W Campbell Rd on SW Century Dr

Congress Street Drainage Improvements

Capital Improvement Project Fact Sheet

CITY OF BEND

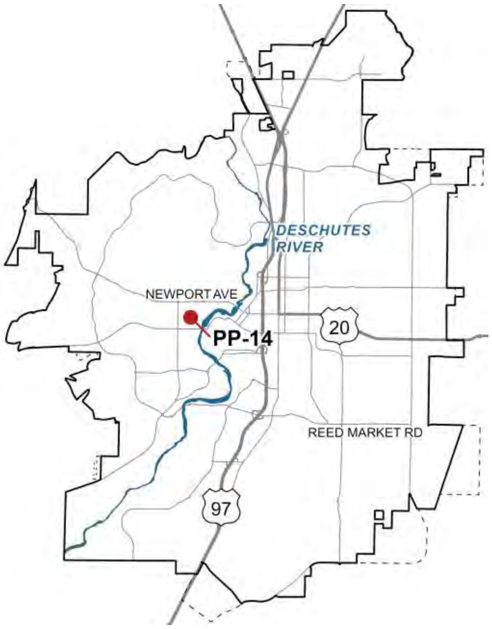
Location	**NW Congress St & NW St Helens Pl**		
ID	**PP-14**	*Rank*	**4**

Problem Summary

A lack of stormwater infrastructure in the area leads to stormwater accumulating in the roads and right-of-way (ROW). During heavy rain events, water exceeds the curb height and floods multiple properties in the neighborhood.

There are documented reports of damage to the interiors of private structures on the west side of NW Congress St between NW Hood Pl and NW St Helens Pl. This project location is part of Old Bend, the historic central core of the city. Old Bend was developed before stormwater drainage was piped and relies on streets draining over the surface to the Deschutes River to the west.

Adding stormwater infrastructure to this area will mitigate localized flooding during rain events.



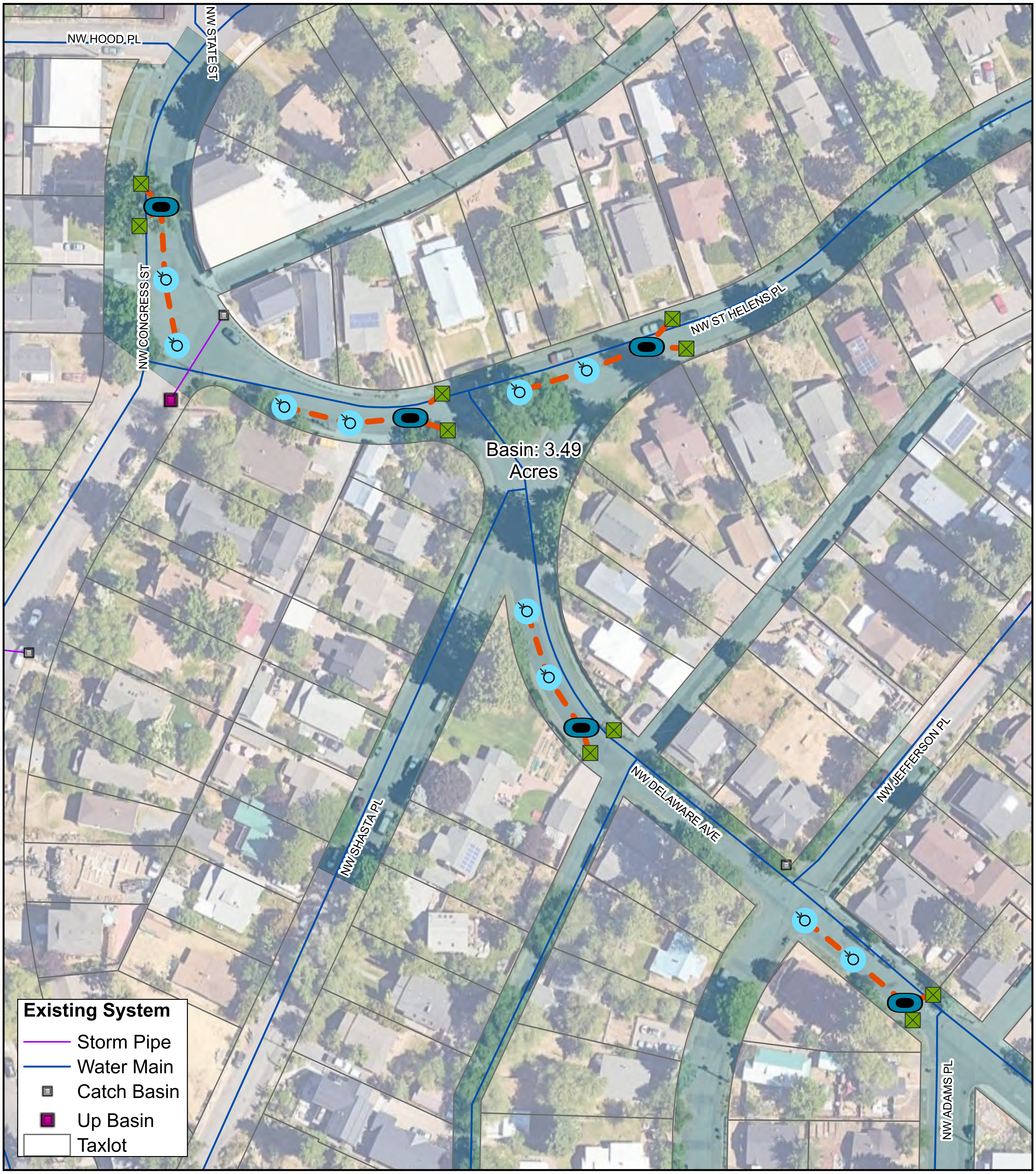
Project Description

To improve drainage in this project area, a series of drywell galleries will be installed. This drainage basin is 3.49 acres, and 2.45 acres of the basin is assumed to be impervious surfaces.

The proposed solution includes five drywell galleries – ten drywells in total. Pre-treatment is required for runoff prior to entering drywells to protect the facility from sediment and spills, improve facility function, and increase water quality of the runoff. One pre-treatment facility, designed for small drainage areas up to one acre, precedes each drywell gallery. Stormwater will enter each new system through two catch basins – ten catch basins in total – and 12-inch diameter storm sewer pipe.

One system of two drywells, one pre-treatment facility, two catch basins, and storm sewer pipe will be installed on NW Congress St, north of NW St Helens Pl. Two systems will be installed on NW St Helens Pl east of NW Congress St. Two systems will be installed on NW Delaware St, one west of NW Jefferson Pl and one south of NW Jefferson Pl. All systems will be installed in the ROW.

See Design and Implementation Considerations and Constraints on page 4 for more information about data needs, site constraints, and alternative solutions to be considered during final design.



BEND STORMWATER MASTER PLAN

Proposed Improvements

- Drywell
- Pre-treatment
- Catch Basin
- Storm Sewer Pipe

0 50 100 150 Feet

PP-14: Congress Street Drainage Improvements

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Cost Estimate*

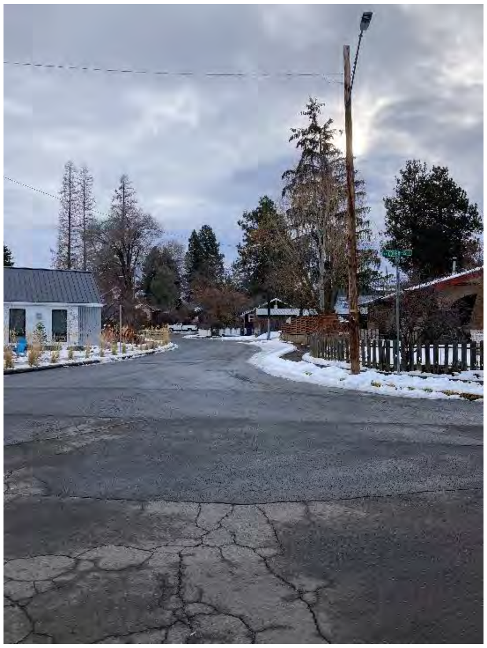
Construction	Qty	Unit	Price	Amount
Stormwater Tool Kit				
Pre-Treatment, for small drainage basin (less than 1 ac.)	5	EA	$12,000.00	$60,000.00
Storm Sewer Pipe, 12-in diam.	730	LF	$180.00	$131,400.00
Drywell	10	EA	$32,000.00	$320,000.00
Catch Basin	10	EA	$3,500.00	$35,000.00
Other Construction Costs (Rounded)				
Mobilization	10	%	of Const.	$101,000.00
Erosion and Sediment Control	2	%	of Const.	$20,000.00
Traffic Control	4	%	of Const.	$40,000.00
Construction Contingency	30	%	of Const.	$303,000.00
			Total Construction	**$1,010,400.00**
Other Costs (Rounded)	**Qty**	**Unit**	**Price**	**Amount**
Engineering	20	%	of Const.	$202,000.00
Administration	10	%	of Const.	$101,000.00
Basic Permitting	1	EA	$3,000.00	$3,000.00
			Total Other Costs	**$306,000.00**
Total Project Cost (Rounded)				**$1,320,000**

**Class V planning level cost estimate. Costs are in 2025 dollars. Escalate unit prices for quantity items when budgeting for implementation.*

Design and Implementation Considerations and Constraints

Data Collection	Survey is needed to identify locations of existing utilities. Impervious area of the drainage basin was assumed to be 90% of the ROW. Actual impervious area will need to be measured. To assess infiltration capacity, a geotechnical assessment is recommended.
Constraints	The project area is near known locations of perched groundwater (where groundwater is trapped above the normal water table by an impervious layer). If perched groundwater occurs in this area, drywells may be infeasible.
Alternatives	If drywells are determined to be infeasible due to perched ground water at the proposed locations, alternatives may need to be considered.
Coordination	All work will occur in the ROW. Coordination may be needed to resolve utility conflicts.

Photos of Project Area



NW Congress St & NW St Helens Pl

Frozen catch basin on NW Congress St

Vicksburg Avenue Drainage Improvements

Capital Improvement Project Fact Sheet

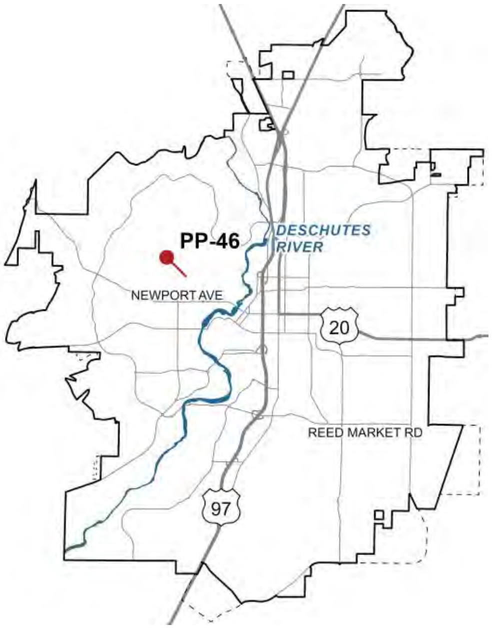
CITY OF BEND

Location	**NW Vicksburg Ave & NW 12th St**		
ID	**PP-46**	*Rank*	**4**

Problem Summary

Existing stormwater infrastructure at NW Vicksburg Ave and NW 12th Street is insufficient for the volume of stormwater runoff in the area. This location is the low point for this drainage basin and is where stormwater collects.

The roads in this area do not have consistent curbs and there are no sidewalks. There are reports of stormwater flowing through private property and damaging the interior of structures on the south side of NW Vicksburg Ave. An asphalt curb was constructed on one side of the road, but it has pushed the drainage issue from one property to another.



Project Description

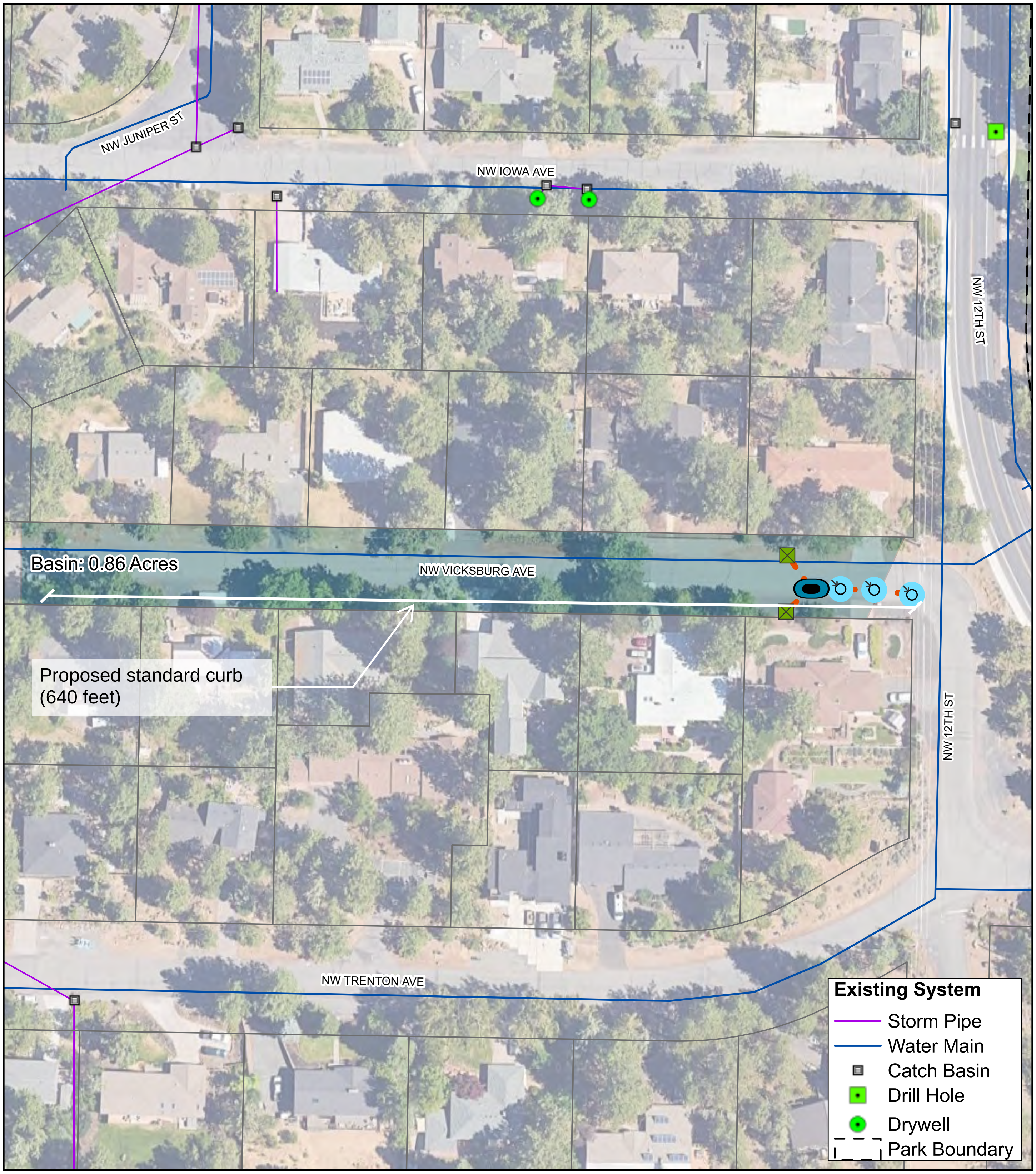
To improve drainage in this area, a gallery of three drywells is proposed. The drainage basin for this project is delineated from the right-of-way (ROW) and is 0.86 acres. Impervious surface area is assumed to be 70% of the basin area.

The drywell gallery will be installed in the ROW on NW Vicksburg Ave, west of 12th St. Pre-treatment is required prior to the drywells to protect facility function and to improve water quality. Because the drywells will be built in a series, one sedimentation manhole for pre-treatment is needed for this proposed design. Two catch basins and 12-inch diameter storm sewer pipe will collect and convey stormwater from the ROW into the new system.

New standard curbs will be installed on the south side of NW Vicksburg Ave. The 640 feet of new curb will keep stormwater runoff in the ROW as it drains into the new drywell system and will prevent runoff from flowing across adjacent properties.

Ongoing capital improvements in the South Awbrey Butte area, which is upstream of this project site, may reduce the amount of runoff draining to this location. Drainage infrastructure is still recommended for this basin to mitigate the risk of flooding during large rain events.

See Design and Implementation Considerations and Constraints on page 4 for more information about data needs, site constraints, and alternative solutions to be considered during final design.



BEND STORMWATER MASTER PLAN

Proposed Improvements

- Drywell
- Pre-treatment
- Catch Basin
- Storm Sewer Pipe

0 50 100 150 Feet

PP-46: Vicksburg Avenue Drainage Improvements

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Cost Estimate*

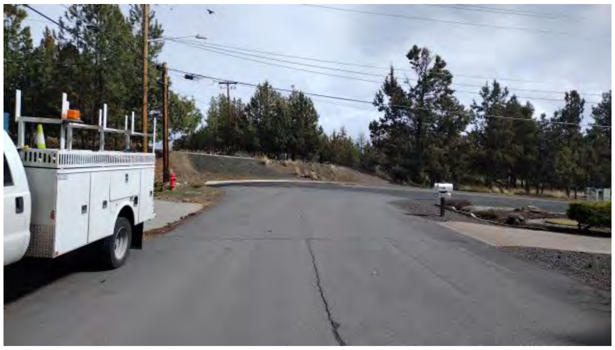
Construction	Qty	Unit	Price	Amount
Stormwater Tool Kit				
Pre-Treatment, for small drainage basin (less than 1 ac.)	1	EA	$12,000.00	$12,000.00
Storm Sewer Pipe, 12-in diam.	130	LF	$180.00	$23,400.00
Drywell	3	EA	$32,000.00	$96,000.00
Standard Curb	640	LF	$40.00	$25,600.00
Catch Basin	2	EA	$3,500.00	$7,000.00
Other Construction Costs (Rounded)				
Mobilization	10	%	of Const.	$37,000.00
Erosion and Sediment Control	2	%	of Const.	$7,000.00
Traffic Control	4	%	of Const.	$15,000.00
Construction Contingency	40	%	of Const.	$148,000.00
			Total Construction	**$371,000.00**
Other Costs (Rounded)	**Qty**	**Unit**	**Price**	**Amount**
Design and Survey	20	%	of Const.	$74,000.00
Administration	10	%	of Const.	$37,000.00
Basic Permitting	1	EA	$3,000.00	$3,000.00
			Total Other Costs	**$114,000.00**
Total Project Cost (Rounded)				**$490,000**

**Class V planning level cost estimate. Costs are in 2025 dollars. Escalate unit prices for quantity items when budgeting for implementation.*

Design and Implementation Considerations and Constraints

Data Collection	To assess infiltration capacity, a geotechnical assessment is recommended. Survey is needed to identify locations of existing utilities and underground infrastructure.
Constraints	The infiltration capacity of the soils in this area is moderate. Drywells are expected to perform well. A geotechnical assessment will confirm this assumption.
Alternatives	There are current and ongoing stormwater infrastructure projects in the South Awbrey Butte area, which may reduce flood severity and frequency at this location during rain events. Waiting until these improvements are complete may impact the design or sizing of this project. Depending on infiltration conditions at this location, deep drywells may be more appropriate. Infiltration testing will inform whether to use drywells or deep drywells. Construction of a piped conveyance system that connects with the Awbrey Butte stormwater system may be an alternative, but the pipe would need to run approximately 600 feet.
Coordination	Coordination may be needed for underground utilities. There is one crossing of a water main in the proposed design.

Photos of Project Area



NW Vicksburg Ave & NW 12th St

NW Vicksburg Ave looking west

Runoff effect from asphalt curb

Fresno Avenue Stormwater Improvements

Capital Improvement Project Fact Sheet

CITY OF BEND

Location	**NW Fresno Ave & NW 12th St**		
ID	**PP-48**	*Rank*	**7**

Problem Summary

Existing stormwater infrastructure at NW Fresno Ave and NW 12th St is not in good condition. A 2023 CCTV inspection revealed that repairs are needed for a section of stormwater pipe that connects to the NW Galveston Ave trunkline. Part of the system is located underneath private property which creates challenging conditions to access the pipe for repairs and maintenance.

Outfall 020 has been identified as a stormwater retrofit project to protect water quality in the Deschutes River. The basin of this project area drains 3.47 acres of impervious area south of NW Galveston Ave between NW 12th St and NW 14th St.

Project Description

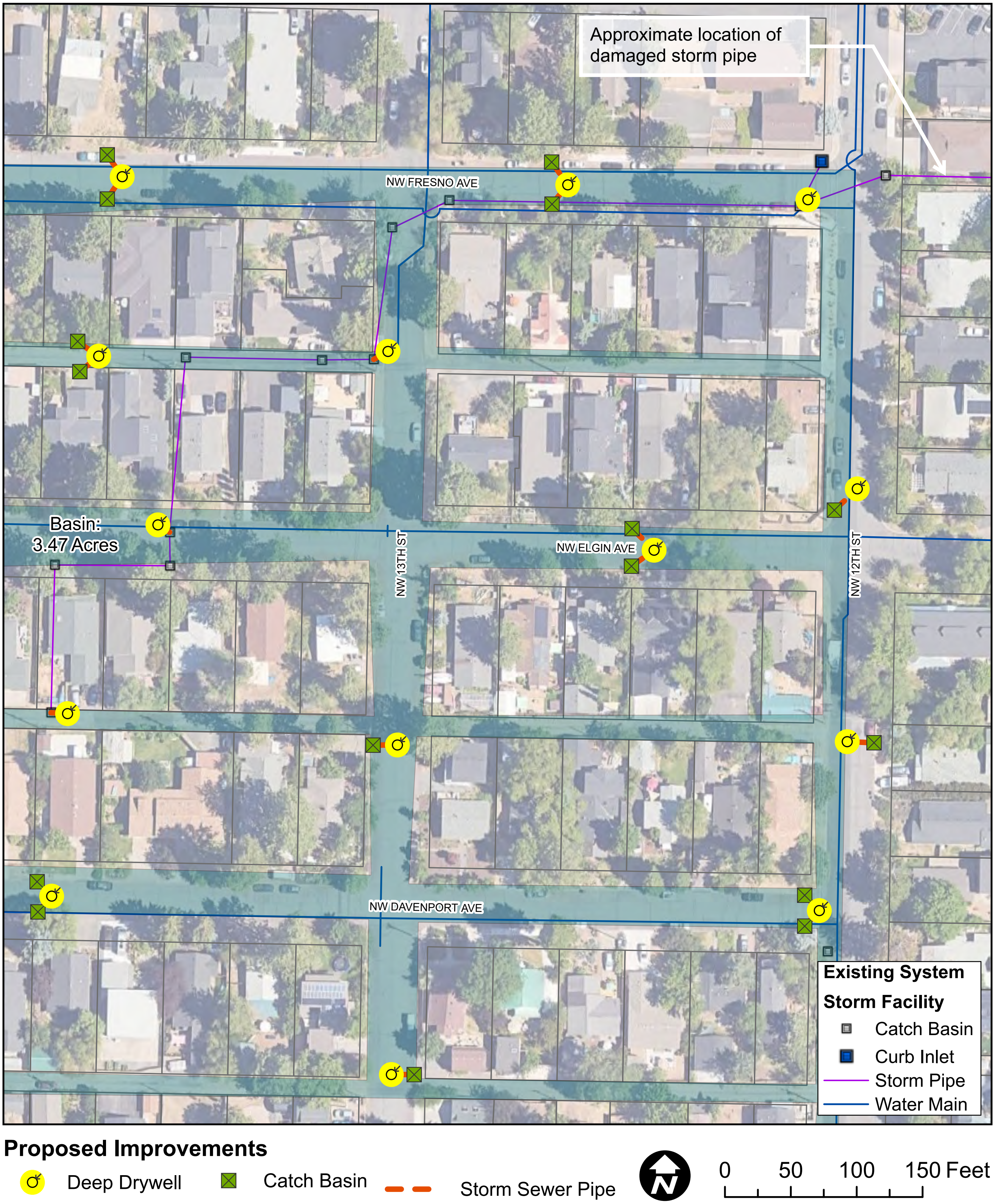
This project will reduce pollutants discharged to the Deschutes River by disconnecting the 3.47 acres of right-of-way (ROW) drainage upstream of this point from Outfall 020. The project area extends south from NW Fresno Ave to NW Davenport Ave, and west from NW 12th St to NW 14th St.

Fourteen deep drywells are proposed. Five deep drywells will connect to the existing system on the northern and western portions of the site, and the remainder will intercept surface runoff throughout the four-square-block ROW drainage basin. To collect and convey stormwater to these facilities, 16 catch basins and 12-inch diameter storm sewer pipe will be installed.

Deep drywells are recommended for this neighborhood-scale project due to the expected challenging soil conditions. Locations west of the Deschutes River and south of Awbrey Butte have generally poor infiltration due to an impermeable layer of rock known as welded tuff. Deep drywells can be drilled through this impermeable layer and infiltrate below it, which standard drywells would not be able to do.

All proposed facilities will be constructed in the ROW. Two are proposed for alleyways and twelve proposed for roadways. This project proposes abandoning 120 feet of the damaged stormwater main under private property east of NW 12th St. The pipe segment in the alley leading to Galveston Ave may remain in service to collect and convey private runoff. By opting to not repair the pipe connecting the project area to Outfall 020, no easement acquisition is required for this project.

See Design and Implementation Considerations and Constraints on page 4 for more information about data needs, site constraints, and alternative solutions to be considered during final design.



PP-48: Fresno Avenue Stormwater Improvements

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Cost Estimate*				
Construction	**Qty**	**Unit**	**Price**	**Amount**
Stormwater Tool Kit				
Storm Sewer Pipe, 12-in diam.	355	LF	$180.00	$63,900.00
Deep Drywell	14	EA	$78,500.00	$1,099,000.00
Catch Basin	16	EA	$3,500.00	$56,000.00
Pipe Lining – Cured in Place Piping (CIPP)	120	LF	$400	$48,000.00
Other Construction Costs (Rounded)				
Mobilization	10	%	of Const.	$325,000.00
Erosion and Sediment Control	2	%	of Const.	$65,000.00
Traffic Control	4	%	of Const.	$130,000.00
Construction Contingency	45	%	of Const.	$1,462,000.00
			Total Construction	**$3,248,900.00**
Other Costs (Rounded)	**Qty**	**Unit**	**Price**	**Amount**
Design and Survey	20	%	of Const.	$650,000.00
Administration	10	%	of Const.	$325,000.00
Basic Permitting	1	EA	$3,000.00	$3,000.00
			Total Other Costs	**$978,000.00**
Total Project Cost (Rounded)				**$4,230,000**

**Class V planning level cost estimate. Costs are in 2025 dollars. Escalate unit prices for quantity items when budgeting for implementation.*

Design and Implementation Considerations and Constraints

Data Collection

A geotechnical assessment is required to determine the exact location and depth of the impermeable welded tuff layer.

Survey will be needed to calculate precise drainage basins for each facility in final design. Deep drywell locations shown are planning-level approximations based on engineering judgment.

Constraints

The prevalence of the impermeable welded tuff layer is this project's most significant constraint. Deep drywell locations will require evaluation of overhead obstructions such as utilities or trees that could prohibit drilling.

Alternatives

The City may consider phasing the project to spread out costs as each deep drywell could be installed as an individual project. Some deep drywells are located in alleys. Paving alleys may be considered to reduce sediment migration into catch basins.

The damaged pipe should be either replaced or re-lined. Due to its suspected location under private property, conventional replacement may not be possible. Using a cured-in-place pipe lining (CIPP) or a slip-lined smaller pipe inside of the main pipe may be preferable. Research into unit costs suggests that CIPP lining unit costs for an 18" diameter pipe could be around $400/LF. Slip-lining costs are more difficult to estimate, but Contech Engineered Systems offers such services with the statement that they can be up to 50% less expensive than CIPP. A more detailed design and cost comparison should be undertaken during later stages of the project design to determine the specific needs and viability of approaches. A rough line-item for the segment under private property could be approximately $48,000, assuming CIPP, with savings a possibility based on the results of that study.

Coordination

Due to the extensive neighborhood drainage improvements, coordination with utility providers will be required and may be complex. Phasing the project's construction to reduce the annual budget impact is an option.

Coordination and communication with properties which use the alleys for access will be required for the duration of planning and construction.

Photos of Project Area

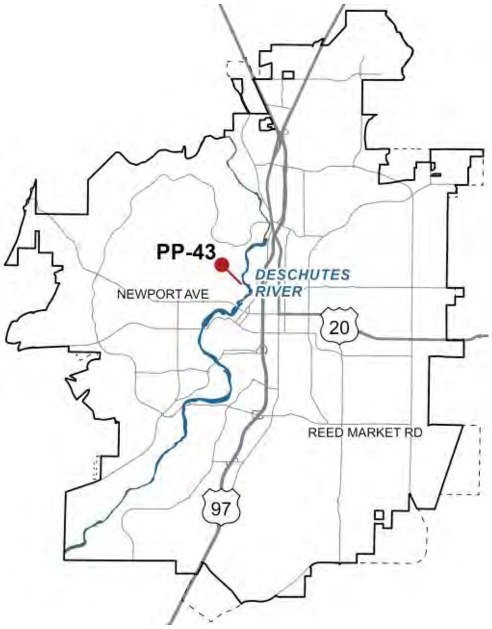
NW Fresno Ave & NW 12th St looking southeast

Curb inlet in the neighborhood

Saginaw Avenue Stormwater Quality Improvements

Capital Improvement Project Fact Sheet

Location	**NW Saginaw Ave & NW 1st St**		
ID	**PP-43**	*Rank*	**11**



Problem Summary

Outfall Basin 013 has been identified as a priority basin for a stormwater retrofit project to protect water quality in the Deschutes River. The outfall drains a basin area of approximately 170 acres west of the river north of NW Portland Ave, which includes parts of Awbrey Butte. Outfall 013 discharges directly into the Deschutes River.

The outfall pipe is beneath private property in several locations, which creates challenges for maintenance and operations. The rights-of-way (ROW) on the surrounding streets are wide and could accommodate a variety of surface-level and underground water quality facilities for stormwater runoff.

Outfall 012 is close to Outfall 013, serves a small area, and is also under private property. Connecting the systems that convey to the outfalls will improve water quality of the whole system.

Project Description

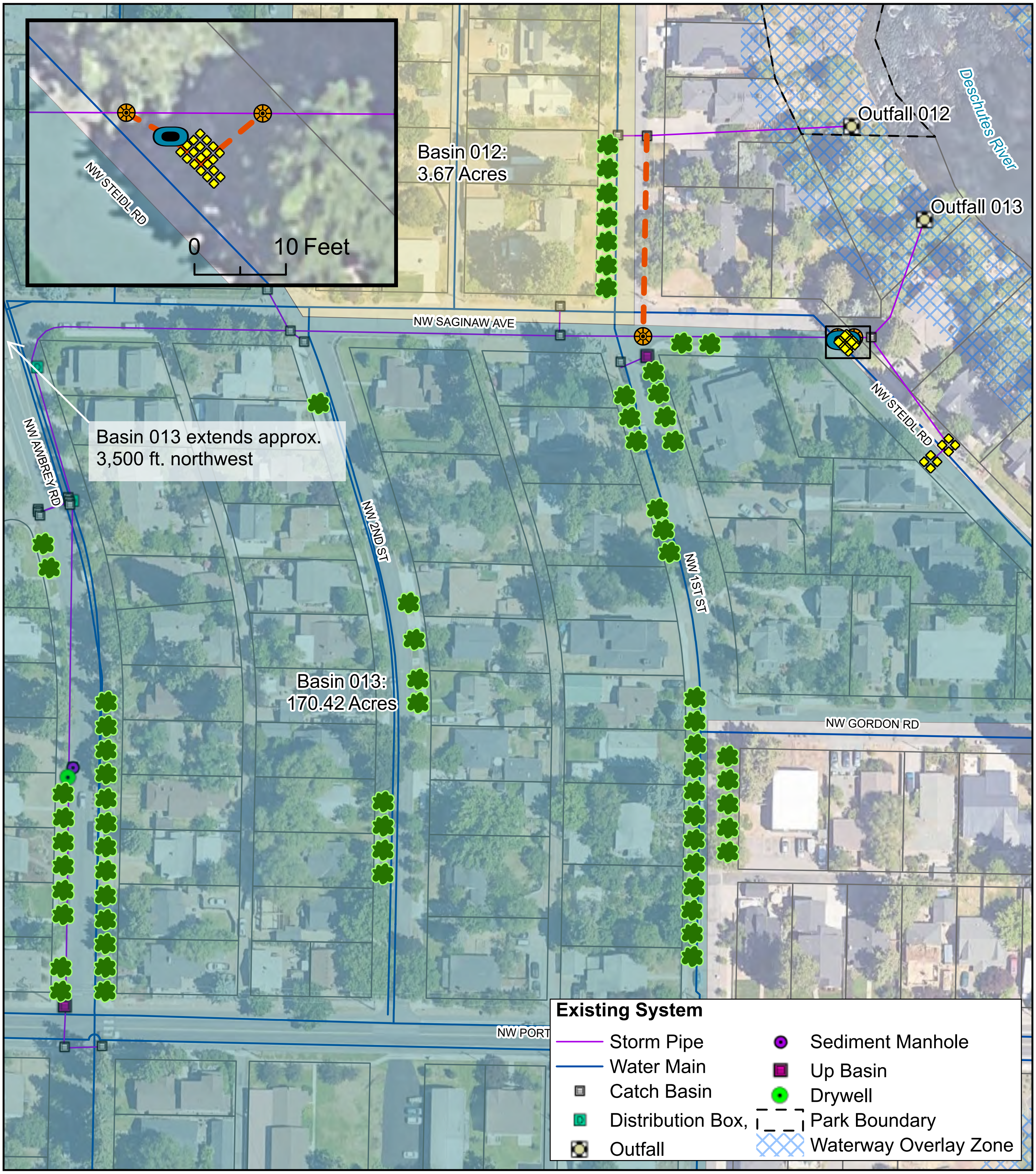
This project proposes a combination of tools to remove quantity of stormwater and improve quality of stormwater to Outfall 013. Of the 170 acres within the outfall basin, 50% were assumed to be impervious.

Where feasible due to existing conditions, 83 stormwater trees have been proposed to provide partial water quality treatment. Stormwater trees are a good fit for this area because they will treat stormwater runoff in the neighborhood, will not require a piped system to Outfall 013 because stormwater will infiltrate, and will add the numerous co-benefits of street trees (e.g. increased aesthetics, shade, habitat, etc.). The primary locations of stormwater trees will be on NW Awbrey Rd, NW 2nd Ave, and NW 1st Ave between NW Saginaw Ave and NW Portland Ave. Due to siting requirements for street trees, planned stormwater trees are 20-feet apart from each other, and at least 15-feet away from intersections. The planning-level assumption is that each stormwater tree can treat runoff from 320 square feet.

To treat the piped runoff not captured by stormwater trees, a vault-style proprietary filter system is proposed at NW Saginaw Ave and Steidl Rd. To meet the minimum treatment requirements, 138 cartridges are needed. This is shown in the cost estimate as five vaults, each holding 28 filters. An additional two catch-basin style proprietary filter systems will be installed on NW Steidl Rd, south of NW Saginaw Ave. Each catch basin system holds one filter.

Outfall 013 will be the primary outfall for this basin. Outfall 012, which is just north of Outfall 013 and drains 3.67 acres, may be rehabilitated under the repair and replacement program to convey water during large rain events. The existing piped segment on NW 1st Ave will be connected to the existing system to the south with a new 12-in diameter storm pipe. Because the pipe to Outfall 013 is underneath private property, an easement is recommended for operations and maintenance.

See Design and Implementation Considerations and Constraints on page 4 for more information about data needs, site constraints, and alternative solutions to be considered during final design.



BEND STORMWATER MASTER PLAN

Proposed Improvements

- Stormwater Trees
- Proprietary Filter System
- Pre-treatment
- Manhole
- Storm Sewer Pipe

PP-43: Saginaw Avenue Stormwater Quality Improvements

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Cost Estimate*

Construction	Qty	Unit	Price	Amount
Stormwater Tool Kit				
Pre-Treatment, for large drainage basin (5-15 ac.)	1	EA	$43,500.00	$43,500.00
Storm Sewer Pipe, 12-in diam.	200	LF	$180.00	$36,000.00
Stormwater Trees	83	EA	$5,400.00	$448,200.00
Proprietary Filter System, Catch Basin-style	2	EA	$11,500.00	$23,000.00
Proprietary Filter System, Vault-style	5	EA	$100,500.00	$502,500.00
Manhole	3	EA	$10,000.00	$30,000.00
Other Construction Costs (Rounded)				
Mobilization	10	%	of Const.	$200,000.00
Erosion and Sediment Control	2	%	of Const.	$40,000.00
Traffic Control	4	%	of Const.	$80,000.00
Construction Contingency	30	%	of Const.	$601,000.00
			Total Construction	**$2,004,200.00**
Other Costs (Rounded)	**Qty**	**Unit**	**Price**	**Amount**
Engineering	20	%	of Const.	$401,000.00
Administration	10	%	of Const.	$200,000.00
Basic Permitting	1	EA	$3,000.00	$3,000.00
Easement Acquisition	1,200.00	SF	$9.00	$10,800.00
			Total Other Costs	**$614,800.00**
Total Project Cost (Rounded)				**$2,620,000**

**Class V planning level cost estimate. Costs are in 2025 dollars. Escalate unit prices for quantity items when budgeting for implementation.*

Design and Implementation Considerations and Constraints

Data Collection The drainage basin areas were taken from the City's Outfall Drainage Basin delineations, provided to Otak in 2024. The area served is assumed to be 50% impervious, applied to the full drainage basin. Actual impervious area will need detailed calculations or measurements.

Constraints Due to the presence of large trees on some private properties and ROW in the project area, some sites may be infeasible or inappropriate for a Stormwater Tree. Mapped locations are approximate. This tool is best used in a wide ROW with a landscaped strip. In areas with overhead utilities like power lines, tree species should be selected which do not grow tall enough to interfere with the lines.

Alternatives Strategic use of pervious pavement may be a viable solution and could reduce untreated impervious area. It is not included in this project.

Reducing the number of stormwater trees is an alternative to reduce overall cost of the project.

Outfall 012 may be decommissioned to reduce the number of outfalls discharging into the Deschutes River.

Coordination The pipe to Outfall 013 is under private property. To facilitate access for maintenance and operations, negotiating an easement with property owners is included in this project.

Photos of Project Area

Intersection of NW Saginaw Ave & NW 1st St, looking northwest

Galveston Avenue Stormwater Quality Improvements

CITY OF BEND

Capital Improvement Project Fact Sheet

Location	**NW Galveston Ave & NW Harmon Ave**		
ID	**PP-47**	*Rank*	**6**

Problem Summary

Outfall 020 has been identified as a priority basin for a stormwater retrofit project to protect water quality in the Deschutes River. The drainage basin for Outfall 020 includes approximately 37 acres west of the river along NW Galveston Ave. A southern portion of the basin drains an area between the Deschutes River and NW 14th St and a northern portion drains an area between NW 12th St and NW 17th St.

Bend's outfall retrofit program aims to reduce the amount of untreated discharge, remove urban stormwater pollutants, and reduce sediment accumulation in existing stormwater infrastructure.

The City of Bend is planning a roadway project on NW Galveston Ave to improve multi-modal transportation and pedestrian experience. The calculations used for this retrofit project assume that the roadway improvement project will not trigger water quality treatment requirements.

Project Description

To improve water quality in the basin for Outfall 020, stormwater trees and a network of proprietary filter systems are proposed to serve an estimated impervious area of 18.56 acres.

Three sets of proprietary filter treatment vault systems are proposed in this design. One set of four vaults with a total of 112 filter cartridges at NW Columbia St and NW Elgin Ave ('A' in the project map) will collect stormwater from three new catch basins and the southern part of the drainage basin. This vault will connect to the existing system with a 12-inch diameter storm sewer pipe at NW Galveston and NW Harmon Blvd. A second sets of four vaults ('B') will be connected in-line to the existing piped system with 18-inch diameter storm sewer pipe at NW Hartford Ave and NW 12th St. A third set of four vaults ('C') approximately 350 feet upstream of Outfall 020 at NW Galveston Ave and NW Columbia St will be connected in-line with the existing piped system with 24-inch diameter storm sewer pipe. Each set of proprietary treatment vaults will be preceded by a pre-treatment facility to protect the vault and filters from sedimentation and improve maintainability.

In addition to the underground proprietary filter systems, 30 stormwater trees are proposed along both sides of the road on NW Galveston Ave, between NW Harmon Blvd and NW 14th St. The planning level assumption is that each stormwater tree can manage runoff from 320 square feet of adjacent pavement. Stormwater trees must be spaced 20-feet apart in the ROW and at least 15-feet away from intersections and driveways.

When considered with 30 stormwater trees, a total of 320 filter cartridges would be needed to meet the minimum treatment requirements for the water quality design storm. The proposed project provides 336 filter cartridges in three locations.

See Design and Implementation Considerations and Constraints on page 4 for more information about data needs, site constraints, and alternative solutions to be considered during final design.

BEND STORMWATER MASTER PLAN

Proposed Improvements

- Stormwater Trees
- Proprietary Filter System
- Pre-treatment
- Catch Basin
- Manhole
- Storm Sewer Pipe

0 120 240 360 Feet

PP-47: Galveston Avenue Stormwater Quality Improvements

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Cost Estimate*

Construction	Qty	Unit	Price	Amount
Stormwater Tool Kit				
Pre-Treatment, for large drainage basin (5-15 ac.)	3	EA	$43,500.00	$130,500.00
Storm Sewer Pipe, 12-in diam.	700	LF	$180.00	$126,000.00
Storm Sewer Pipe, 18-in diam.	60	LF	$220.00	$13,200.00
Storm Sewer Pipe, 24-in diam.	60	LF	$280.00	$16,800.00
Stormwater Trees	30	EA	$5,400.00	$162,000.00
Proprietary Filter System, Vault-style	12	EA	$100,500.00	$1,206,000.00
Catch Basin	3	EA	$3,500.00	$10,500.00
Manhole	8	EA	$10,000.00	$80,000.00
Other Construction Costs (Rounded)				
Mobilization	10	%	of Const.	$447,000.00
Erosion and Sediment Control	2	%	of Const.	$89,000.00
Traffic Control	4	%	of Const.	$179,000.00
Construction Contingency	45	%	of Const.	$2,012,000.00
			Total Construction	**$4,472,000.00**
Other Costs (Rounded)	**Qty**	**Unit**	**Price**	**Amount**
Engineering	20	%	of Const.	$894,000.00
Administration	10	%	of Const.	$447,000.00
Basic Permitting	1	EA	$3,000.00	$3,000.00
			Total Other Costs	**$1,344,000.00**
Total Project Cost (Rounded)				**$5,820,000**

**Class V planning level cost estimate. Costs are in 2025 dollars. Escalate unit prices for quantity items when budgeting for implementation*

Design and Implementation Considerations and Constraints

Data Collection	Survey and analysis is needed to confirm the area of impervious surfaces in this drainage basin. The planning-level assumption is the 37-acre basin is 50% impervious.
Constraints	The distribution of the proprietary filter cartridges in this basin is roughly even across the three sites. Exact quantities at each site will be determined by space available and amount of impervious area being treated. This will be addressed in the design phase. To fit the number of filter cartridges required at NW Galveston Ave & NW Columbia St ('B') and NW Hartford Ave & NW 12th St ('C'), the vaults may need to be sited in the travel lanes of the ROW, fitted with traffic-rated access covers. The design process will need to verify how much stormwater gets to the southern vault location ('A') and how to get water there. Due to the presence of large trees on some private properties and ROW in the project area, some sites may be infeasible or inappropriate for a stormwater tree. Mapped locations are approximate. This tool is best used in a wide ROW with a landscape strip. In areas with overhead utilities like power lines, tree species should be selected which do not grow tall enough to interfere with the lines. Due to significant potential conflicts with underground utilities, an extra 15% was added to the construction contingency.
Alternatives	Quantities and locations of stormwater trees may change due to the planned roadway improvements project on NW Galveston Ave. The vault sizes and number of filter cartridges may be reduced due to available space in the ROW, ability to provide safe designs for pedestrian, bicycle, and vehicle traffic, or cost.
Coordination	Inter-departmental coordination with the Galveston Ave road improvements project is needed. Siting and final design will be phased and coordinated to align with the other road projects.

Photos of Project Area

NW Galveston Ave & NW 12th St looking west

Catch basin on NW Galveston Ave, eastbound

12th Street Stormwater Quality Improvements

Capital Improvement Project Fact Sheet

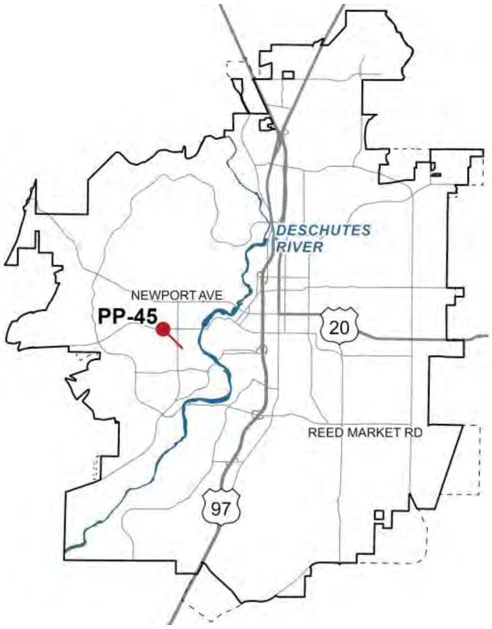
CITY OF BEND

Location	**NW 12th St & NW Baltimore Ave**		
ID	**PP-45**	*Rank*	**9**

Problem Summary

Outfall 024 has been identified as a priority basin for a stormwater retrofit project to protect water quality in the Deschutes River. The outfall drains a large basin area, approximately 70 acres extending west-southwest of the river to SW Mount Washington Drive. This outfall discharges directly into the river at Columbia Park.

Bend's outfall retrofit program aims to reduce the amount of untreated discharge, remove urban stormwater pollutants, and reduce sediment accumulation in existing stormwater infrastructure.



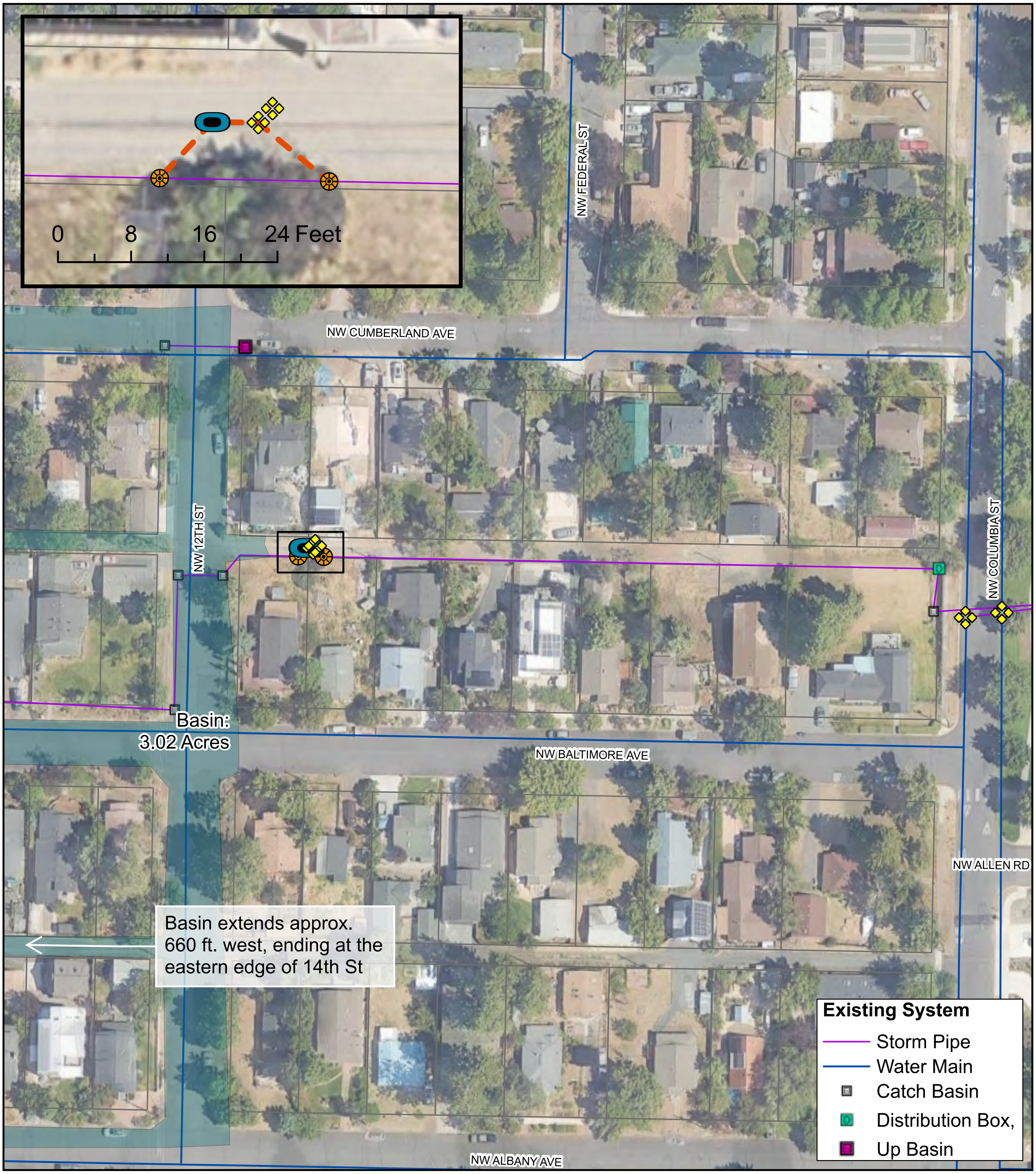
Project Description

To provide water quality treatment for Outfall 024, a pre-treatment vault and a two vault-style proprietary filter systems will be constructed in a dead-end alley between NW Cumberland Ave and NW Baltimore Ave, east of NW 12th Ave. Two catch-basin-style proprietary filter systems will be installed on Columbia Ave, treating the remainder of the system to Outfall 024.

This project is sited approximately 750 feet upstream of Outfall 024 and the Deschutes River. The basin for this project location includes approximately 3 acres of impervious surfaces delineated from the right-of-way (ROW). To provide full treatment for the contributing basin area, 44 filter cartridges are needed; 56 are proposed. This system will be off-line from the current system and reconnect post-treatment.

To ensure maintenance access and to reduce potential easement acquisitions, this proposed solution will be installed in the ROW, requiring a traffic-rated lid for vaults. Two manholes are included in the cost of this project.

See Design and Implementation Considerations and Constraints on page 4 for more information about data needs, site constraints, and alternative solutions to be considered during final design.



Basin extends approx. 660 ft. west, ending at the eastern edge of 14th St

BEND STORMWATER MASTER PLAN

Proposed Improvements

- Proprietary Filter System
- Manhole
- Storm Sewer Pipe
- Pre-treatment

0 50 100 150 Feet

PP-45: 12th Street Stormwater Quality Improvements

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Cost Estimate*

Construction	Qty	Unit	Price	Amount
Stormwater Tool Kit				
Pre-Treatment, for medium drainage basin (1-5 ac.)	1	EA	$18,000.00	$18,000.00
Storm Sewer Pipe, 12-in diam.	50	LF	$180.00	$9,000.00
Proprietary Filter System, Catch Basin style	2	EA	$11,500.00	$23,000.00
Proprietary Filter System, Vault-style	2	EA	$100,500.00	$201,000.00
Manhole	2	EA	$10,000.00	$20,000.00
Other Construction Costs (Rounded)				
Mobilization	10	%	of Const.	$80,000.00
Erosion and Sediment Control	2	%	of Const.	$16,000.00
Traffic Control	4	%	of Const.	$32,000.00
Construction Contingency	50	%	of Const.	$400,000.00
			Total Construction	**$799,000.00**
Other Costs (Rounded)	**Qty**	**Unit**	**Price**	**Amount**
Engineering	20	%	of Const.	$160,000.00
Administration	10	%	of Const.	$80,000.00
Basic Permitting	1	EA	$3,000.00	$3,000.00
			Total Other Costs	**$243,000.00**
Total Project Cost (Rounded)				**$1,040,000**

* *Class V planning level cost estimate. Costs are in 2025 dollars. Escalate unit prices for quantity items when budgeting for implementation.*

Design and Implementation Considerations and Constraints

Data Collection

Survey is required to identify precise locations of property lines and ROW area. The amount of impervious area for this basin was assumed to be the area of the ROW draining to the project location. Actual impervious area may vary.

Constraints

This project location does not have significant usable area in the ROW for above-ground solutions. There may be existing utilities that create conflicts for the proposed underground improvements

A retrofit project within Columbia Park closer to Outfall 024 was determined to be infeasible because maintaining open space on land owned by Bend Park and Recreation District (BPRD) is a priority. Upstream opportunities needed to be considered.

Alternatives

The flow to Outfall 024 at this location is mostly through piped infrastructure, not overland. Alternatives best suited for this project should connect to the existing piped system.

To treat Outfall 024 to the city's treatment standard using the 1-inch water quality design storm, a vault containing 44 filter cartridges would be needed. The cost assumption includes two vault-style proprietary filter systems each containing 28 cartridges for a total of 56 cartridges; a single larger vault housing all necessary cartridges may be more efficient.

Coordination

Because this project is located on a dead-end alley, coordination and communication with properties who use the alley for access will be required for the duration of planning and construction.

Coordination with utilities is expected for this proposed project.

Stormwater Pond

Stormwater Tool Kit Fact Sheet

CITY OF BEND

Description

Stormwater Pond can provide water quality treatment and/or flow control, depending on its design. Stormwater Pond can be used as a Wetpond, Extended Detention Dry Pond, or Bioretention/Infiltration Pond. This tool is created by excavating a depression to capture and treat stormwater. Temporarily storing stormwater and controlling the rate of flow leaving the pond into a pipe reduces flooding and improves water quality. When infiltration is feasible, ponded runoff infiltrates into the ground instead of discharging to the City's storm sewer.

Stormwater Pond uses ponding, plants, and engineered soil media to provide water quality treatment. When infiltration is feasible, Stormwater Pond provides flow control. It is a good choice where there is a large contributing drainage area, adequate space to integrate the facility into landscaping, and access for maintenance. When used as an Infiltration Basin, Stormwater Pond may require pre-treatment.

Uses

Stormwater Pond is often used in the following situations:

- Manage and cleanse stormwater from several lots or a larger drainage basin
- Used in wellhead protection areas and where UICs are not permitted

Benefits

The benefits of Stormwater Pond include:

- Removes pollutants from runoff
- Mitigates flooding during storms
- Infiltration for groundwater recharge
- Centralizes stormwater management in a neighborhood
- Easy to see if it's working
- Snow storage

Maintenance is moderate. Maintenance typically requires trash removal and/or vegetation management multiple times per year. Sediment should be removed from the outlet structure and settling basin as needed. An annual inspection is recommended. Eventually, accumulated sediment must be removed from the pond bottom.

Costs

Design Unit

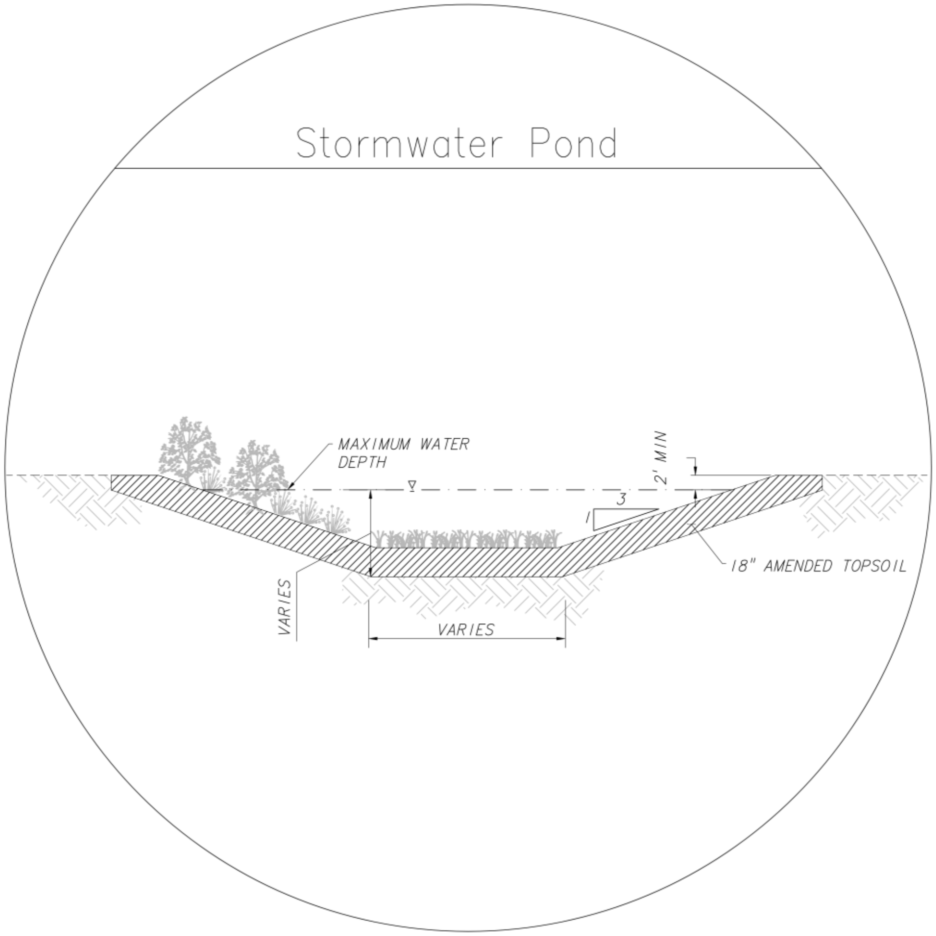
The unit of measurement for design of Stormwater Pond is cubic feet (CF) of storage. Costs do not include outlet structure, ditch inlets, or outfall protection.

Cost Assumption Per Unit

The cost assumption was developed for a hypothetical 20,000 CF pond.

Item	Qty	Unit	Unit Price	Amount
General Excavation	1,130	CY	$65	$73,450
Amended Topsoil (12-in depth)	260	CY	$95	$24,700
Bark Mulch (3-in depth)	40	CY	$150	$6,000
Small Shrub (1-gal)	280	EA	$30	$8,400
Large Shrub/Small Tree (2-gal)	120	EA	$45	$5,400
Deciduous Tree (1-in cal)	40	EA	$80	$3,200
Permanent Seeding	0.2	AC	$10,000	$2,000
Irrigation System ($2.00/SF)	1	EA	$13,690	$13,690
Total				**$136,840**

Per CF of Storage (rounded) **$7.00**



Implementation

Implementation effort for Stormwater Pond is moderate. It requires design by an engineer. Construction requires extensive earthwork and revegetation. Plant establishment will take two to three years.

Outfall Scour Protection

Stormwater Tool Kit Fact Sheet

CITY OF BEND

Description

Where pipes or culverts discharge high-velocity flows to streams, rivers, or stormwater facilities, the bank can erode (called “scour”). Outfall Scour Protection uses rock pads, gabions, larger wood, or cement pads as a barrier to protect soils from high flows and reduce the energy of flows by spreading them out and creating roughness in the flow path.

A common Outfall Scour Protection technique is placement of riprap, loose angular stones of various sizes, around and above the outfall pipe and extending to the opposite side of the bank. Riprap is typically placed over geotextile, which provides additional protection for the soil.

Uses

Outfall Scour Protection is often used in the following situations:

- Prevent erosion problems at any location where a storm pipe or culvert discharges to a stream, river, or pond
- Prevent erosion problems at any point discharge

Benefits

The benefits of Outfall Scour Protection include:

- Proactive solution to prevent erosion problems
- Effective retrofit to halt existing erosion problems

Maintenance effort for Outfall Scour Protection is low. An annual inspection is recommended to look for signs of exposed geotextile, soil erosion, and loss of riprap material. Trash and sediment should be removed as needed.

Costs

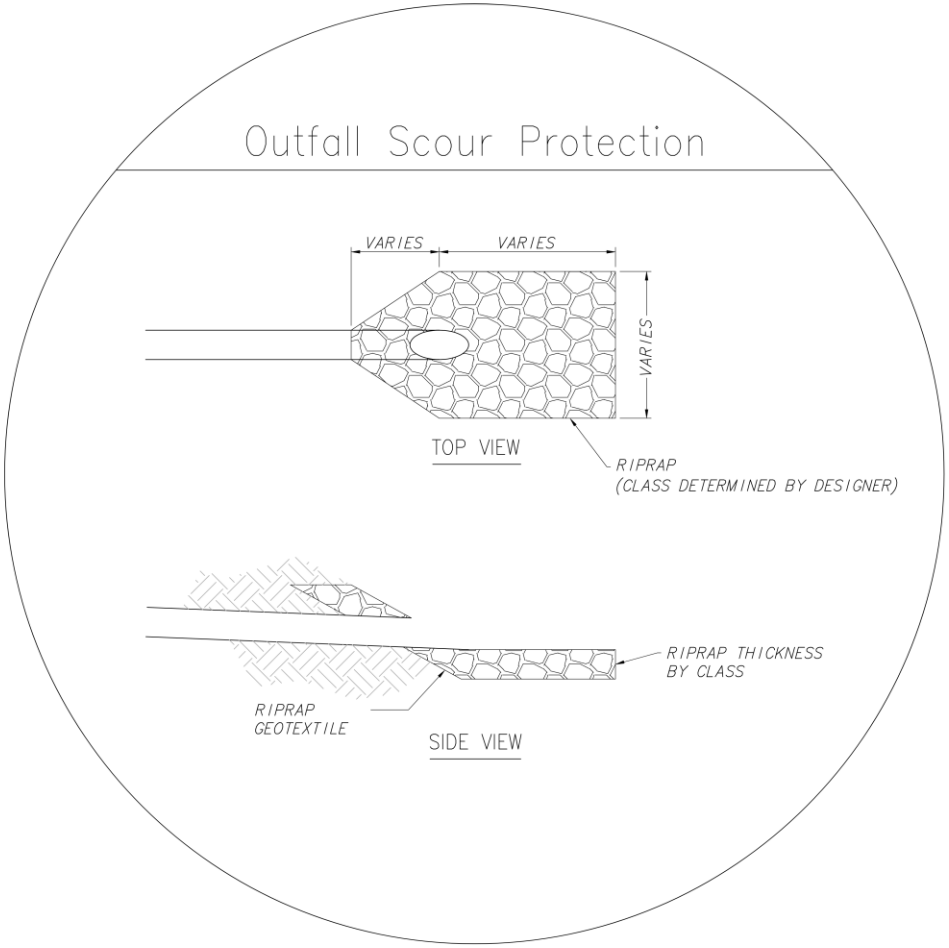
Design Unit

The unit of measurement for design of Outfall Scour Protection is diameter of pipe.

Cost Assumption Per Unit

The detailed cost assumption was developed for a hypothetical 24-in diameter outfall pipe with riprap placed 8-ft wide by 8-ft long and buried 2-ft deep. Prices per unit are given for various ranges of pipe sizes: less than 30-in diameter and 30-in to 48-in diameter. This assumption does not include costs associated with in-water work.

Item	Qty	Unit	Unit Price	Amount
Riprap (ODOT Class 100)	9.3	CY	$150	$1,391
Riprap Geotextile – Type 1	19	SY	$10	$193
General Excavation	9.3	CY	$65	$603
Total				**$2,187**
Per Outfall (less than 30” diameter; rounded)				**$2,200**
Per Outfall (30”-48” diameter)				**$7,000**



Implementation

Implementation effort for Outfall Scour Protection is <u>moderate</u>. Outfall Scour Protection requires varying engineering design effort. Construction below ordinary high water (OHW) usually needs to occur during the established in-water work period. Construction equipment is needed for excavation and placement of riprap.

Infiltration Trench

Stormwater Tool Kit Fact Sheet

CITY OF BEND

Description

Infiltration Trench is an excavated linear trench that is lined with a geotextile fabric and backfilled with coarse stone aggregate. Stormwater may enter this tool through surface runoff or through a perforated pipe. An Infiltration Trench temporarily stores stormwater which then slowly infiltrates into the surrounding soil.

Infiltration Trenches with a perforated pipe are considered “Class V Injection Wells” under the federal Safe Drinking Water Act and are regulated by Oregon Department of Environmental Quality’s UIC Program.

Uses

Infiltration Trenches are best used in the following situations:

- Adjacent to linear areas (e.g. roads)
- At the bottom of slopes
- Areas where surface space is limited
- Ares where impermeable layers are at least 24 inches away from the bottom of the trench

Benefits

The benefits of Infiltration Trench include:

- Mitigates flooding
- Improves water quality
- Mimics pre-development drainage conditions
- Allows parking on top (if perforated pipe not used)

Maintenance effort for an Infiltration Trench is moderate. Routine maintenance includes observations for potential erosion and slow infiltration rates. An annual inspection is recommended to check for sediment accumulation on the surface of the tool.

Costs

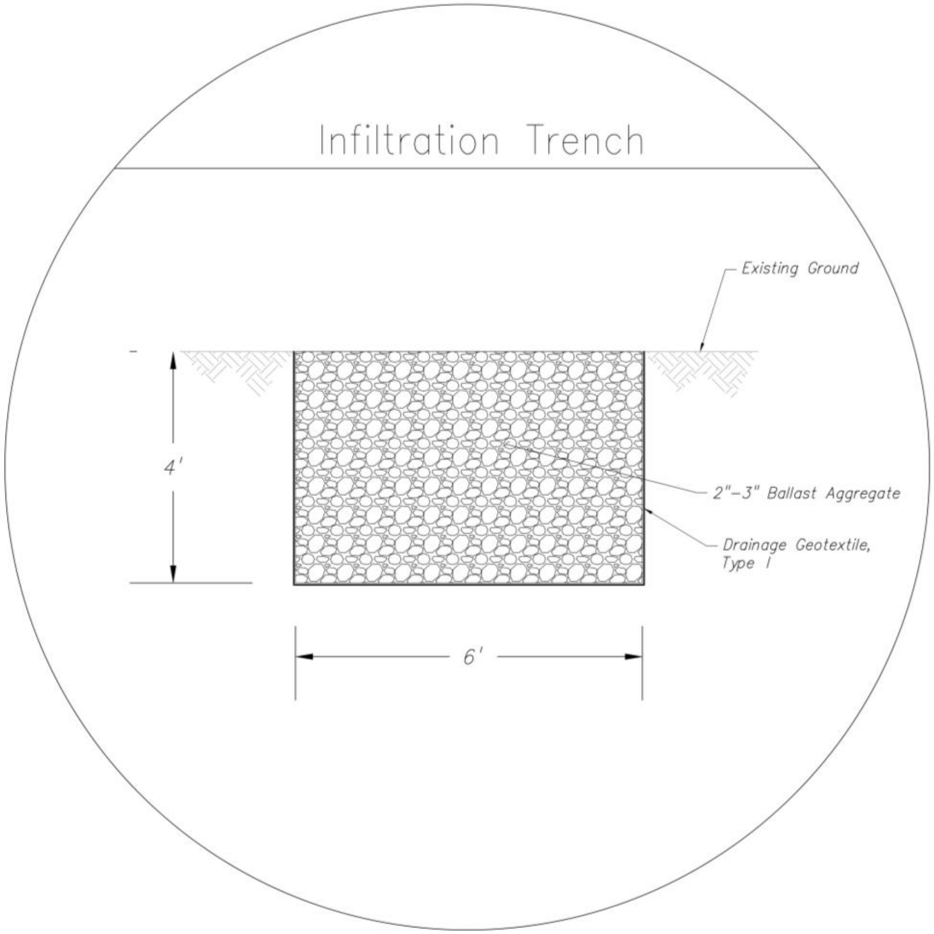
Design Unit

The unit of measurement for design of Infiltration Trench is square-feet (SF) of trench area.

Cost Assumption Per Unit

The cost assumption was developed for a hypothetical Infiltration Trench that is a 6-ft wide, 100-ft long, and 4-ft deep where the infiltration rate is 10-inches/hour.

Item	Qty	Unit	Unit Price	Amount
General Excavation	89	CY	$65	$5,785
2-in to 3-in Ballast Aggregate	89	CY	$120	$10,680
Drainage Geotextile – Type 1	161	SY	$6	$966
Total				**$17,431**
Per SF of Trench Area (Rounded)				**$30**



Implementation

Implementation effort Infiltration Trench is moderate. This tool requires a thorough site assessment of drainage patterns and soil conditions as well as engineering design. Construction of this tool requires excavation. An infiltration Trench in a high-traffic area may require more frequent maintenance and is expensive to clean if clogged.

Pre-Treatment

Stormwater Tool Kit Fact Sheet

CITY OF BEND

Description

Pre-Treatment is a small basin, chamber, or manhole preceding either a drywell or a stormwater facility. It allows larger sediment particles or trash to settle out of piped runoff before it enters a facility. Pre-Treatment also mitigates potential impacts from spills by separating oil or other contaminants.

Pre-Treatment improves the treatment performance of a water quality facility, and it extends the length of time before the main facility must be excavated to remove accumulated sediment. It increases the life of a drywell by protecting it from sediment that is difficult to remove. Pre-Treatment should be easy to access and generally easy to clean using hand tools and/or Vactor equipment.

Uses

Pre-Treatment is often used in the following situations:

- Before stormwater enters a water quality facility, surface infiltration facility, drywell, or drillhole
- New stormwater facilities
- Retrofit existing stormwater facilities for longer life

Benefits

The benefits of Pre-Treatment include:

- Increases ease of facility maintenance
- Improves water quality
- Low ongoing maintenance cost
- Extends life of facilities by reducing pollutant loads
- Protects groundwater and surface water from contamination

Ongoing maintenance of this tool is <u>low</u> and reduces frequency of major maintenance needed for the primary water quality elements of the facility. The need for confined space entry should be minimized but planned for with the design. Typical maintenance activities include trash removal and sediment removal using Vactor equipment.

Costs

Design Unit

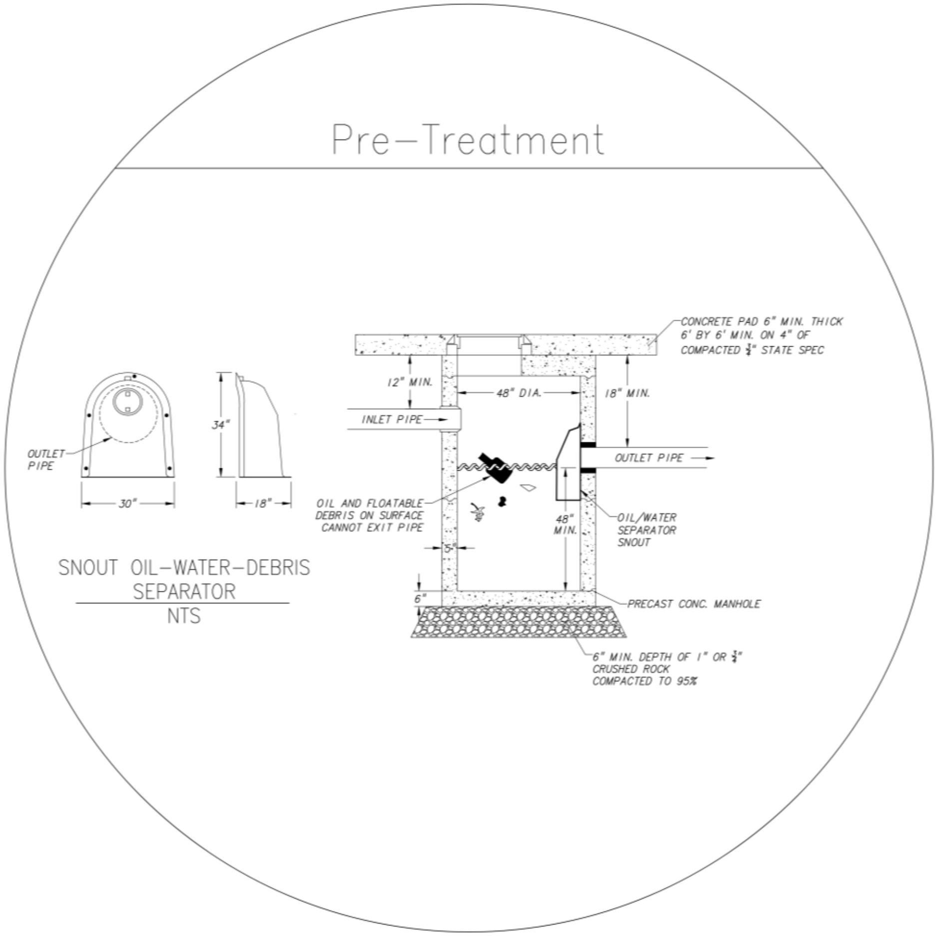
The unit of measurement for design of Pre-Treatment is each installed structure. Cost varies considerably based on size of the structure to serve the contributing area.

Cost Assumption Per Unit

The detailed cost assumption was developed for a simple 60-in diameter water quality manhole serving a medium-sized drainage basin of one to five acres and designed to manage 20 cubic feet / 1.0 CFS flow up to the 25-year flow. Prices per basin are also given for a 48-in diameter water quality manhole serving a small basin and an 8-ft by 18-ft vault that serves a large basin. The cost includes delivery, excavation, installation, backfill, and surface restoration.

Item	Qty	Unit	Unit Price	Amount
60-in diameter water quality manhole	1	EA	$18,000	$18,000
Total				**$18,000**

Small Drainage Basin (less than 1 Acre; Rounded)	**$12,000**
Medium Drainage Basin (1-5 Acres; Rounded)	**$18,000**
Large Drainage Basin (5-15 Acres; Rounded)	**$43,500**



Implementation

Implementation effort for Pre-Treatment is moderate. Pre-Treatment requires engineering design. Construction requires heavy equipment for excavation and placing the manhole or vault. These devices should be located for easy maintenance access, so construction access should also be easy. Restoration of surface material is required. System needs to be designed with appropriate access for maintenance and operations.

Storm Sewer Pipe

Stormwater Tool Kit Fact Sheet

CITY OF BEND

Description

Storm Sewer Pipe is laid underground and conveys runoff as part of the drainage system or within a stormwater facility.

The size of the pipe depends on the flow of stormwater expected. Using the correct size and placement of pipe can reduce local flooding and prevent degradation of nearby infrastructure (e.g. roads).

Installation will follow City of Bend Standards and Specifications for materials, depth, separation, and other specifications.

Uses

Storm Sewer Pipe is often used in the following situations:

- Convey stormwater underground
- Replace aging pipes
- Replace pipes that are too small

Benefits

The benefits of Storm Sewer Pipe include:

- Reduces flooding
- Protects infrastructure
- Creates space for other development
- Transports stormwater to treatment structures

Maintenance effort of Storm Sewer Pipe is low. Television camera inspection and pipe jetting may be performed at a scheduled frequency.

Costs

Design Unit

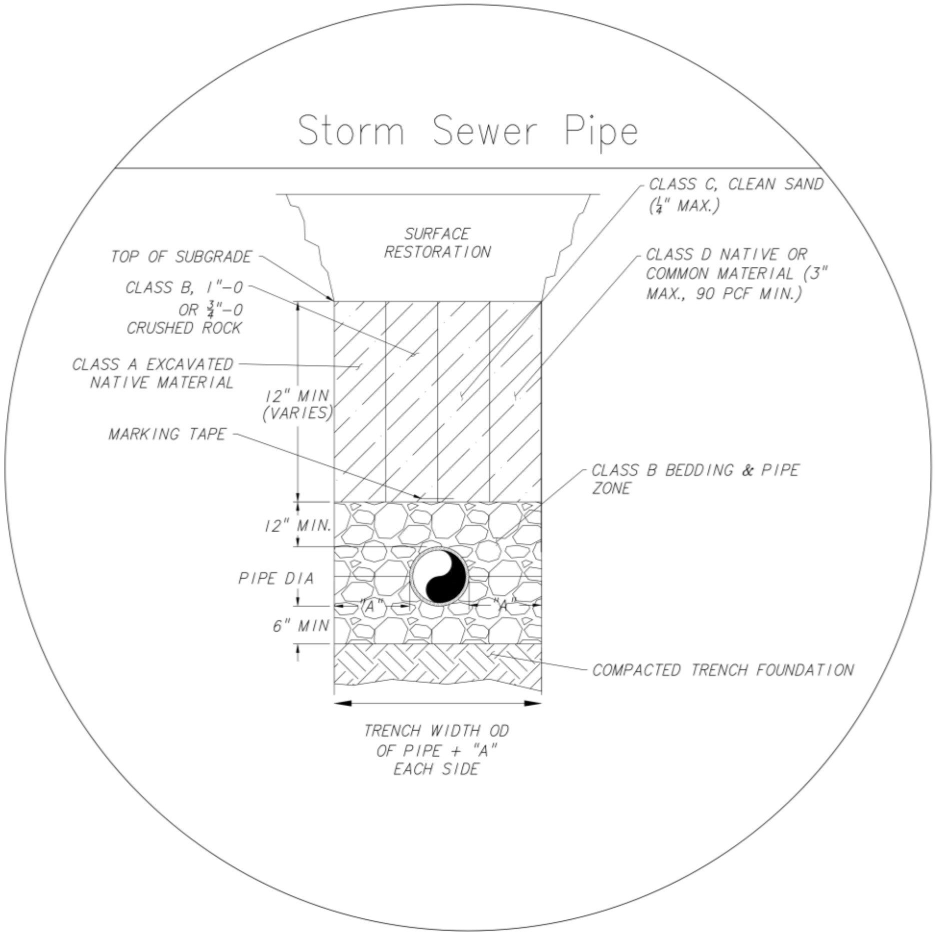
The unit of measurement for design of Storm Sewer Pipe is linear foot (LF) of installed pipe. Storm Sewer Pipe is available in a variety of diameters, and installation costs depend on buried depth.

Cost Assumption Per Unit

The detailed cost assumption was developed for a hypothetical 600-ft 18-in diameter pipe buried at 6 feet. Price per unit is also given for 12-in and 24-in pipe. Cost includes excavation, installation, backfill, and surface restoration.

Item	Qty	Unit	Unit Price	Amount
18-in Storm Sewer Pipe	600	LF	$220	$132,000
Total				**$132,000**

Per LF of 12” Pipe (Rounded)	**$180**
Per LF of 18” Pipe (Rounded)	**$220**
Per LF of 24” Pipe (Rounded)	**$280**



Implementation

Implementation effort for Storm Sewer Pipes is moderate. Design of Storm Sewer Pipe requires engineering to calculate the optimal pipe size, depth, and placement. Construction requires equipment for trenching and placing pipe underground. Shoring of trenches may be required. In urban areas, construction may require traffic management when Storm Sewer Pipe is placed under or near a roadway. Restoration of surface material is required.

Underground Storage

Stormwater Tool Kit Fact Sheet

CITY OF BEND

Description

Underground Storage is created by installing large underground pipe or chambers to temporarily store stormwater runoff. Temporarily storing runoff slows down the flow of runoff through the urban landscape, and can help reduce both localized and downstream flooding, erosion, and sedimentation.

Underground Storage may be used under parking lots, parking structures, roads, and in other highly developed locations where there is not enough room for a stormwater pond.

Uses

Underground Storage is often used in the following situations:
- New urban development with limited space for aboveground storage
- Adding detention in an existing system to address downstream flooding, erosion, or sedimentation

Benefits

The benefits of Underground Storage include:
- Saves surface space
- Can be used to retrofit urban areas developed prior to use of adequate stormwater controls

Maintenance of Underground Storage is <u>moderate</u>. This tool requires routine inspection to monitor sediment build-up in the structure. In some systems, sediment may be removed directly from the structure using vactor equipment. In other systems, sediment may be pushed into an access structure or manhole using water-jetting equipment and then removed using vactor equipment. The control structure, which controls how quickly stored runoff is released, must also be monitored for build-up of sediment and floatables that may impede the discharge of water.

Costs

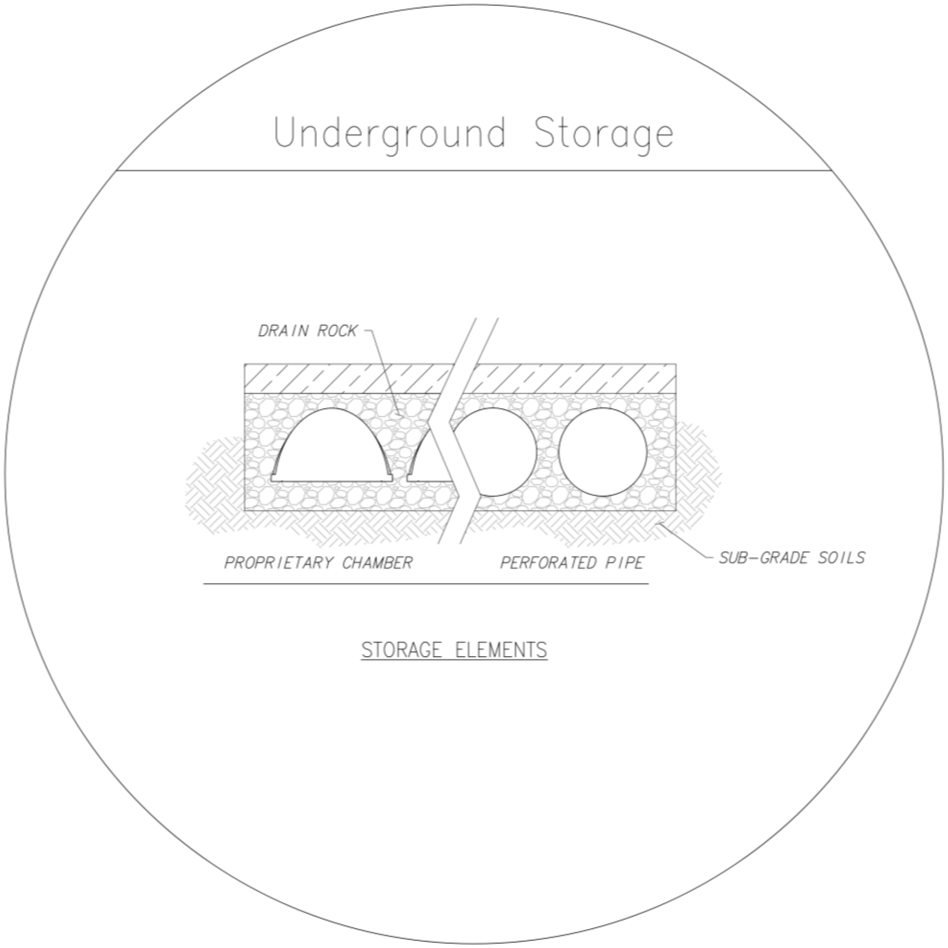
Design Unit

The unit of measurement for design of Underground Storage is cubic feet (CF) of storage volume.

Cost Assumption Per Unit

The cost assumption was developed for the hypothetical storage of 100,000 CF of runoff in a proprietary system manufactured by Contech.

Item	Qty	Unit	Unit Price	Amount
Contech Chambers (40 Rows x 65 Chambers)	100,000	CF	$5.25	$525,000
Excavation	13,061	CY	$65	$653,067
Drainage Rock	6,760	CY	$40	$270,400
Installation (25%)	1	LS	$198,850	$198,850
Total				**$1,843,237**
Per CF (Rounded)				**$18**



Implementation

Implementation effort for Underground Storage is moderate. Construction of this tool typically requires work in a developed urban area, which may result in scheduling issues and the need for traffic control. Construction requires considerable excavation. Heavy equipment is needed for excavating, filling, and for placing some of the prefabricated structural components in the ground. Restoration of the surface (roadway, parking lot, plaza, lawn, etc.) is required.

Permanent Stabilization

Stormwater Tool Kit Fact Sheet

CITY OF BEND

Description

Permanent Stabilization stabilizes soils to prevent erosion. It can be used after construction or maintenance activities to stabilize stormwater facilities or revegetate riverbanks. It can be used to stabilize steep slopes or denuded areas that erode soils into the storm system or river. This tool protects stormwater pipes, stormwater facilities, and rivers from sedimentation.

Permanent Stabilization may use native plantings, rock rip-rap, or a combination of these.

Uses

Permanent Stabilization may be used in the following situations:

- Streambanks denuded by overuse or construction activities
- Stabilizing slopes
- Within vegetated stormwater facilities
- Reconditioning of disturbed areas

Benefits

The benefits of Permanent Stabilization include:

- Enhanced aesthetics
- Green solution
- Prevents erosion of streambanks, slopes, and stormwater facilities
- Reduce maintenance of downstream stormwater system

Maintenance effort for Permanent Stabilization is moderate. Ongoing routine maintenance of vegetation in a water quality facility is typically required at least two times per year. Methods of vegetation control include mowing, weed whacking, or use of hand tools. Maintenance of greenway areas usually involves control of invasive plants and requires minimal effort after establishment.

Costs

Design Unit

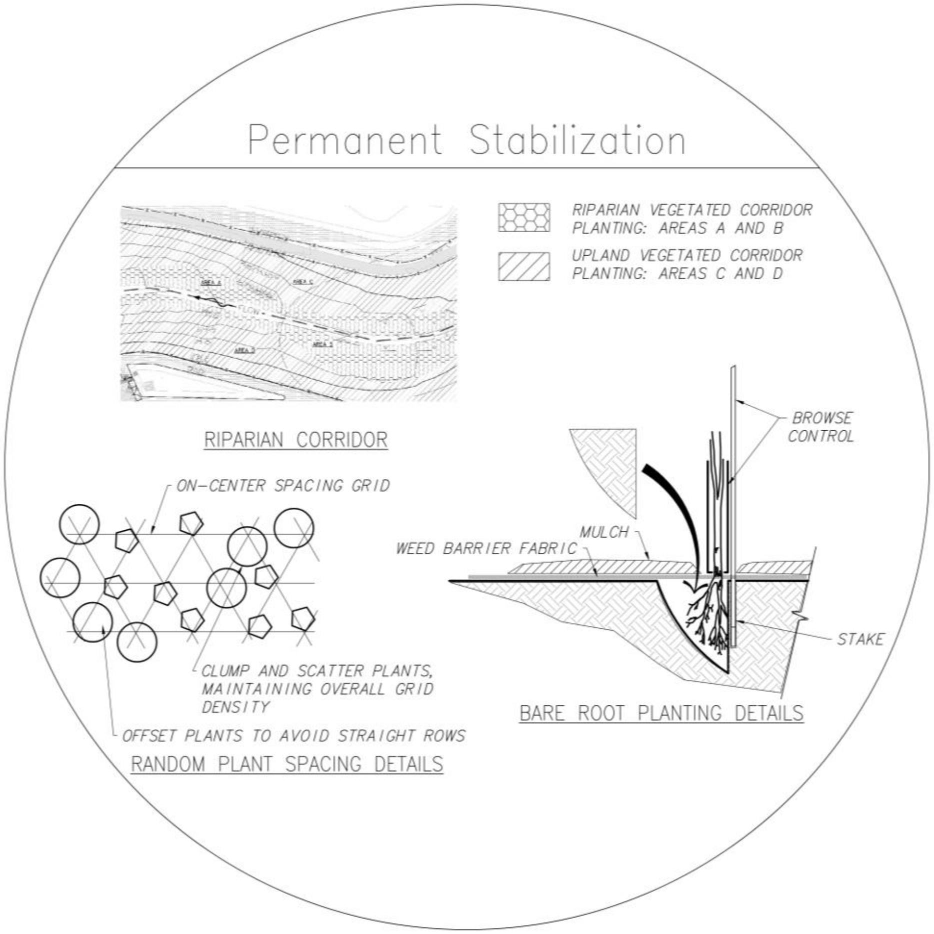
The unit of measurement for design of Permanent Stabilization is square foot (SF) of area to be stabilized.

Cost Assumption Per Unit

The detailed cost assumption was developed for a hypothetical Permanent Stabilization using native vegetation in a 20,000-SF slope stabilization area. Mulch can include either bark or rock mulch.

Item	Qty	Unit	Unit Price	Amount
Mulch (3-in depth)	185	CY	$150	$27,750
Small Shrub (1-gal)	800	EA	$30	$24,000
Large Shrub/Small Tree (2-gal)	600	EA	$45	$27,000
Trees (1" cal)	200	EA	$80	$16,000
Permanent Seeding	0.46	AC	$10,000	$4,591
Irrigation System	1	EA	$21,480	$21,480
Total				**$120,821**

Per SF of Slope Stabilization (Rounded)	**$6**



Implementation

Implementing Permanent Stabilization requires moderate effort. If using native vegetation, planting is typically done manually using hand tools and low-cost laborers. A temporary irrigation system is usually recommended for the first couple years. Most failures of this tool occur during the establishment period, so proper planning and allocation of resources is necessary to ensure a successful outcome.

Drywell

Stormwater Tool Kit Fact Sheet

CITY OF BEND

Description

Drywell is a subsurface concrete structure that temporarily detains stormwater runoff before it infiltrates into the surrounding soil. The drywell's rate of infiltration depends on the ability of the surrounding soil to absorb water. Some drywells have an overflow that connects to a storm conveyance system and others are standalone structures. Structures may be cast in place or pre-cast. Pretreatment is required prior to infiltration.

Drywells reduce localized flooding and recharge groundwater by allowing stormwater to soak into the ground in a way that resembles the natural pre-development drainage path, filtering stormwater through the ground and recharging groundwater. Drywells must be placed with care to avoid proximity to drinking water wells and to ensure sufficient vertical separation from groundwater resources. Drywells are regulated as "Class V Injection Wells" under the federal Safe Drinking Water Act.

Uses

Drywells are one of the most common stormwater management tools in Bend. They are best used in the following situations:

- Areas with good soil infiltration rates (greater than 2-in per hour)
- Away from drinking water wells
- Away from areas where urban or industrial pollutants are likely

Benefits

The benefits of Drywells include:

- Reduce localized flooding
- Groundwater recharge
- Allow development where a municipal storm conveyance system is lacking

Maintenance needs for drywells are limited. Periodic inspection is recommended to ensure proper function. Typical maintenance includes removing debris and unclogging inlets and emergency overflow.

Costs

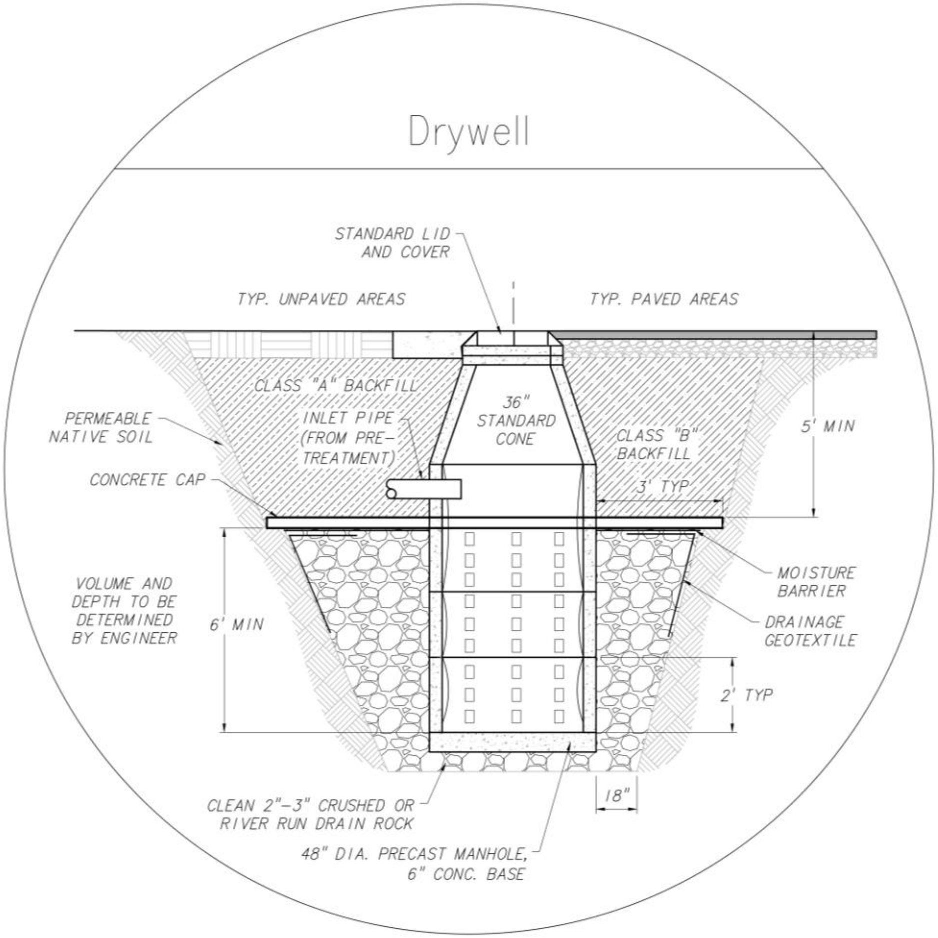
Design Unit

The unit of measurement for design of Drywell is each installed structure. A standard Drywell has a 48-in diameter and is 20-ft deep.

Cost Assumption Per Unit

The detailed cost assumption is for a standard depth pre-cast drywell. Cost includes excavation, installation, backfill, and surface restoration assuming a 10-in per hour infiltration rate.

Item	Qty	Unit	Unit Price	Amount
General Excavation	64	CY	$75	$4,800
Class "B" Backfill	16	CY	$50	$800
Drain Rock	33	CY	$120	$3,960
Drywell	1	EA	$20,000	$20,000
Heavyweight Vinyl Screen	21	SY	$8	$168
Drainage Geotextile – Type 1	8	SY	$6	$48
Moisture Barrier	4	SY	$10	$40
Concrete Cap	1	EA	$2,000	$2,000
Total				**$31,816**
Per Standard Drywell (Rounded)				**$32,000**



Implementation

Implementation effort for Drywells is moderate. Drywell requires engineering design and compliance with Central Oregon Stormwater Manual and City of Bend Standard Design Drawings. Drywells require pre-treatment except in limited residential conditions as defined in OAR and by DEQ. Blasting may be required during construction to improve infiltration rates.

Stormwater Planter

Stormwater Tool Kit Fact Sheet

CITY OF BEND

Description

Stormwater Planter is a walled basin that temporarily stores and treats stormwater runoff though a combination of vegetation and engineered soil mix. Stormwater planter is a good choice where space is limited. Often Stormwater Planter is constructed between the sidewalk and roadway and collects runoff from the adjacent road and sidewalk, or it is constructed between a building and sidewalk and collects roof runoff.

Stormwater Planter can be used for flow control when designed with infiltration or an underdrain with controlled outlet. Controlling the rate of flow leaving the planter and into a pipe or stream reduces flooding, erosion, and sedimentation.

Uses

Stormwater Planter is often used to:

- Remove pollutants from runoff
- Reduce localized flooding from storms
- Allow some runoff to infiltrate into the ground

Benefits

The benefits include:

- Protects water quality of streams and rivers
- Easy to see if it’s working
- Infiltration and groundwater recharge
- Can provide aesthetic appeal similar to landscape plantings

Maintenance effort for Stormwater Planters is <u>moderate</u>. Ongoing maintenance typically requires vegetation management multiple times per year. Sediment should be removed from the overflow structure as needed. An annual inspection is recommended to check for erosion, filling of the overflow structure, and standing water. Eventually, accumulated sediment must be removed from the planter bottom. Replacement of vegetation is required as needed.

Costs

Design Unit

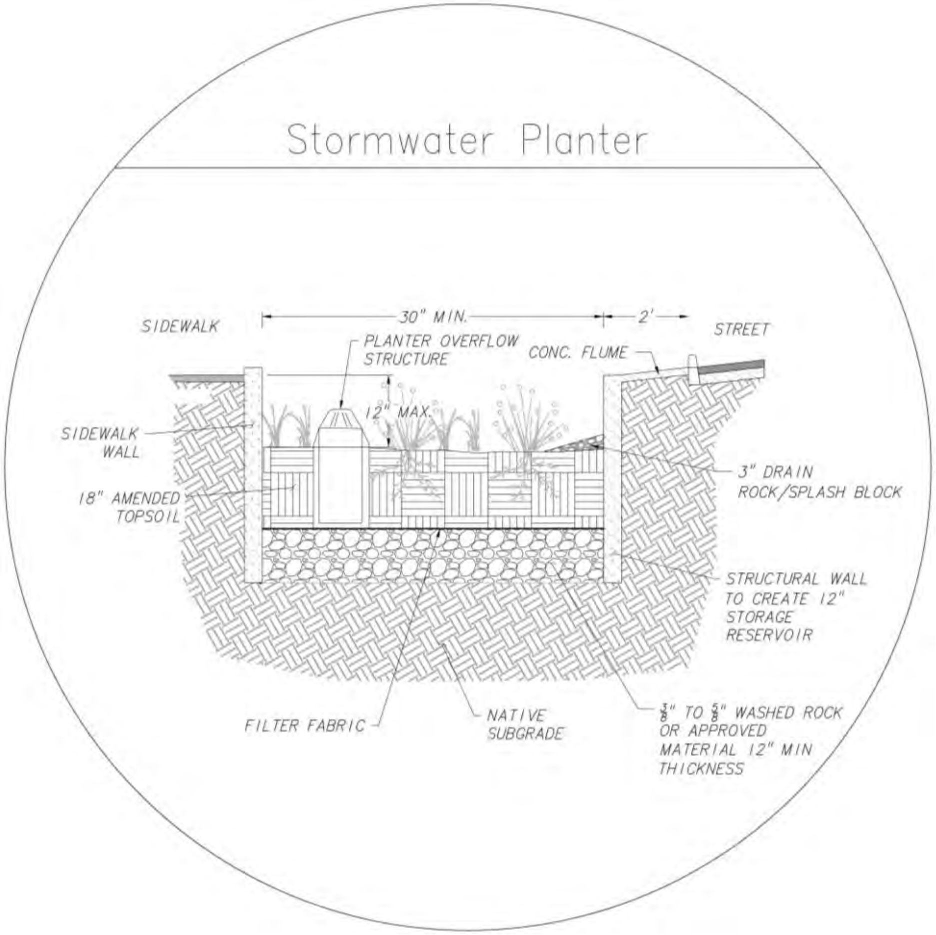
The unit of measurement for design of Stormwater Planter is square feet (SF) of planter.

Cost Assumption Per Unit

The cost assumption was developed for a hypothetical 4-foot wide by 30-foot-long (120 SF) planter that is planted with plugs.

Item	Qty	Unit	Unit Price	Amount
General Excavation	21	CY	$65	$1,365
Amended Topsoil	7	CY	$95	$665
Washed Rock	4	CY	$120	$480
Catch Basin (Pre-Treatment)	1	EA	$2,200	$2,200
Beehive Inlet	1	EA	$1,650	$1,650
Sidewalk Wall	38	LF	$110	$4,180
Structural Wall	30	LF	$110	$3,300
Curb Cut	2	EA	$550	$1,100
Plugs (Sedges and Rushes)	360	SF	$1	$360
Irrigation System	1	LS	$5,200	$5,200
Total				**$20,500**

Per SF of Planter (Rounded)	**$170**



Implementation

Implementation effort for Stormwater Planter is moderate. This tool requires design by an engineer. Construction requires earthwork and revegetation. Plant establishment will take two to three years. Cost of the planter decreases as length increases due to high cost of the curbs.

Deep Drywell

Stormwater Tool Kit Fact Sheet

CITY OF BEND

Description

Deep Drywell is a subsurface concrete structure with an integrated pre-treatment device and a drilled shaft extending up to 100 feet underground. The purpose of this tool is to prevent localized flooding by collecting runoff from streets and other surfaces. Integrated pre-treatment protects the shaft from sedimentation and protects groundwater quality.

Deep Drywells manage runoff by allowing stormwater to soak into the ground, filtering stormwater through the soil, and recharging groundwater. Deep Drywells are regulated as "Class V Injection Wells" under the federal Safe Drinking Water Act.

Compared to typical drywells, Deep Drywell manages stormwater in a smaller footprint. Because they require drilling equipment and extend deep into the ground, careful siting is necessary to avoid overhead utilities and prevent groundwater contamination.

Uses

Deep Drywells are best used in the following situations:

- Areas with poor infiltration rates at shallow depths, but excellent infiltration capacity at greater depths
- Away from drinking water wells
- Away from areas where pollutants from industry, railroads, and high-traffic roads are present

Benefits

The benefits include:

- Reduce localized flooding
- Integrated pre-treatment is space-efficient
- Groundwater recharge
- Allow development where a municipal storm conveyance system is lacking
- Manage runoff in a smaller footprint than typical drywells

Maintenance needs for Deep Drywells are limited. Periodic inspection is recommended to ensure proper function. Typical maintenance includes removing debris, unclogging inlets, and removing sediment from the sump.

Images (clockwise from top):
1. Drilling deep drywell in Bend
2. Deep drywell installation in progress
3. Completed deep drywell after road surface restoration

Costs

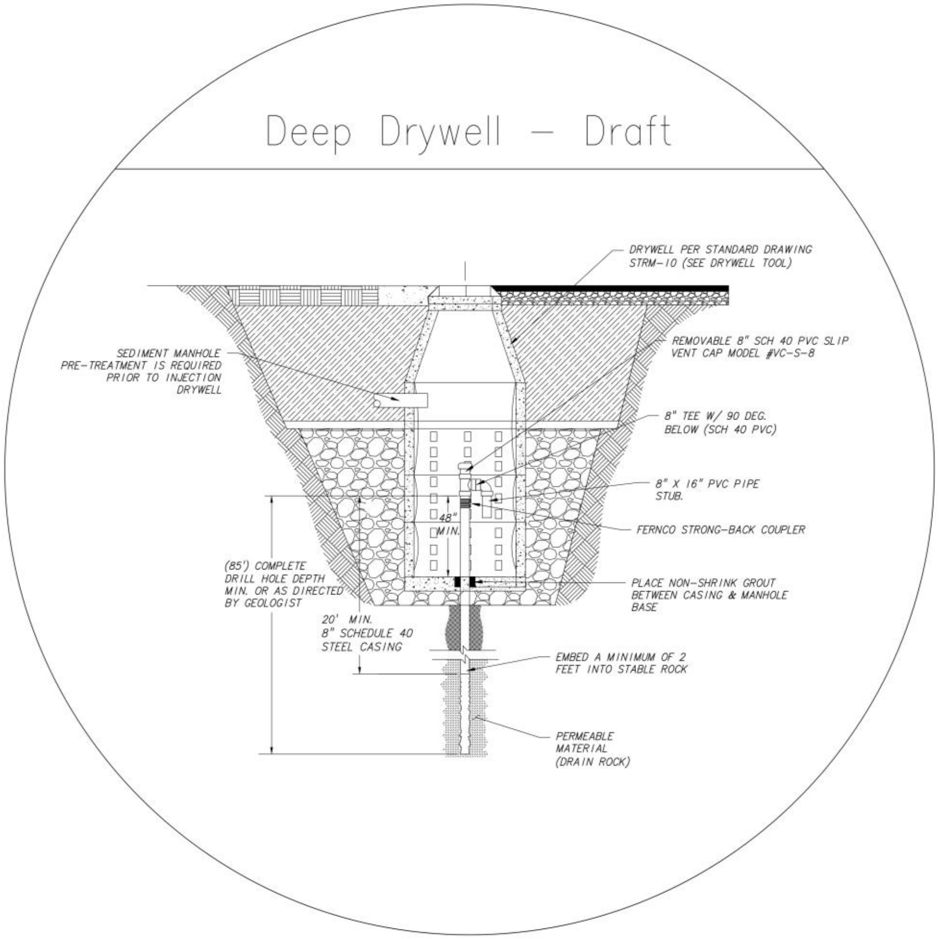
Design Unit

The unit of measurement for design of Deep Drywell is each installed structure.

Cost Assumption Per Unit

The detailed cost assumption was developed for one deep drywell with a 48-in diameter manhole, 10-ft deep including integrated pre-treatment, with an 8-in well casing in a 24-in diameter, 85-ft deep drilled shaft.

Item	Qty	Unit	Unit Price	Amount
General Excavation	64	CY	$75	$4,800
Class "B" Backfill	16	CY	$50	$800
Drilled Excavation	10	CY	$150	$1,500
Drain Rock	48	CY	$120	$5,740
Drywell	1	EA	$20,000	$20,000
Well Casing	85	LF	$500	$42,500
8" Tee w/ 90 Deg. Elbow	1	EA	$1,050	$1,050
Concrete Cap	1	EA	$2,000	$2,000
Drainage Geotextile – Type 1	8	SY	$6	$48
Moisture Barrier	4	SY	$10	$40
Total				**$78,478**
Per Deep Drywell (Rounded)				**$78,500**



Implementation

Implementation effort for Deep Drywells is <u>moderate</u>. Deep Drywells require engineering design and compliance with Bend Title 16, Central Oregon Stormwater Manual, and DEQ regulations regarding UICs. As of 2025, Bend is developing siting and acceptance criteria for this tool. This tool should be placed in areas with low risk of exposure to contaminants. The system needs to be designed with appropriate access for maintenance and operations.

Stormwater Trees

Stormwater Tool Kit Fact Sheet

CITY OF BEND

Description

Stormwater Trees are strategically planted trees adjacent to impervious areas which are designed to manage and mitigate stormwater runoff. This tool is integrated into urban landscapes and green infrastructure projects to capture, absorb, and filter stormwater runoff.

Stormwater Trees reduce runoff flow by capturing and infiltrating stormwater and improving water quality by filtering pollutants through roots and soil media. Structural soils under the adjacent sidewalk provide additional oxygen and capacity for managing occasional high flows due to their high void ratios and organic fillers. There are significant long-term co-benefits to this tool which increases in value over time.

Uses

Stormwater Trees are often used in the following situations:

- Capture, absorb, and filter stormwater runoff
- Reduce impacts of flooding
- Supplement other green stormwater infrastructure systems

Benefits

The benefits of Stormwater Trees include:

- Enhances aesthetics
- Provides shade and cooling
- Supports biodiversity
- Improves water quality and erosion control
- Helps meet development and code requirements

Maintenance effort for Stormwater Trees is moderate. Ongoing maintenance typically requires routine pruning of branches, removal of dead or hazard trees, periodic mulching, and pest management. Stormwater trees must be watered for the first two growing seasons at a minimum.

Costs

Design Unit

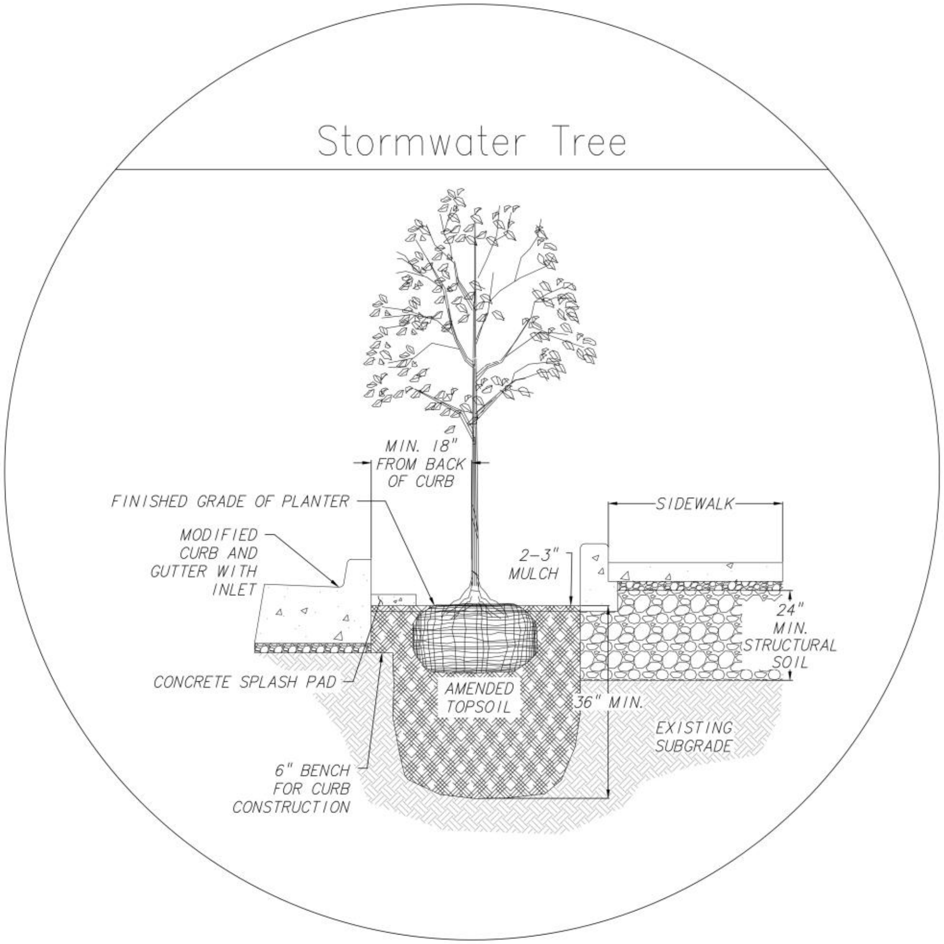
The design unit for Stormwater Trees is each Stormwater Tree.

Cost Assumption Per Unit

The detailed cost assumption of Stormwater Tree includes a 4-ft by 4-ft planter managing runoff and providing water quality treatment from 320 sf of contributing impervious area.

Item	Qty	Unit	Unit Price	Amount
General Excavation	5	CY	$150	$753
Modified Curb and Gutter	5	LF	$110	$550
Curb Cut and Splash Pad	1	EA	$750	$750
Planter Wall	13	LF	$110	$1,430
Bark Mulch (3-in depth)	1	CY	$150	$150
Amended Topsoil	2	CY	$95	$190
Structural Soil	2	CY	$150	$300
Deciduous Trees (2-in caliper)	1	EA	$450	$450
Irrigation System	1	EA	$800	$800
Total				**$5,373**

Per Stormwater Tree (Rounded)	**$5,400**



Implementation

Implementation effort for Stormwater Trees is moderate. Proper site assessment and preparation is needed to minimize a Stormwater Tree’s impacts to existing infrastructure and maximize chances of the tree’s survival. After planting, Stormwater Trees require ongoing maintenance to ensure benefits are realized.

Proprietary Filter System

Stormwater Tool Kit Fact Sheet

CITY OF BEND

Description

Proprietary Filter System is an underground stormwater treatment device designed to efficiently manage and treat stormwater runoff. This tool prevents pollutants from entering natural water bodies and municipal systems. Proprietary Filter System typically utilizes advanced materials and technologies to capture sediments, hydrocarbons, dissolved metals, and other contaminants commonly found in stormwater. Different filter media in the Proprietary Filter System can target specific pollutants.

Proprietary Filter System often works most efficiently when preceded by a pretreatment facility which removes larger sediments before they can clog the filter vault.

Uses

Proprietary Filter System is often used in the following situations:

- Locations where there is not room for above-ground stormwater treatment facilities
- Prevent sediment and pollutants from entering streams and stormwater systems

Benefits

Benefits include:

- Efficient use of space
- Flexible system configurations can be sized from very small to very large
- Removes pollutants from stormwater runoff
- Availability of multiple media types allows for targeted pollutant removal

Maintenance effort for Proprietary Filter System is <u>moderate</u>. Ongoing maintenance considerations include routine inspections for sediment buildup and replacement of the filters to prevent system failure. Inspection and replacement frequency can vary and depend on a site's conditions and amount of runoff.

Costs

Design Unit

The unit of measurement for design of a Proprietary Filter System is each Proprietary Filter System. Filter cartridges are installed underground and filter pollutants from stormwater runoff.

Cost Assumption Per Unit

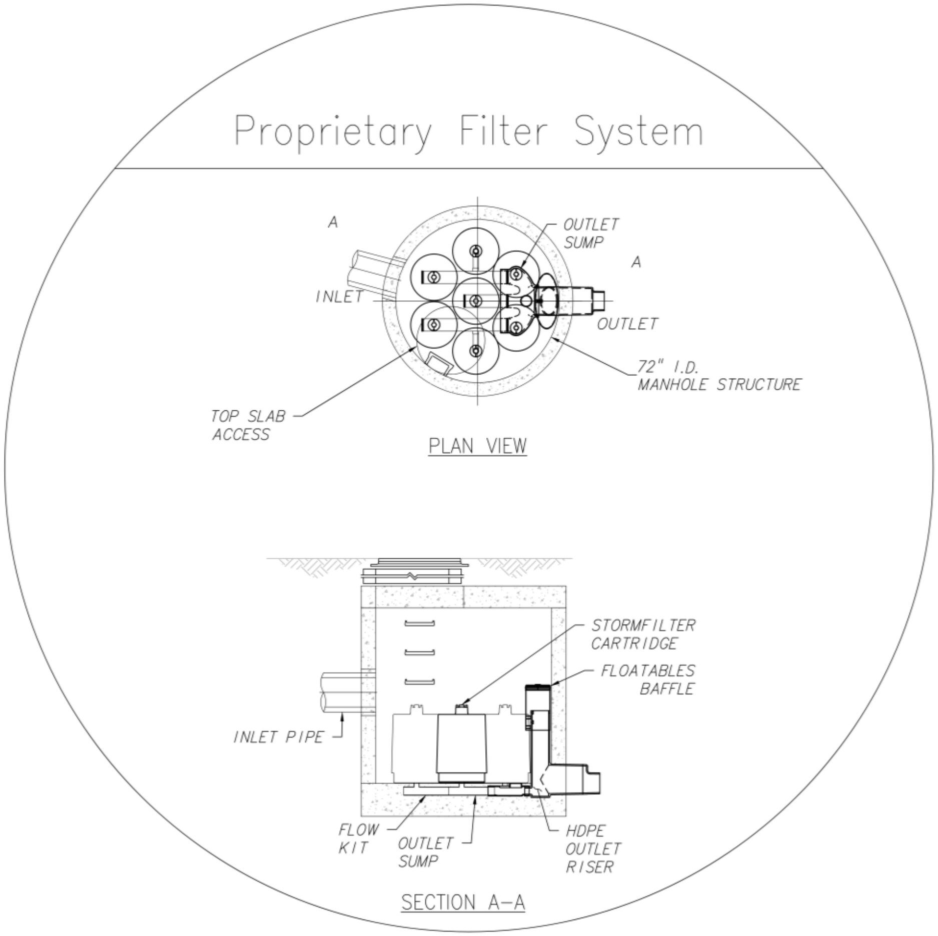
A cost assumption was developed for three applications of Proprietary Filter System: catch basin, manhole, and 8-ft by 12-ft vault. Costs assume use of an 18-in cartridge height using perlite media and a 15-gal/min flow rate. Installation costs include delivery, excavation, backfill, and surface

Item	Qty	Unit	Unit Price	Amount
Catch Basin with Proprietary Filter Cartridge (1)	1	EA	$8,750	$8,750
Installation (30%)	1	LS	$2,625	$2,625
Total				**$11,375**

Item	Qty	Unit	Unit Price	Amount
72-in Dia. Manhole with Proprietary Filter Cartridges (7)	1	EA	$34,000	$34,000
Installation (30%)	1	LS	$10,200	$10,200
Total				**$44,200**

Item	Qty	Unit	Unit Price	Amount
8-ft by 12-ft Vault with Proprietary Filter Cartridges (28)	1	EA	$77,000	$77,000
Installation (30%)	1	LS	$23,100	$23,100
Total				**$100,100**

Per Proprietary Filter System – Catch Basin (Rounded)	**$11,500**
Per Proprietary Filter System – Manhole (Rounded)	**$44,500**
Per Proprietary Filter System – Vault (Rounded)	**$100,500**



Implementation

Implementation effort for Proprietary Filter System is <u>moderate</u>. Installation typically involves excavation and connections to existing stormwater facilities. Systems with multiple cartridges or those designed to target specific pollutants may require more detailed planning and installation considerations. System needs to be designed with appropriate access for maintenance and operations.

Swale / Infiltration Swale

Stormwater Tool Kit Fact Sheet

CITY OF BEND

Description

A Swale/Infiltration Swale is a broad and shallow channel used for the collection, temporary storage, treatment, and infiltration of stormwater. Temporarily storing stormwater and controlling the rate of flow leaving the swale reduces downstream flooding, erosion, and sedimentation. Vegetated swales can be used in front of drywells to provide treatment.

Swales/Infiltration Swales can be rocky or vegetated. Vegetation is required for any Swale/Infiltration Swale that provides pretreatment prior to discharge to a drywell or surface water body.

Uses

Swales/Infiltration Swales are best used in the following situations:

- Adjacent to linear areas (e.g. roads)
- Part of a series of stormwater controls

Benefits

The benefits of Swales/Infiltration Swales include:

- Reduces flooding
- Improves water quality
- Enhances aesthetics
- Stores snow
- Mimics pre-development drainage conditions

Maintenance effort for a Swale/Infiltration Swale is moderate. Routine maintenance includes trash removal and weed control. If the tool is vegetated, periodic maintenance of the vegetation is needed. An annual inspection is recommended to check for sediment accumulation in the overflow structure, erosion at inlets and outlets, and evidence of piping through berms.

Costs

Design Unit

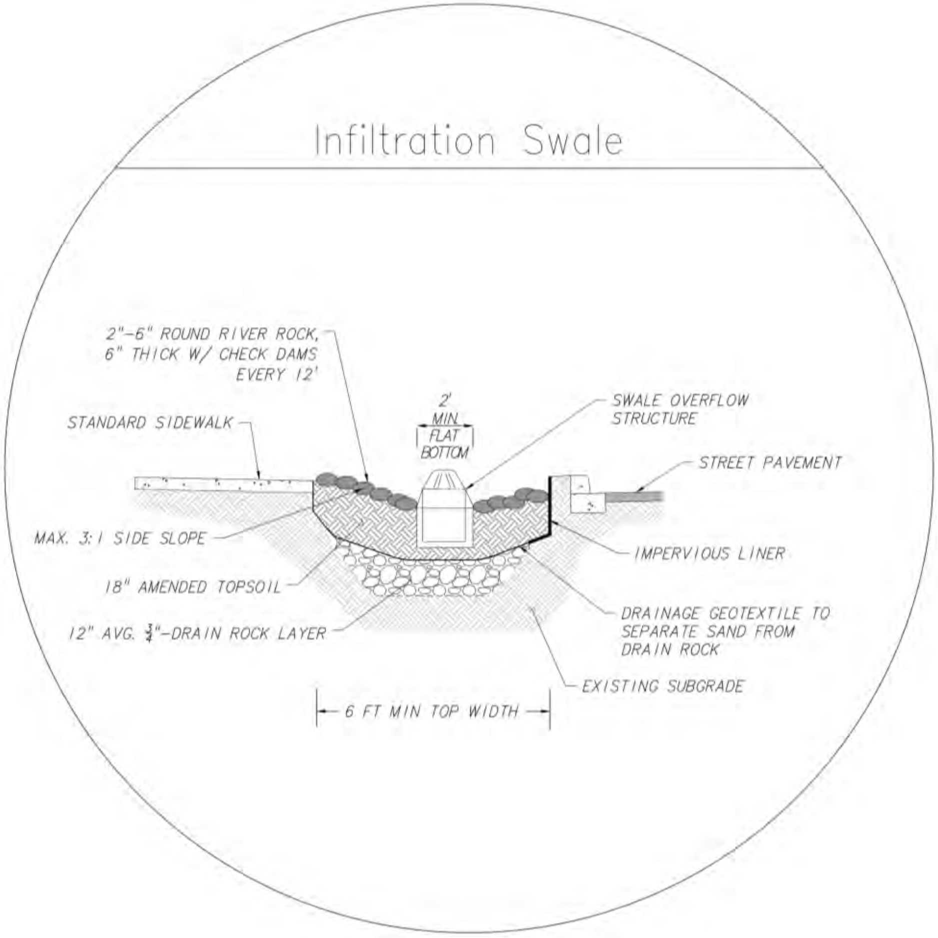
The unit of measurement for design of Swale/Infiltration Swale is square feet of swale area.

Cost Assumption Per Unit

The cost assumption was developed for a hypothetical infiltration swale that has a 4-ft wide bottom by 100-ft long (400-sqft bottom). Cost includes liner on road-side and sumped catch basin for pre-treatment.

Item	Qty	Unit	Unit Price	Amount
General Excavation	132	CY	$65	$8,580
Amended Topsoil	65	CY	$95	$6,175
Rock Mulch	8	CY	$150	$1,200
Drain Rock	30	CY	$120	$3,600
Curb Cut	2	EA	$550	$1,100
Check Dam	9	EA	$200	$1,800
Impervious Liner	34	SY	$20	$680
Drainage Geotextile – Type 1	118	SY	$6	$708
Total				**$23,843**

Per SF of Swale/Infiltration Swale (Rounded)	**$60**



Implementation

Implementation effort for Swale/Infiltration Swale is <u>moderate</u>. This tool requires a thorough site assessment of drainage patterns and soil conditions as well as engineering design. Construction of this tool requires excavation and potential planting.

Appendix C:

Programmatic Solutions Fact Sheets

Drillhole Water Quality Retrofit

Programmatic Solution Fact Sheet

CITY OF BEND

Problem Summary

Underground Injection Controls (UICs) are systems that place fluids below ground. The City uses roughly 6,500 UICs to manage stormwater runoff within the public rights-of-way where connections to a storm sewer system are not available. Drillholes are a type of UIC that are typically 6-inch diameter open boreholes that can extend up to 100 feet below ground. The top 10 to 20 feet of drillholes have a steel surface casing. About 1,000 of the City's UICs are drillholes. New drillholes have not been permitted in City standards for several years due to maintenance issues, lack of pretreatment, and difficulty and expense of retrofitting.

The City's goal with this program is to efficiently manage stormwater by infiltration in a manner that is protective of groundwater quality. Pollutant fate and transport modeling was conducted for common stormwater pollutants and emerging stormwater pollutants of concern, with a specific focus on PFAS. Existing drillholes were then evaluated and prioritized for retrofit and rehabilitation. Based on the results, 15 drillholes were prioritized for this program.

Solution Options and Recommendation

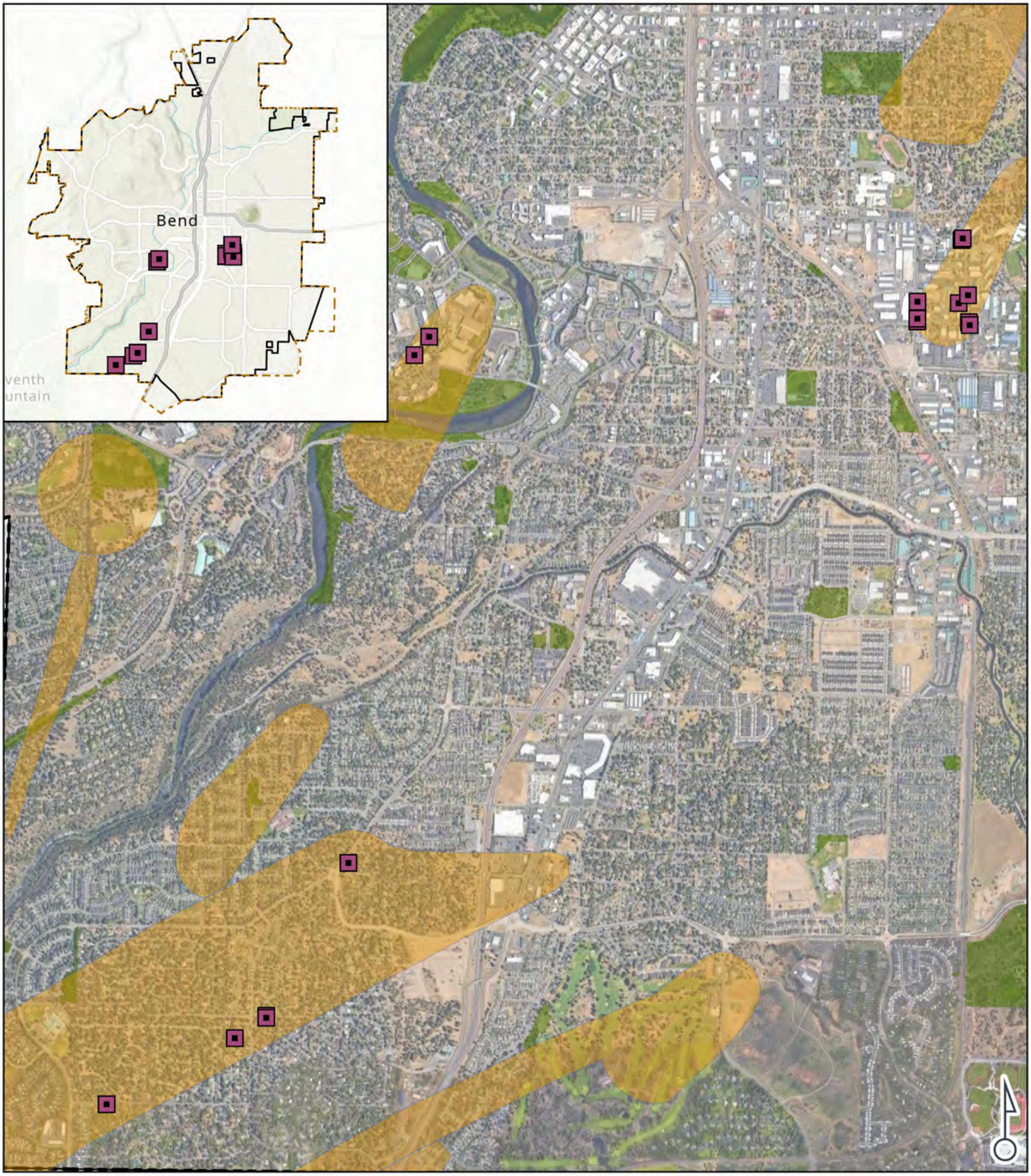
The recommendation for this program is to provide groundwater protection from UICs that pose a high risk of contamination to drinking water. While activated carbon and biochar have been shown to remove PFAS from stormwater, effectiveness, treatment capacity, and maintenance of these systems are highly variable based on the types and concentrations of stormwater pollutants present at individual treatment locations. Due to high uncertainty of emerging pollutant removal efficiency, solutions that focused on placing greater distance between the infiltration location and sensitive groundwater were prioritized.

It is recommended that drillholes be decommissioned whenever possible and relocated outside of the two-year time of travel zone relative to municipal water wells. Catch basins and pre-treatment for small drainage basins will be provided near the locations of decommissioned drillholes. Storm sewer will be installed to connect the pre-treatment for small drainage basin to new drywells located in appropriate infiltration sites. Due to the distance between the decommissioned drillholes and the new drywells outside of the two-year time of travel zone, feasibility of this option must be assessed for each drillhole. This solution is expected to be implemented by a contractor. Based on the likely cost, this is considered a high-cost option.

A lower cost option would include redrilling the drillhole to improve infiltration capacity and installing a connecting catch basin and an upgraded version of the City's typical water quality manhole to control sediment, oils, and trash.

The upgraded water quality manhole is similar to the City's standard detail for a stormwater sedimentation manhole with a sump to capture sediment and a snout oil-water-debris separator to prevent floatable contaminants from entering the drillhole. However, a baffle wall is installed between the incoming and outgoing pipes to reduce the resuspension of sediment collected in the sump during subsequent storm events (see page 3 for detail). Installation of a baffle in manholes has been shown to perform as well as hydrodynamic separators, but at a fraction of the cost. The catch basin and water quality manhole pair will effectively remove pollutants from stormwater prior to entering these priority drillholes.

The benefits of this program include:
- Reduce risk to municipal drinking water quality
- Increase infiltration of stormwater
- Increase stormwater pollutant removal



DRILLHOLE WATER QUALITY RETROFIT PROGRAM

BEND STORMWATER MASTER PLAN

BEND, OREGON

Data Sources: City of Bend, Deschutes County, USGS, Google Maps.
Date: 8/18/2025
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

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LEGEND

- ▭ Bend City Limits
- ⬚ Urban Growth Boundary
- 🟧 Extra High Risk: Two-year TOT Public Well Water Zones
- 🟩 Parks
- ▣ Drillhole Water Quality Retrofit

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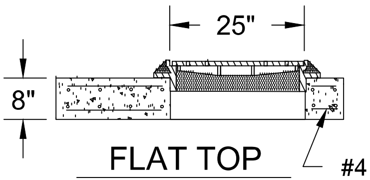
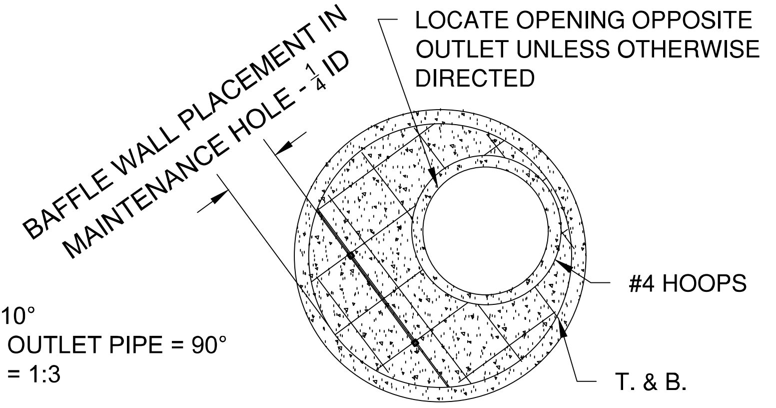
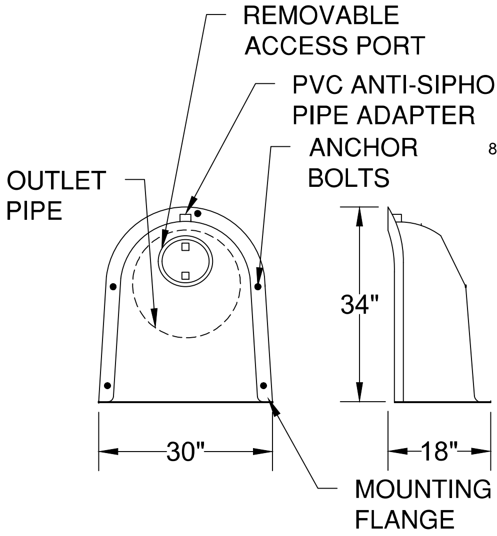


FLAT TOP
NTS

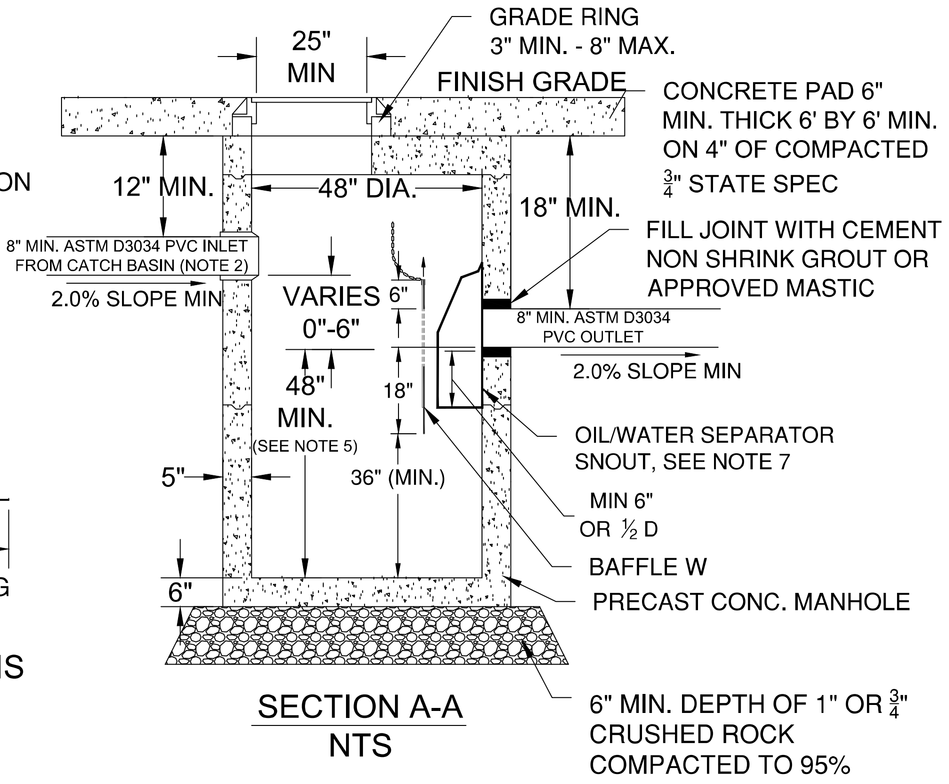


TOP VIEW

NOTES:
1. MINIMUM ANGLE BETWEEN INLET PIPES = 110°
2. MINIMUM ANGLE BETWEEN INLET PIPE AND OUTLET PIPE = 90°
3. RATIO OF VERTICAL TO HORIZONTAL FLOW = 1:3



SNOUT OIL-WATER-DEBRIS
SEPARATOR
NTS



SECTION A-A
NTS

NOTES:
1. ALL PRE-CAST SECTIONS SHALL CONFORM TO REQUIREMENTS OF ASTM C-478.
2. AWWA C900 PIPE SHALL BE USED WITHIN TRAVEL AREAS. ASTM D3034 PIPE WHERE STORM PIPE WILL BE INSTALLED PERSANITARY SEWER REQUIREMENTS OR OUTSIDE OF TRAVEL AREAS.
3. MANHOLES SHALL BE PLACED OUTSIDE SIDEWALK, APRONS & STREET SURFACES UNLESS APPROVED BY THE CITY ENGINEER.
4. A 3 POINT MECHANICAL ADJUSTMENT SYSTEM SUCH AS RAD`S OR APPROVED EQUAL SHALL BE USED TO ADJUST MANHOLE FRAME AND COVER TO FINISH GRADE.
5. SUMP SIZE TO BE DESIGNED IN ACCORDANCE WITH COSM - 20 CF OF SUMP VOLUME FOR EACH 1.0 CFS DESIGN FLOW - NOT LESS THAN 48" DEPTH.
6. MANHOLES WITH MORE THAN 3 CONNECTIONS, OR PIPES 12" OR LARGER TO BE 60" MANHOLES
7. OIL/WATER SEPARATOR SNOUT BMP 24R, OR APPROVED EQUAL. SECURE TO MANHOLE WITH FIVE (5)$\frac{3}{8}$"x1-12" STAINLESS STEEL RED HEAD BOLTS, WASHERS AND NUTS, OR AS APPROVED BY MANUFACTURER.
8. BAFFLE WALL MATERIAL SHALL BE 1/8" PERFORATED STAINLESS STEEL OR 1/2" THICK HDPE FLAT STOCK. SECURE BAFFLE WALL TO MANHOLE WALL PER MANUFACTURER'S RECOMMENDATIONS.

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WATER QUALITY MANHOLE WITH BAFFLE DETAIL
NTS

Program Cost Estimate – High-Cost Option*				
Construction	**Qty**	**Unit**	**Price**	**Amount**
Stormwater Tool Kit				
Pre-Treatment, for small drainage basin (less than 1 ac.)	1	EA	$12,000.00	$12,000.00
Storm Sewer Pipe, 12-in diam.	30	LF	$180.00	$5,400.00
Storm Sewer Pipe, 18-in diam.	200	LF	$220.00	$44,000.00
Drywell	1	EA	$32,000.00	$32,000.00
Decomission Drillhole	1	EA	$3,000.00	$3,000.00
Catch Basin	1	EA	$3,500.00	$3,500.00
Manhole	1	EA	$10,000.00	$10,000.00
			Total Per Unit	**$109,900.00**
Program Costs				
Units Constructed	15	EA	$109,900.00	$1,648,500.00
Other Construction Costs (Rounded)				
Mobilization	10	%	of Const.	$305,000.00
Erosion and Sediment Control	2	%	of Const.	$61,000.00
Traffic Control	4	%	of Const.	$122,000.00
Construction Contingency	30	%	of Const.	$916,000.00
			Total Construction	**$3,052,500.00**
Other Costs (Rounded)	**Qty**	**Unit**	**Price**	**Amount**
Design and Survey	20	%	of Const.	$611,000.00
Administration	10	%	of Const.	$305,000.00
			Total Other Costs	**$916,000.00**
Total Program Cost (Rounded)				**$3,970,000**

**Class V planning level cost estimate. Costs are in 2025 dollars. Escalate unit prices for quantity items when budgeting for implementation*

Program Cost Estimate – Low-Cost Option*				
Construction	**Qty**	**Unit**	**Price**	**Amount**
Stormwater Tool Kit				
Pre-Treatment, for small drainage basin (less than 1 ac.)	1	EA	$12,000.00	$12,000.00
Storm Sewer Pipe, 12-in diam.	30	LF	$180.00	$5,400.00
Modification of Pre-Treatment (WQ Manhole with Baffle)	1	EA	$7,200.00	$7,200.00
Catch Basin	1	EA	$3,500.00	$3,500.00
Manhole	1	EA	$10,000.00	$10,000.00
			Total Per Unit	**$38,100.00**
Program Costs				
Units Constructed	15	EA	$38,100.00	$571,500.00
Other Construction Costs (Rounded)				
Mobilization	10	%	of Const.	$130,000.00
Erosion and Sediment Control	2	%	of Const.	$26,000.00
Traffic Control	4	%	of Const.	$52,000.00
Construction Contingency	40	%	of Const.	$520,000.00
			Total Construction	**$1,299,500.00**
Other Costs (Rounded)	**Qty**	**Unit**	**Price**	**Amount**
Design and Survey	20	%	of Const.	$260,000.00
Administration	10	%	of Const.	$130,000.00
			Total Other Costs	**$390,000.00**
Total Program Cost (Rounded)				**$1,690,000**

**Class V planning level cost estimate. Costs are in 2025 dollars. Escalate unit prices for quantity items when budgeting for implementation*

Failing UIC Drainage Improvements

Programmatic Solution Fact Sheet

CITY OF BEND

Problem Summary

Underground Injection Controls (UICs) are systems that place fluids below ground. The City uses roughly 6,500 UICs to manage stormwater runoff within the public rights-of-way where connections to a storm sewer system are not available. About 5,500 of the City's UICs are drywells and 1,000 are drillholes. Drywells are a type of UIC that are typically 10 to 20 feet deep cylindrical structures constructed of 4-foot diameter concrete rings. The concrete rings are perforated with multiple holes to allow for infiltration. Drillholes are a type of UIC that are typically open boreholes that extend up to 100 feet belowground.

There are 21 locations where drywells and drillholes within the city are underperforming (see page 2) due to a variety of factors including high sediment loads, increases in stormwater runoff, and inadequate infiltration capacity. The failing UICs cause stormwater runoff to accumulate on roads and private property, often leading to traffic impacts and damage to structures. After storm events, City staff respond to drainage complaints at these locations frequently. Additionally, many drywells and drillholes lack pretreatment to address water quality concerns from both common stormwater pollutants and emerging pollutants of concern, such as PFAS.

Solution Options and Recommendation

The recommendation for this program is to provide water quality treatment for stormwater runoff prior to entering existing drywells and to add additional infiltration capacity. Additional capacity will be provided by connecting additional drywells together in series with underground storm sewer.

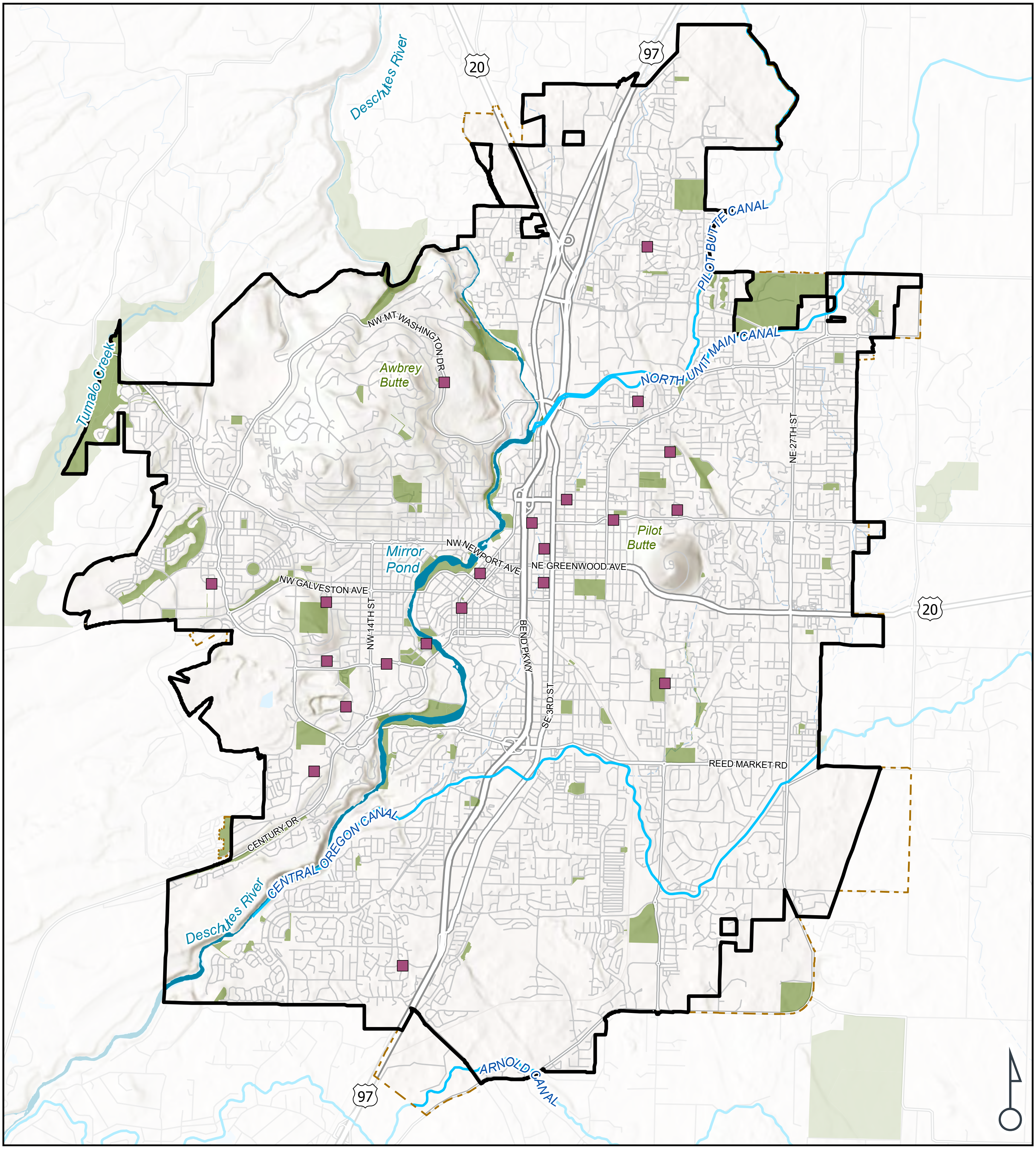
The following assumptions have been used to generate a planning-level cost estimate for addressing the 21 prioritized failing UICs. System design at each site may vary and will be determined during implementation.

Drywells prioritized for this program will be redrilled, retrofitted with a catch basin and water quality manhole to provide pretreatment, and connected in series with two new drywells to provide additional infiltration capacity.

To address emerging pollutants of concern, it is recommended that proposed UICs provide a minimum of 53 feet of vertical separation between the bottom of the drywell and the seasonal high of groundwater. A 100-foot setback between UICs and public water wells is also recommended, similar to the Oregon Health Authority requirement. Failing UICs located in areas of perched groundwater will require greater coordination and design efforts to protect groundwater quality.

The benefits of this program include:

- Remove stormwater pollutants
- Increase infiltration of stormwater
- Reduce nuisance flooding
- Provide a single point of maintenance access



FAILING UIC DRAINAGE IMPROVEMENTS PROGRAM

BEND STORMWATER MASTER PLAN

BEND, OREGON

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LEGEND

▭	Bend City Limits	—	Streams
⬚	Urban Growth Boundary	—	Canals
🟩	Parks	■	Failing UIC

CITY OF BEND

Data Sources: City of Bend, Deschutes County, USGS, Google Maps.
Date: 11/18/2025
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

O:\PROJECT\20300\20359\04 CAD\GIS\APRX\20359 BEND MASTER PLAN MAPS JR.APRX

Program Cost Estimate*				
Construction	**Qty**	**Unit**	**Price**	**Amount**
Stormwater Tool Kit				
Pre-Treatment, for medium drainage basin (1-5 ac.)	1	EA	$18,000.00	$18,000.00
Storm Sewer Pipe, 12-in diam.	60	LF	$180.00	$10,800.00
Drywell	2	EA	$32,000.00	$64,000.00
Clean Drywell	1	EA	$10,000.00	$10,000.00
Catch Basin	1	EA	$3,500.00	$3,500.00
			Total Per Unit	**$106,300.00**
Program Costs				
Units Constructed	21	EA	$106,300.00	$2,232,300.00
Other Construction Costs (Rounded)				
Mobilization	10	%	of Const.	$413,000.00
Erosion and Sediment Control	2	%	of Const.	$83,000.00
Traffic Control	4	%	of Const.	$165,000.00
Construction Contingency	30	%	of Const.	$1,240,000.00
			Total Construction	**$4,133,300.00**
Other Costs (Rounded)	**Qty**	**Unit**	**Price**	**Amount**
Engineering	20	%	of Const.	$827,000.00
Administration	10	%	of Const.	$413,000.00
			Total Other Costs	**$1,240,000.00**
Total Program Cost (Rounded)				**$5,370,000**

**Class V planning level cost estimate. Costs are in 2025 dollars. Escalate unit prices for quantity items when budgeting for implementation*

Ponding on NW Olney Ave impacting travel

Ponding on SW McMullin impacting property

Appendix D:

Policy Papers and Presentations

Bend Stormwater Master Plan

Drainage and Density: Stormwater Management Options for Increasingly Dense Development

Final

Submitted to:

City of Bend
710 NW Wall Street
Bend, OR 97701

July 2025

Prepared by:

Otak, Inc.
808 SW Third Avenue
Suite 800
Portland, OR 97204

Project No. 20359

Disclaimer

This white paper reviews development codes, engineering standards, specifications, and stormwater regulations in Bend for the purpose of discussing alternative options for managing stormwater on development sites. The authors do not guarantee that all such stormwater-related codes, standards, specifications, and regulations in Bend have been considered. This paper is not a substitute for Bend's land use and engineering regulations and may not be used to guide applicants or employees in adhering to development code, making land use decisions, or developing engineering plans.

Table of Contents

TABLES

FIGURES

Definitions of Key Concepts

The definitions below describe how key concepts are used in this white paper. The topic of this paper pertains to the development and redevelopment of land in the present time. Use of terms such as “typical”, “common”, “allowed”, and “disallowed” refer to current codes and practices in Bend and are not intended to describe all existing stormwater systems or historic stormwater management practices in Bend.

On-site stormwater management is used in the Pacific Northwest to describe the practice of managing the volume and quality of stormwater on a development site before discharging it off the site either to a municipal stormwater conveyance or to a receiving water such as a stream, river, gulch, or wetland.

Lot-scale stormwater management means providing a stormwater management facility such as a drywell or swale on each individual lot in a development to manage runoff from that lot. Bend’s standards do not allow for runoff from storms up to the 25-year event to leave the site. This form of on-site stormwater management is considered the typical pattern in Bend in this white paper.

Centralized on-site stormwater management means the practice of conveying stormwater from lots and new streets in a development to one or a small number of larger stormwater facilities serving the whole development. This is a form of on-site stormwater management and is explored in this paper as an option to lot-scale stormwater management in a variety of situations.

ROW comingled stormwater management means the practice of conveying private runoff to an existing City street or to a stormwater system in an existing City street and allowing the private runoff to comingle with public runoff in the public stormwater system. This practice is explored in this paper as an alternative to lot-scale stormwater management in limited situations.

Regional stormwater facility means a large stormwater management solution strategically situated and designed to serve multiple properties – often under varied ownership and spanning a large area – to optimize stormwater management as part of a development project or to facilitate redevelopment. This practice is explored in this paper as an alternative to lot-scale stormwater management where the City wishes to encourage economic development through redevelopment.

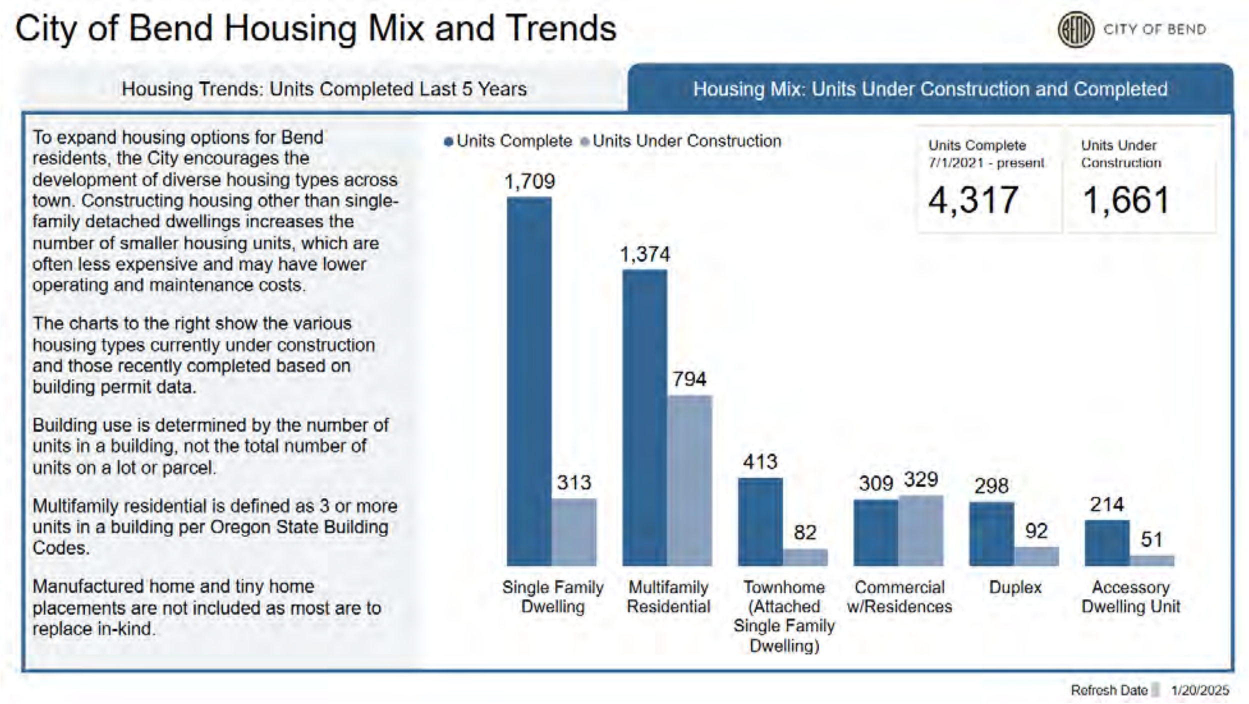
Section 1. Introduction

The City of Bend is updating its 2014 Stormwater Master Plan. The Stormwater Master Plan (SMP) Update will provide direction for the City's stormwater utility system upgrades, repair and replacement, operations and maintenance, and stormwater policy considerations.

City's Increasing Density

Bend's 2016 Comprehensive Plan identified the need for 17,234 new housing units and the City is also planning for 60,000 new jobs by 2028. With municipal expansion limited to the urban growth boundary (UGB) by the State of Oregon's urban growth planning laws, the City has enacted policies to create a diversity of housing options, increase density of development overall, and identify land to support economic development, embracing the mantra, "wisely growing up and out." In addition to the City's comprehensive plan, several changes in state law have been passed since 2017 that direct cities to allow more types of housing, including middle housing, within urban growth boundaries. Examples include but are not limited to Senate Bill (SB) 1052 (2017), House Bill (HB) 2001 (2019), and HB 2001 (2023). Also, the Land Conservation and Development Commission adopted Climate Friendly and Equitable Communities (CFEC) rules in 2022.

Figure 1 illustrates the mix of housing types constructed and under construction between July 2021 and January 2025.



City of Bend Housing Mix and Trends

To expand housing options for Bend residents, the City encourages the development of diverse housing types across town. Constructing housing other than single-family detached dwellings increases the number of smaller housing units, which are often less expensive and may have lower operating and maintenance costs.

The charts to the right show the various housing types currently under construction and those recently completed based on building permit data.

Building use is determined by the number of units in a building, not the total number of units on a lot or parcel.

Multifamily residential is defined as 3 or more units in a building per Oregon State Building Codes.

Manufactured home and tiny home placements are not included as most are to replace in-kind.

Refresh Date 1/20/2025

Figure 1. Housing Mix and Trends Graph Captured from City's Dashboard 1/20/2025

Purpose and Goals of this White Paper

With rapid growth, and with the City's focus on providing a range of housing types and employment opportunities, development is densifying. Increasingly, lots are smaller, leaving little room on construction sites for stormwater management. In addition, more and more lots with geology and site conditions that are not conducive to stormwater management are being developed. For these variety of reasons, City staff and developers are calling for more options for managing stormwater both on-site and in a more centralized or regional fashion.

This white paper further explores some of the limitations of the existing approaches to managing stormwater, and it contemplates additional options.

Stormwater Policy for Development

Bend's default pattern for stormwater system development is decentralized and privatized. As codified below, unless specific arrangements are made, stormwater must be kept on the lot of origin and managed by the property owner. For the purposes of this white paper, we are calling this method of managing stormwater on individual lots "lot-scale stormwater management." While the lot-scale pattern relieves the City of providing an all-inclusive public stormwater system, it has drawbacks such as consuming private land for stormwater management, assuming that individual lots have physical capacity to manage urban stormwater runoff, and charging individual property owners or HOAs with responsibility for systems that can be difficult to inspect, operate, and maintain.

This section highlights the elements of Bend's stormwater policy documents that relate to drainage and density.

Bend Municipal Code - Title 16

Title 16 of Bend Municipal Code (BMC) includes the requirements for grading, erosion control, post-construction stormwater control, illicit discharge, tree protection, and well-drilling. This title provides authority for Bend to establish minimum stormwater standards for new development and redevelopment on property or in the right of way. Bend has adopted the Central Oregon Stormwater Manual (COSM) as the design manual for stormwater in addition to publishing Standards and Specifications. The COSM was last updated in 2010, and Bend's Title 16 and Standards and Specifications were last updated in 2024.

Chapter 16.15 describes the stormwater management design and maintenance standards, including required drainage submittals, for post-construction stormwater facilities. Chapter 16.15 applies to all land development that meets one or more of the following criteria:

- Adds 5,000 square feet (sf) of impervious area or disturbs one or more acres
- Proposes a UIC
- Is a manufactured or mobile home park
- Triggers a commercial building permit or site plan review prior to issuing of building or grading permits
- Triggers a clearing, grading and erosion control permit not in conjunction with a building permit
- Is a new public or private road project
- Proposes the installation, removal, or modification of drainage systems
- Is a land development activity that is smaller than the minimum applicability criteria but is part of larger common plan of development that meets the applicability criteria when considered in total over different phases and schedules.

The drainage submittal requirements in Chapter 16.15.010.B allow developments to apply stormwater management standards to the common land development plan as a whole, rather than lot by lot, if the development has a master plan formalizing arrangements for stormwater drainage across multiple properties. Master planning is addressed in Bend Development Code (BDC).

BMC 16.15.010.B also requires stormwater facilities to contain the 25-year design storm with one of the following options for overflow: a) convey to an existing or historical natural drainage point, b) maintain the 100-year design storm on site, or c) provide safe off-site passage of the 100-year, 24-hour design storm through formal agreements with affected property owners and the City. Outfall to irrigation district facilities is not allowed without a district's written approval.

BMC 16.15.040 contains the Post-Construction Performance Standards for Stormwater Management.

BMC 16.15.040.A.4 requires stormwater drainage to be retained on the lot of origin and not trespass onto the public right-of-way (ROW) or private property except: a) if City determines retaining would pose a threat to public safety or adjacent properties, b) when the owners of the lots of origin compensate the City for the cost of constructing, operating, and maintaining additional stormwater drainage and treatment capacity, c) access is provided to on-site stormwater facilities, or d) if the development has a master plan that includes formal arrangements for stormwater drainage across multiple properties.

BMC 16.15.040.A.6 allows stormwater facilities within residential subdivisions to serve multiple lots and/or combination of lots and roadways if stormwater facilities are located on a lot owned and maintained by an entity of common ownership, unless an alternate arrangement is approved by the City. Either the lot owner or an entity of common ownership must maintain the facilities.

BMC 16.15.040.A.8 allows runoff in excess of predevelopment rates or volumes to enter the City's municipal small storm sewer system (MS4) or publicly owned storm sewer with authorization from the City and if the applicant demonstrates the system has adequate capacity. Staff have noted that this provision is not encouraged under current procedures.

BMC 16.15.040.A.10 requires stormwater BMPs to consider public health, safety, and welfare and requires them to prevent flooding, prevent standing water that breeds mosquitoes, prevent attractive nuisances and dangerous conditions based on depth or velocity of water or access to drops, and prevent aesthetic nuisances due to excessive slopes, cuts, fills, vegetation mortality, or other.

BMC 16.15.040.A.11 requires conformance with the latest edition of COSM.

BMC 16.15.050 is the Stormwater System Maintenance Agreement. Owners are responsible for the operation and maintenance of stormwater facilities on their property, and maintenance agreements are required when a drainage submittal requires stormwater management measures.

BMC 16.30.090 requires property owners to maintain the private stormwater facility in a properly functioning condition. The section defines an improperly maintained or operated private stormwater facility that results in excessive flooding or erosion as a nuisance that may be abated by code enforcement.

Bend Design Standards and Specifications

Part II of Bend's Design Standards includes Chapter 6 which regulates stormwater. Many provisions echo COSM's technical specifications for design storms, volume and flow and hydrologic design criteria.

6.2.1 Hydrologic Design Criteria contains the following pertinent standards:

- Size of drywells in the ROW is limited to managing no more than 25,000 gallons based on the 25-year storm event outside of a sag location.
- Catchment delineations for public streets must include 20 feet of adjacent private lots and must account for anticipated future impervious surfaces such as driveways.
- When a regional storm basin is proposed that collects private property runoff into a public street, a geotechnical infiltration investigation is required, and system redundancy is required.
- Stormwater facilities may not be installed over top of franchise utilities not in the Public Utilities Easement (PUE).
- Private drainage facilities do not have a maximum size unless they flow into the public ROW or onto a neighboring property.

Specification 6.4.1 regulates residential conveyance to the ROW. It prohibits commercial and industrial lots from discharging to the ROW and allows residential subdivisions and lots to pipe private stormwater to the ROW if the arrangement was approved during land use review and the ROW infrastructure has been designed, constructed and tested to accommodate the additional capacity. The section provides design requirements and ownership rules to regulate these occurrences.

COSM

We have performed a minimal review of the COSM because we are primarily concerned with language regulating the locations and ownership of stormwater management facilities, which is found primarily in Bend's own codes and standards. However, we do note the following omissions from COSM which could provide better control over the use of infiltration facilities and more flexibility in choosing facilities to manage stormwater:

- COSM lacks prohibitions for using infiltration near steep slopes, near foundations, or in other locations where infiltration may pose a risk to buildings or downslope properties and resources.
- COSM lacks selection and design guidance for some emerging stormwater facility types such as deep drywells and stormwater trees.

Bend Development Code

Bend Development Code (BDC) is the comprehensive land use and development code within Bend, and it also contains public improvement standards. Staff use the BDC to review land use applications. The relevant portions of BDC are reviewed below.

Title 2 is Land Use Districts. Master plans under BDC 2.7 are required to provide 10% for open space - another option for stormwater retention onsite. Title 2 also contains code governing each adopted master planned development in the City.

Title 3 is Design Standards. BDC 3.4.500, Public Improvement Standards, Storm Drainage Improvements, requires:

A. Storm facilities to be designed and constructed in accordance with the City of Bend Standards and Specifications and BMC Title 16.
B. Requires accommodation of upstream drainage by designing and constructing facilities that do not increase rates of discharge compared to existing conditions prior to the proposed development
C. Downstream drainage improvements if additional runoff from the development will overload an existing drainage facility. This item also prohibits drainage from being directed to an existing watercourse, stream, or canal.

D. Providing easements for drainage through existing watercourses that traverse a development such as natural watercourses, drainage ways, channels, streams, irrigation canals, laterals, ditches, and other existing drainage facilities.
E. Providing easements over any new drainage facilities provided as part of a development that include elements located outside the dedicated public ROW.

BDC 3.5.600, On-Site Drainage, requires:

A. On-site surface water drainage, including roof drainage, must be retained on the lot or parcel of origin and not flow onto the public ROW or other private property. Engineered grading and drainage plans must be submitted in accordance with BMC Title 16, Grading, Excavation, and Stormwater Management.
B. Drainage facilities must be designed and constructed to accommodate increased runoff from the development. Drainage must not be directed to an existing watercourse, channel, stream or canal. Storm drainage facilities must comply with applicable State and Federal regulatory requirements.
C. Where an existing watercourse traverses a development, such as a natural watercourse, drainage way, channel or stream, or any other existing drainage facility including but not limited to irrigation canals, laterals and associated ditches, a recorded easement conforming substantially with the lines of such existing watercourses and such further width as will be adequate for conveyance and maintenance, as determined by the City Engineer, must be provided.
D. On-site drainage facilities must not be located in any public utility or slope easements. On-site drainage facilities must not be located in any irrigation district easement or Bend Park and Recreation District easement without their consent.

Title 4 is Applications and Review Procedures.

BDC 4.2 describes review procedures, including categories for Minimum Development Standards (MDS) Review, Site Plan Review, and Design Review. We point out some of the pertinent language here. MDS applies to single-family detached, townhomes, ADUs, duplexes, triplexes, quadplexes, and other small residential development. MDS streamlines development review for smaller developments while ensuring compliance with specific standards. The MDS code sections do not mention compliance with stormwater standards.

BDC 4.5.100 allows for Master Planning. The purpose of a master plan is "to promote and facilitate coordinated development. Master plans provide a process to consider future development on larger sites and to analyze future demand on public facilities. Master plans provide an opportunity for innovative and creative development while providing long-term predictability for the applicants, surrounding neighborhoods, and the entire community." (BDC 4.5.100.A)

One of the purposes of providing for a master plan is to provide the developer with more flexibility for creating a final land use pattern consistent with the Comprehensive Plan, and it is one way to acquire more flexibility to the requirements for on-site stormwater management to be provided on each lot.

The categories for master planning are: 1) Community Master Plan, which includes both a major and a minor category, Institutional Master Plan, and Employment Master Plan. A major community master plan is required when the applicant wishes to change current zoning or land uses outlined in the Bend Comprehensive Plan. Major master plans require a significant amount of review, public comments, and public hearings.

Minor community master plans and major community master plans that do not require rezoning are Type II administrative review procedures, which are similar in nature to the Type II review procedures required for the land division associated with a subdivision.

Incipient Regulatory Changes

Bend holds a municipal storm sewer system (MS4) permit and a Water Pollution Control Facilities (WPCF) permit from Oregon Department of Environmental Quality (DEQ). The permits authorize stormwater discharges to the Deschutes River and to groundwaters through underground injection controls such as drywells. The City is preparing to update stormwater standards in 2025 to meet requirements of both permits.

Bend will need to adjust thresholds for stormwater management in development.

- Bend is exploring requiring compliance with COSM for post-construction stormwater management on all development and redevelopment sites adding or replacing 5,000 square feet of impervious area, including individual single-family home and duplex development sites, which are currently required to submit drainage plans but are not required to document that the drainage plans are compliant with COSM.
- Bend must demonstrate that it has, or must implement, an “infiltration first” stormwater management hierarchy that requires sites to achieve a numeric stormwater retention requirement (NSRR).
- Bend will adjust horizontal and vertical separation requirements of UICs from drinking water wells and groundwater resources.

Stormwater Rate Structure

Options for stormwater management in development are tied to the City’s available resources for funding public drainage facility capital construction, operation and maintenance.

The City of Bend has an established stormwater utility fee which has been in place since 2007 and is periodically updated. This fee is based on impervious surface coverage per Equivalent Residential Unit (ERU). In Bend, one ERU is equivalent to 3,800 square feet of impervious surface coverage. This is the average amount of impervious surface for a single-family residence within the city. The monthly stormwater utility fee is currently $7.55 per ERU, with the most recent fee study completed in 2019. Bend’s stormwater rate structure is flat. All properties are charged equally per ERU; residential properties are assumed to comprise 1 ERU.

The City does not charge a System Development Charge (SDC) for stormwater improvements. By contrast, the City collects one-time SDCs for sewer, water, and transportation improvements.

Section 2. Lot-Scale Stormwater Management (Current Strategy)

This section reviews how lot-scale stormwater management pattern works with different development types and assesses the limitations of this approach.

The typical application of stormwater provisions of BMC, COSM, and Bend Standards and Specifications results in stormwater design and review outcomes described in Table 1.

Table 1. Current typical stormwater design and review outcomes

Sites	▪ Development must retain all stormwater on-site (generally on each lot) ▪ Single-family lots often use surface retention in the landscape or infiltration trenches ▪ Many private non-residential sites choose drywells
Street / ROW	▪ Stormwater facilities in City streets / ROW are designed with the assumption that a 20-ft width of ROW frontage for each adjacent lot drains to street ▪ Where soil conditions allow for infiltration, drywells with pretreatment manholes are the preferred stormwater facility type
Master Plans	▪ A few master planned developments combine public and private runoff and/or the runoff from multiple lots into a unified drainage plan for a larger area

Residential Subdivisions and Partitions

Single-family, duplex, triplex, quadplex, and townhome style residential subdivisions range in size from a subdivision with hundreds of parcels to be platted and constructed in phases to a partition resulting in two or three parcels. Based on records downloaded from the City's Community Development Data Viewer in February 2025, the City's Planning Department received 38 Final Plat applications for residential subdivisions or partitions in 2024, which includes middle housing land divisions, and 40 in 2023.

Some residential subdivisions are developed from land use through construction of homes by a single entity (a developer). In other cases, one entity develops the residential subdivisions from land use through construction of plat infrastructure such as roads, utilities, and rough grading of lots, and then sells individual lots to builders, who construct the homes. We make this distinction because the two scenarios have differing challenges when considering stormwater management options that are not lot-scale. The potential ramifications of this distinction are discussed in future sections.

These types of residential developments often result in ownership of homes by individuals and families and often result in the development of new public streets with stormwater systems that are separate from the systems on the parcels, since Bend's regulations generally prohibit runoff from parcels entering the ROW. These systems handle runoff from the ROW only, are built within the ROW to the public improvement standards and are dedicated to the City.

Typically, each lot has one or more stormwater facilities and either the developer's engineer or the builder selects the stormwater facility types with no input from eventual homeowners. Common choices include drywells, infiltration trenches, bioretention, and infiltration swales. Note that if the lot construction itself does not trigger the 5,000 sf threshold for requiring post-construction stormwater management, then the City Building Department requires a simplified and self-directed drainage plan submittal with the Building Permit and does not enforce COSM. Homeowners are then entrusted to operate, maintain, and inspect their stormwater facilities.

In the example below (Figure 2), if constructed as shown on the plans, this development would have produced 38 new privately-owned stormwater facilities. This development also includes an existing centralized stormwater facility (not shown on Figure 2) which manages runoff from the streets and is owned and operated by an HOA in the existing condition.

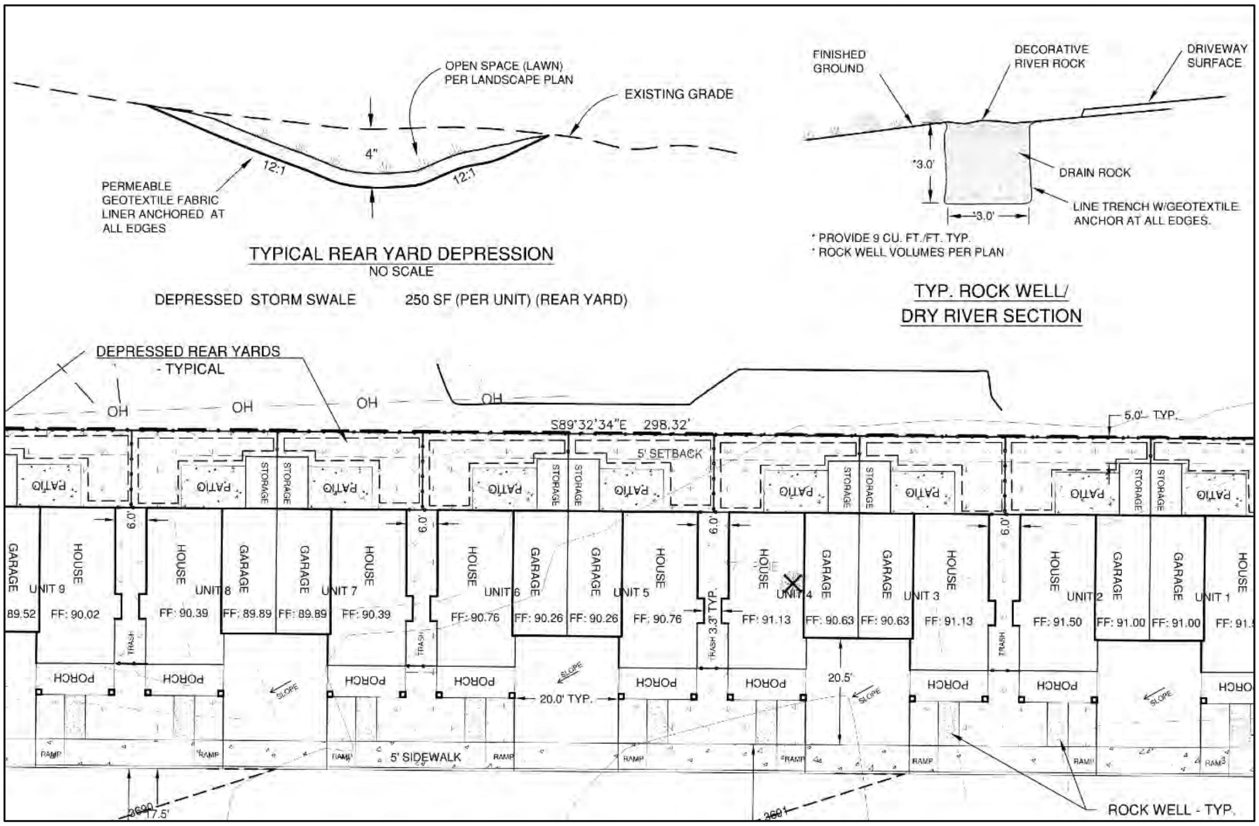


Figure 2. Excerpts of Draft Woodhaven Grading, Drainage and Erosion Control Plan, Sun Country Engineering Incorporated, 2020

In the examples below (Figure 3 through Figure 5), the drainage plan for a large subdivision includes only plat infrastructure while drainage plans for two individual lots and photographs of those sites demonstrate that the individual stormwater facilities are difficult to fit onto residential lots and may have been placed without respect to setbacks.

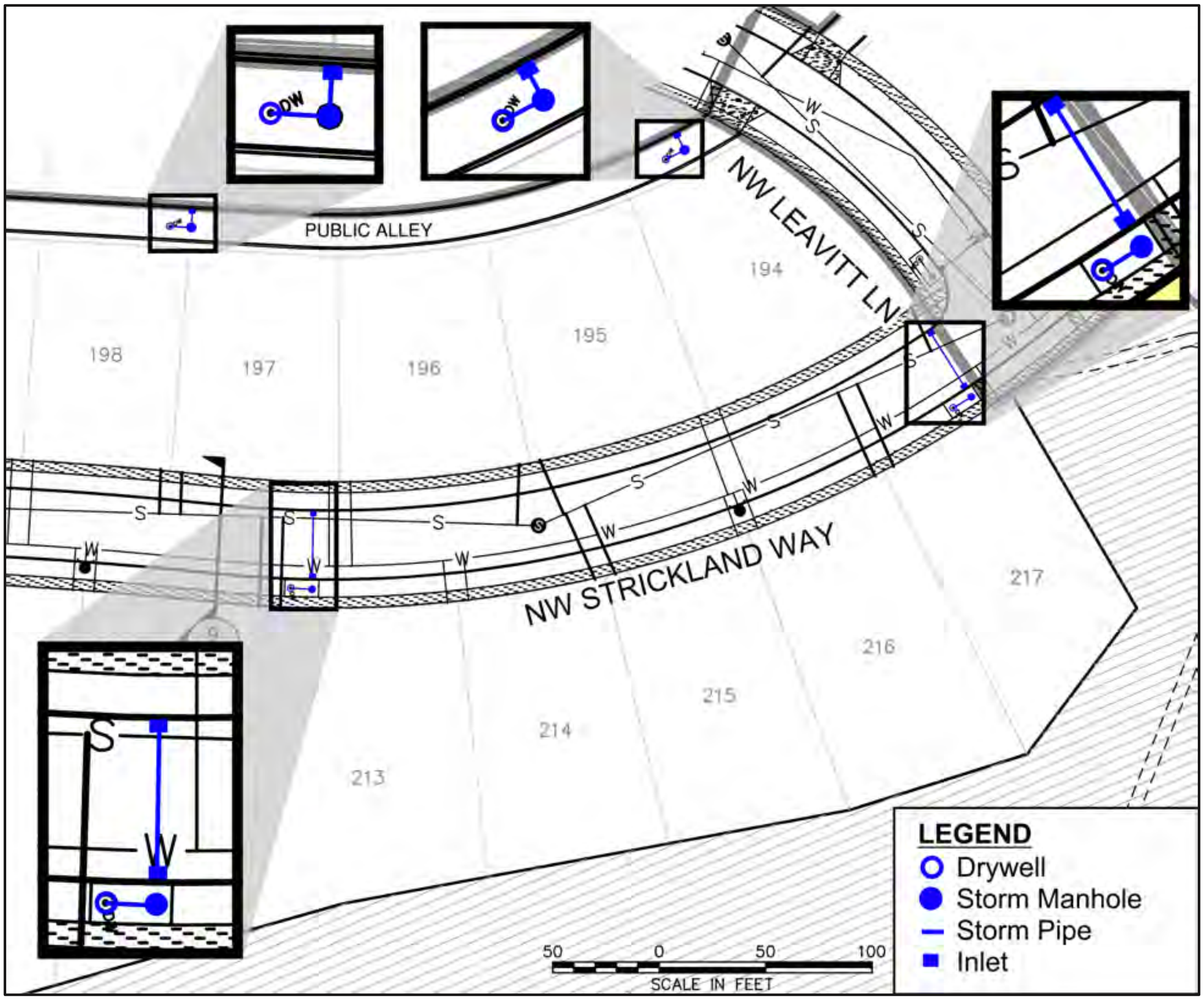


Figure 3. Illustration of partial drainage plan based on submitted drawings of Discovery West Phase 5 by DOWL.

Stormwater management for the plat infrastructure (public streets) is provided by drywells in the ROW, dedicated to the City. The subdivision grading and drainage plan does not include any stormwater management for individual lots.

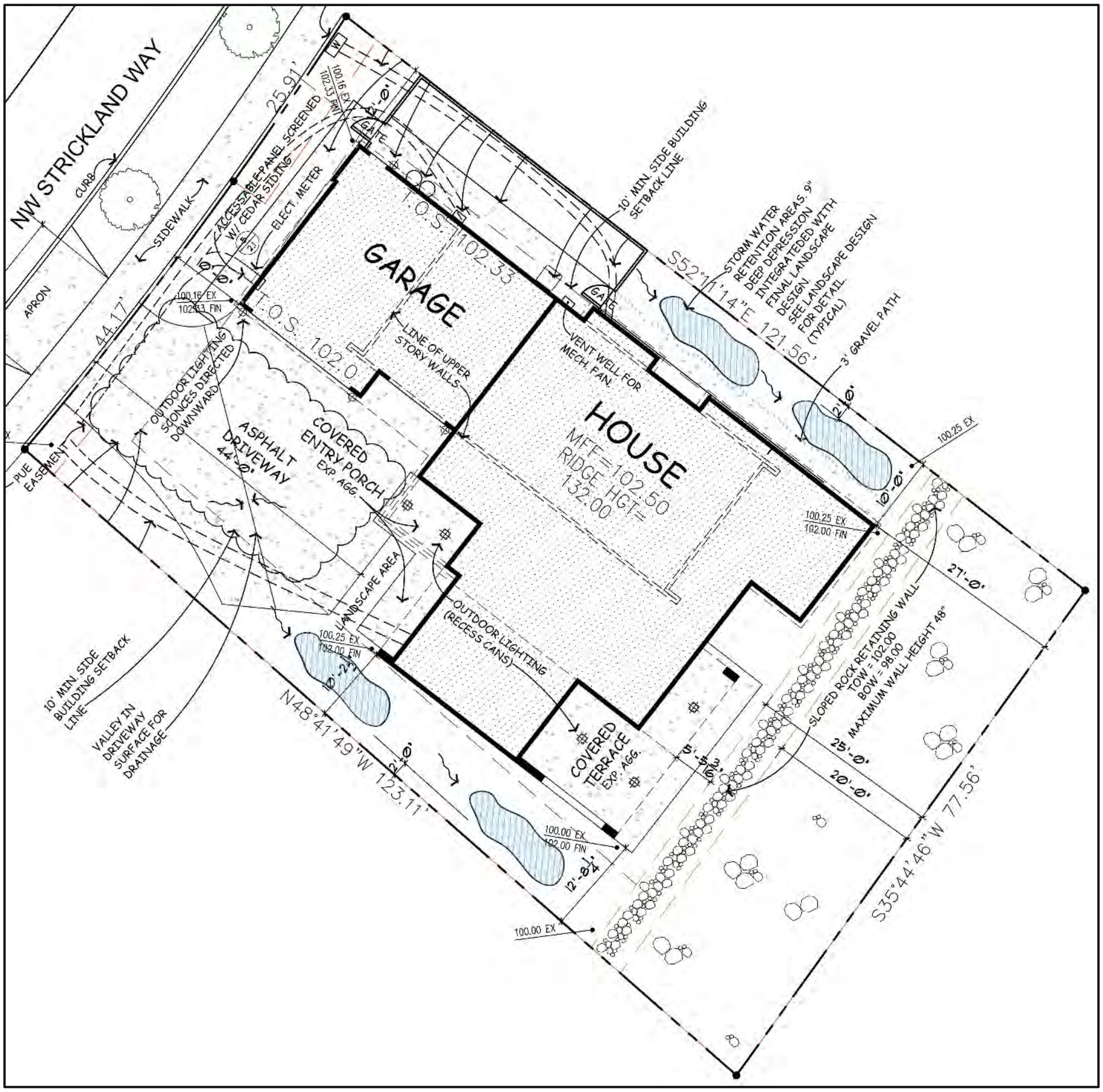


Figure 4. Illustration of single-family residential lot stormwater management in Discovery West Phase 5 development based on a site plan drawing submitted by Structure Development NW.

The illustrated plan is typical of the stormwater management provided for lots on NW Strickland Way, consisting of several small non-specific “retention areas” located within side yards or back yards in close proximity to property lines, foundations, retaining walls, and steep slopes.

Figure 5. Collage of photographs of stormwater management facilities on lots in Discovery West Ph 5, showing proximity to lot lines, foundations, retaining walls, and steep slopes.

Non-Residential Site Development

We are using the term "non-residential site development" in this paper to mean commercial development, larger multifamily developments with 5+ units, and mixed-use developments on larger tracts of unimproved land, generally those sites qualifying to schedule a "Commercial Pre-Submittal Meeting" with the Bend Planning Division. In order to get a sense of these sites, we reviewed four grading and drainage site plans from 2020-2025 and found that each one included parking and/or landscaped areas. Because of the presence of parking, drive aisles, and/or landscaping, we assume that these non-residential site plans have relative ease of siting private stormwater facilities to be operated by the landowner or eventual business tenants of these developments.

Of the sites we reviewed, stormwater systems were sited in parking areas and/or landscaped areas. In these developments, the owner typically operates and maintains a private stormwater system consisting of drainage, treatment, and disposal. Based on our review and anecdotal information provided by staff, these stormwater systems often discharge ultimately to drywells or surface infiltration facilities, while occasionally the systems discharge through a private outfall to the Deschutes River. Applicants submit Stormwater Maintenance Agreements for recording. When frontage and ROW improvements are required, the stormwater systems for the ROW are typically separate, built to the public improvement standards, and dedicated to the City.

Property owners are often businesses that may have staff or contractors for facility maintenance and/or grounds maintenance that may be tasked with identifying, inspecting, operating, and maintaining stormwater facilities on the site.

Infill

Infill is described in BDC 3.8.400, Infill Development, as development on small vacant or underutilized properties in the form of flag lots, mid-block developments, T-courts, or shared courts. For this paper, we also include individual homesites and individual small commercial buildings on vacant lots in areas of existing development in the definition of infill.

Infill development increases density where buildings, roads, and utilities are already laid out. Stormwater systems rely on gravity and are therefore sensitive to topography. Stormwater systems also require setbacks from foundations, roads, lot lines, and existing utilities, both for safety of the existing properties and infrastructure as well as for functionality and maintenance of the stormwater systems. Requirements for street trees (BDC 3.2.4) can also present challenges when ROW limitations necessitate tree plantings on property (5' setback from back of walk). Therefore, siting stormwater facilities on infill lots within an existing suite of utilities, property lines, buildings, and roads can be challenging.

Bend requires some types of residential infill developments to record Covenants, Conditions and Restrictions (CC&Rs) to create a homeowners' association and provide for maintenance of common areas.

Summary of Lot-Scale Stormwater Management (Current Practice)

Table 2. Summary of Lot-Scale Stormwater Management (Current Practice)

Development Type	Location of Stormwater Facility	Who is Draining	Facility Owner
Residential Subdivision / Partition – portion of development on lots	Lot / Homesite	Private	Individual Property Owner
Residential Subdivision / Partition – portion of development creating new ROW	ROW	Public	City
Non-Residential Site Development	Lot / Parking or Landscaping	Private	Commercial Property Owner
Infill	Lot / Homesite or Commercial	Private	Individual Property Owner or Commercial Property Owner or HOA

Limitations of Lot-Scale Stormwater Management

Lot-scale stormwater management has many advantages, which we will not discuss here. However, it has limitations. Disadvantages are present in the siting, permitting, and lifetime operations of lot-scale stormwater facilities. Some disadvantages arise from the ubiquity of stormwater facilities in this pattern. Disadvantages appear to be most prevalent for residential development and for urban redevelopment areas where minimal or no setbacks are a part of the incentive for redeveloping such as the Central Core.

Siting

On small residential lots, stormwater management facilities can take up a significant portion of each lot's available lawn or landscaping space and may be unpopular with residents. As shown in Figure 2, for a development of townhomes, each backyard is fully occupied by the combination of a small storage cabinet, small patio, and 250 square feet of "depressed rear yard," which also act as stormwater swale. In the same development, each residence has an infiltration rock well between the front porch and sidewalk, occupying approximately 1/3 of each yard.

The City is allowing or encouraging very dense redevelopment in the Central Core as part of an economic revitalization plan. However, lot-scale stormwater management requirements pose a barrier to achieving site layouts with small setbacks to lot lines. Because stormwater management facilities often take up space on the landscape and have setbacks from lot lines, it can be technically infeasible to both manage stormwater on a lot and make full use of the allowed developable area for buildings, parking, and appurtenances. This reduces the incentive for redeveloping these properties and is contrary to the City's goals for incentivizing redevelopment in the urban renewal area.

Permitting

Small lot-scale stormwater facilities on residential lots may be sized and designed using simplified calculations and assumptions rather than by site-specific investigations and detailed engineering. BMC 16.15.010.B.8 requires the drainage submittal to include appropriate field tests for verifying sizing and infiltration capability, and COSM Chapter 4 describes field testing requirements for infiltration facilities. We did not review drainage submittals to verify that these requirements were strictly met. The cost to the developer to field verify numerous small facilities on a large residential subdivision would be high. The cost to the City to individually review the number of field tests both before and after construction on a residential subdivision could be equally prohibitive.

When a residential lot within a subdivision does not independently meet the 5,000 sf impervious threshold for providing post-construction stormwater management, the Building Department reviews the drainage plan with the building permit. Since these lots have not been required to demonstrate compliance with COSM, staff have documented the placement of infiltration swales or facilities within setbacks to foundations, near retaining walls, and near steep slopes, and they have reviewed drainage plans containing declarations that the design storm is retained on-site through the use of unconventional methods, such as a low berm around the parcel. The City does not require a recorded maintenance agreement for these sites at present.

More investigation into the permitting process for distributed stormwater management is warranted.

Operation

City code requires property owners to inspect, operate, and maintain the stormwater facility(ies) on the property (BMC 16.30.090). This responsibility can be significant for an owner, particularly a homeowner. Drywells are underground structures that are difficult to inspect and maintain and may be overlooked by homeowners. Drywells are subject to clogging from silt and sediment, which affects their capacity, and contamination from spills of oils and chemicals, which may harm groundwater resources. Infiltration trenches and swales are below-ground or on the surface, respectively, and are also subject to clogging from silt and sediment. Swales may be vegetated or rocky and may be mistaken for landscaping features that the homeowners can fill in or modify at will. The City is currently working to establish an inspection and education program for the owners of private facilities that were constructed under the COSM standards to meet permit requirements, but this will not reduce requirements or costs to private facilities owners. This program also would not address the numerous private facilities on lots in subdivisions that do not independently reach the 5,000 sf impervious threshold to trigger the requirement to use COSM.

Section 3. Centralized On-site Stormwater Management Options

To mitigate some of the disadvantages of lot-scale stormwater management, we are exploring options for the City to allow or promote centralized on-site stormwater management. We are defining centralized on-site stormwater management as the provision of a unified stormwater conveyance network and centralized stormwater treatment facilities which may manage runoff from both private lots and public streets. The options include techniques other than lot-scale stormwater management that are allowed but infrequently used as well as techniques that may not currently be allowed in Bend.

This section both discusses existing practices in Bend that constitute centralized on-site stormwater management and recommends topics for further exploration.

Oregon's Department of Environmental Quality (DEQ) has recently indicated through conversation that the MS4 permit will consider "on-site stormwater management" to include stormwater facilities provided to serve a subdivision or a drainage basin (Martos, 2025). Other permittees in Oregon have also used this definition of on-site stormwater management. Therefore, it is likely that the MS4 permit will not provide an impediment to considering stormwater facilities that are centralized within one development as "on-site stormwater management" techniques that can meet the requirements of the permit's stormwater selection hierarchy (see Section 1).

Centralized on-site stormwater management is allowed in Bend through a master planned development. Based on the City's Special Planned District GIS data, four master planned developments were approved from 2023 to present, and staff indicate that numerous others have also been approved in recent years. Our review of BMC and BDC indicates that centralized on-site stormwater management may also be allowed in other circumstances but may not be used. Our review of governing policies finds that:

- The drainage submittal requirements in BMC 16.15.010.B allow for residential, commercial, institutional, or industrial development to apply stormwater management standards to the common land development plan, rather than lot by lot, if the development has a master plan that includes formal arrangements for stormwater drainage across multiple properties. However, Specification 6.4.1 allows only residential developments to pipe runoff to the ROW. City staff have indicated that no commercial or industrial projects have been permitted to comingle runoff with public runoff in the ROW.
- BMC 16.15.040.A.4 requires stormwater drainage in excess of the predevelopment rates or volumes to be retained on the lot of origin and not trespass onto the public right-of-way or private property except: a) if City determines retaining would pose a threat to public safety or adjacent properties, b) when the owners of the lots of origin compensate the City for the cost of constructing, operating, and maintaining additional stormwater drainage and treatment capacity, c) access is provided to on-site stormwater facilities, or d) if the development has a master plan that includes formal arrangements for stormwater drainage across multiple properties
- BMC 16.15.040.A.6 allows stormwater facilities within residential subdivisions to serve multiple lots and/or combination of lots and roadways if stormwater facilities are located on a lot owned and maintained by an HOA.

Residential Subdivisions

Larger residential subdivisions may provide some of the best opportunities for centralizing on-site stormwater management. Land divisions can accommodate the creation of tracts where larger stormwater facilities can be located (either above ground or underground). A stormwater tract does not have to meet legal definition of a developable lot, can be an odd shape, and can be located in otherwise undesirable locations, as long as drainage can be routed there by gravity. New land divisions provide an opportunity to coordinate all utilities and roads together, reducing utility conflicts and setback restrictions.

There are numerous possible configurations for a unified and centralized on-site stormwater management system in a residential subdivision. Configurations from the Portland-area and from Bend are illustrated in the figures below.

The subdivision illustrated in Figure 6 and Figure 7 has a unified and centralized stormwater plan. Each lot has a private rain garden (PRG) providing water quality on-site. The public streets are lined with vegetated swales providing water quality for street runoff. Tract G is a common area tract for stormwater treatment purposes and was deeded to the HOA. It contains a detention pond which was sized to manage runoff from the immediate phase and future upstream phases of the master planned development (not shown). It is subject to a storm drainage easement to benefit the City of Wilsonville over its entirety and is subject to stormwater pipeline easements to benefit City of Wilsonville as shown on the plat. The stormwater plan designates the private entity as the party responsible for maintaining all vegetated facilities.

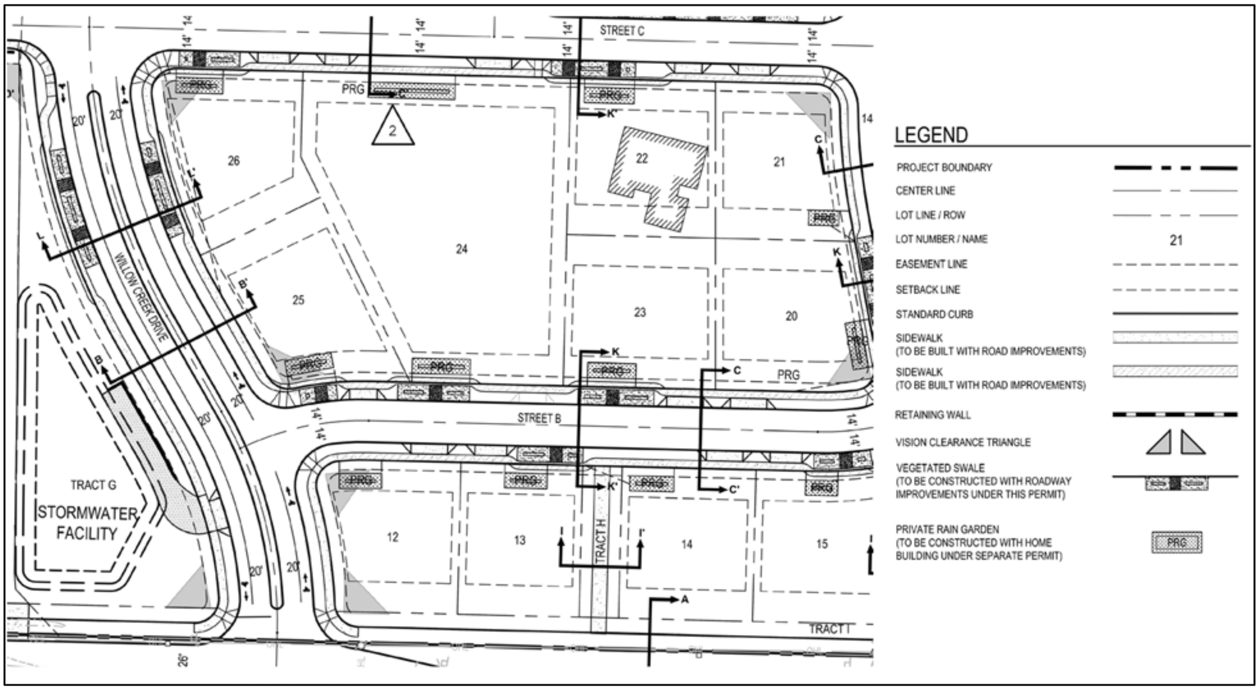


Figure 6. Excerpts from a Portland, Oregon-area residential subdivision plan with a unified and centralized on-site stormwater management plan by Otak.

Figure 7. Aerial drone photograph looking southwest of the partially constructed subdivision phase showing detention pond in Tract G, examples of private rain gardens, and examples of vegetated swales serving public ROW.

Figure 8 shows a similar example of centralized stormwater management in a subdivision but without distributed facilities. In this example, the centralized stormwater facility provides all the water quality and water quantity control for the neighborhood. The City owns the tract and is responsible for maintaining the facility. The stormwater facility also acts as a community amenity.

Figure 8. Aerial drone photograph of a regional stormwater quality and quantity control facility (bottom left) serving a large subdivision – including public roads and private parcels – in Tigard, Oregon.

Figure 9 illustrates the Luderman Crossing stormwater facility in Bend. Luderman Crossing features two central drainage facilities. The one pictured is the size of two lots. This facility reduced the number of drywells by half, and the subdivision retains the 100-year storm on-site. The City owns this facility while the HOA is responsible for its maintenance.

Figure 9. **Luderman Crossing stormwater facility**

Figure 10 is a photograph of recent townhome development in Bend. The subdivision features a centralized vegetated swale for stormwater management on the common area which is designed as part of the landscaping.

Figure 10. **Photograph of a centralized stormwater facility at Calaveras townhome development near Empire Ave and Boyd Acres Rd**

Our review of BDC 2.7, Master Planned Developments, reveals that at least seven existing master planned developments allow for flexible implementation of stormwater requirements in residential zones (Figure 11) using language either similar to or identical to this example from BDC 2.7.4150.J, the On-Site Surface Water Drainage standards for the Easton Master Planned Development:

1. On-site surface water drainage may be addressed in the following ways. Alternatives may be approved by the City Engineer:
    a. Roof drainage originating from residential properties may be conveyed to a public street and/or public storm drain collection and disposal system by subsurface piping, or curb weepholes, as approved by the City Engineer during permit review.
    b. Roof and surface drainage originating from residential properties may be conveyed to a private storm drain collection and disposal system located in a private tract or easement. The City may allow for private drainage systems in the public right-of-way if deemed appropriate by the City and maintenance agreements are executed between the homeowners' association and the City.
    c. Roof drainage originating from residential properties may be commingled with drainage originating from public streets, private streets, and/or alleys and conveyed to a non-UIC system located within a private tract to be owned by a homeowners' association with a maintenance agreement between the homeowners' association and the City outlining operational and maintenance responsibilities. The City may allow for commingled drainage to be conveyed to a non-UIC system located in the public right-of-way if deemed appropriate by the City and maintenance agreements are executed between the homeowners' association and the City.
    d. Private drainage facilities must be contained within the same or previous subdivision phase, or a stormwater easement must be provided for the stormwater facilities.
    e. Stormwater easements must be provided for public drainage facilities located on private property.
    f. A homeowners' association must be responsible for installing and maintaining any required landscaping in private facilities located in a private tract.
    g. A stormwater maintenance agreement must be signed with the City prior to final plat of the subdivision phase. (Easton Master Planned Development Ord. NS-2415, 2021 and NS-2391, 2020)

We did not research the actual residential subdivisions resulting from these master planned areas to determine how often more flexible stormwater arrangements were used. We note that the available master planned areas represent a significant portion of Bend's recent and near-future residential growth. We note the limitation on comingling private and public stormwater in a UIC system and recommend further research on the reasons for disallowing comingling in UIC systems.

As discussed in Section 2, there are two broad approaches to residential subdivision development in Bend. In one approach, a developer is responsible for a subdivision from land use review though construction of homes. In another approach, a developer is responsible for a subdivision from land use review through construction of the plat infrastructure and then sells lots to builders, who construct the homes. The former approach poses fewer barriers to centralized on-site stormwater management because one entity plans and constructs everything within the subdivision, including the layout of lots and tracts, roads, site utilities, and drainage. With one initial owner, the incentive to provide a unified drainage and stormwater treatment system is higher because the developer will end up bearing the cost for all drainage and stormwater facility construction, regardless of whether there is a unified system or a distributed system. In the latter approach, the developer is economically incentivized to allow a distributed system of lot-scale stormwater management because the cost of the individual stormwater system on each lot will be borne by each builder. In considering whether to allow, reduce barriers to, incentivize, or require centralized on-site stormwater management, Bend will need to consider how the two approaches to residential subdivision development impact developers' decisions on stormwater system planning.

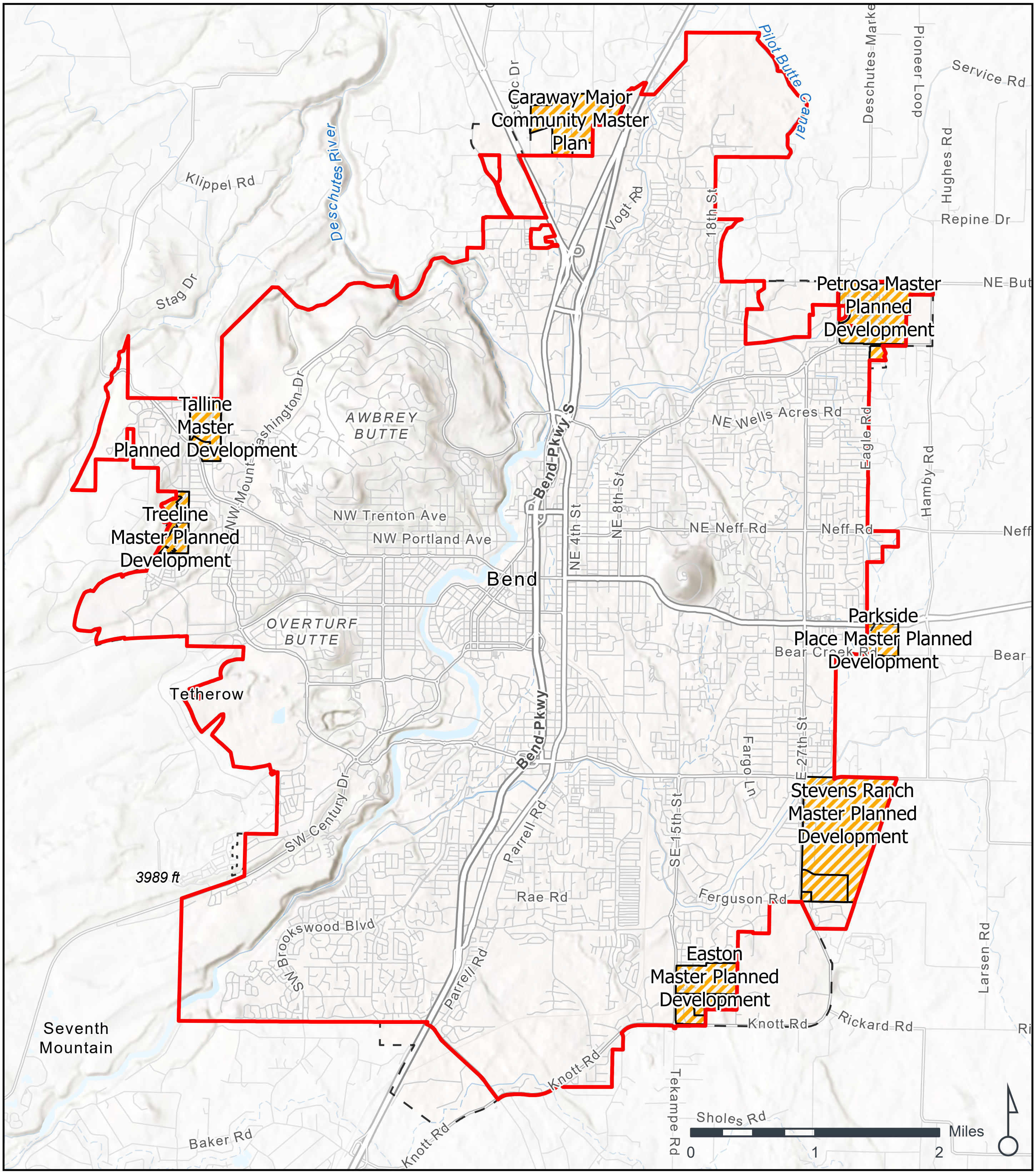


FIGURE 11
MASTER PLANS ALLOWING FLEXIBLE STORMWATER MANAGEMENT

BEND SMP | PROJECT #20359

BEND, OREGON

LEGEND

▭ City Limit

▨ Select Master Planned Developments

┄ Urban Growth Boundary

Data Sources:
Date: 3/18/2025
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

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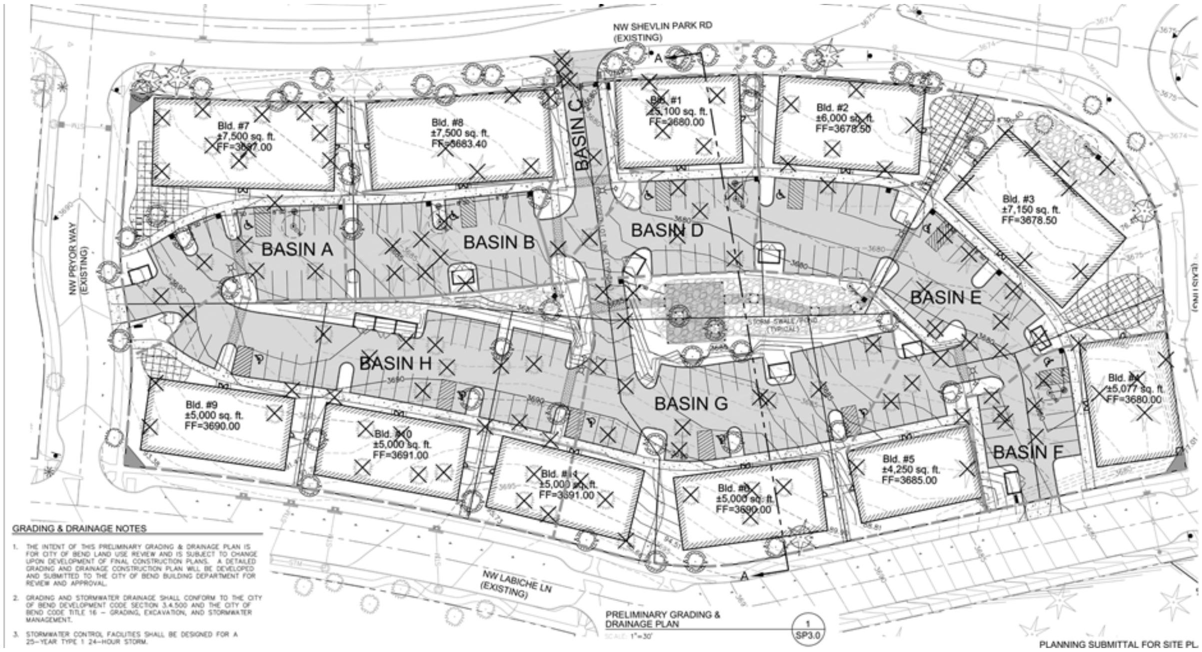
Non-residential Site Development

After reviewing several non-residential site plan applications from 2024, we did not find any commercial site that centralized stormwater management across multiple property owners. In the plans we reviewed, each basin on the site had a private stormwater management facility operated and maintained by the owner. In the reviewed plans, stormwater facilities were located under parking areas or in landscaped areas. ROW improvements were also separated in the site plans we reviewed. City staff are aware of a commercial site plan approved around 2014 which has a centralized on-site stormwater management system that future phases of the commercial development connected to over time (Figure 12). The site depicted is now known as Shevlin Health and Wellness Center.



GRADING & DRAINAGE NOTES

1. THE INTENT OF THIS PRELIMINARY GRADING & DRAINAGE PLAN IS FOR CITY OF BEND LAND USE REVIEW AND IS SUBJECT TO CHANGE UPON DEVELOPMENT OF FINAL CONSTRUCTION PLANS. A DETAILED GRADING AND DRAINAGE CONSTRUCTION PLAN WILL BE DEVELOPED AND SUBMITTED TO THE CITY OF BEND BUILDING DEPARTMENT FOR REVIEW AND APPROVAL.
2. GRADING AND STORMWATER DRAINAGE SHALL CONFORM TO THE CITY OF BEND DEVELOPMENT CODE SECTION 3.4.500 AND THE CITY OF BEND CODE TITLE 16 – GRADING, EXCAVATION, AND STORMWATER MANAGEMENT.
3. STORMWATER CONTROL FACILITIES SHALL BE DESIGNED FOR A 25–YEAR TYPE 1 24–HOUR STORM.

Figure 12. 2014 grading and drainage plan for Northwest Crossing Medical Center by Taylor Brooks LLC. The stormwater management system for the site is located in the center of the site plan.

City staff have indicated that economic development plans for Central Core and multi-use developments elsewhere in the City have been proposed and permitted without parking. For the purpose of considering stormwater management options, non-residential sites without parking or sufficient required landscaping to accommodate stormwater facilities may be better treated either as infill (discussed below) or as candidates for service by a regional stormwater facility (Section 5).

Infill

In Bend, centralized on-site stormwater management for residential locations often relies on common areas such as tracts that can be managed by an HOA. Residential infill is often permitted through the Minimum Development Standards (MDS) process, which includes less oversight of utilities than a site plan/subdivision review. Staff have indicated that infill developments can create a centralized shared stormwater system using cross drainage easements, and some do this. We did not investigate infill drainage plans to assess how these are typically laid out. Our definition of infill for this paper also includes individual homesites and single small commercial buildings in areas of existing development. For these types of infill, City staff would like to explore whether the sites could discharge drainage to the public street if the site soil conditions or layout make lot-scale stormwater management infeasible. ROW stormwater systems have not been designed for additional flow from private lots, which creates a barrier to this option. Options for centralizing stormwater management on infill could benefit from more investigation.

Summary of Centralized On-Site Stormwater Management

Table 3. Summary of Centralized On-Site Stormwater Management Options

Development Type	Location of Stormwater Facility	Who is Draining	Facility Owner Existing Options **[Recommended]**	Approval Process
Residential Subdivision, streets and lots managed together	Street, tract, or individual lot, or combination	Lots and Street	Varies, HOA or City **[HOA on tract; City in ROW]**	Typically Type II
Non-Residential Site Development	Lot	Lot	Commercial/Multifamily property owner **[Commercial/Multifamily property owner]**	Typically Type II
Infill	Private property within easement or Street, in limited cases	Private	Private, could be HOA or individual owners	MDS

Barriers to Options for Centralized On-site Stormwater Management

We briefly assess barriers to the options for centralized on-site stormwater management including current code, standards, procedures, and public funding.

Current Code and Standards

Alternate stormwater management strategies are allowed in the master planning process (16.15.010.B). Seven current master planned developments have codified various approvable methods for managing stormwater from residential zones, which include mixing private runoff with public street runoff and managing runoff in the ROW. The flexibility for managing residential runoff in the ROW for these master plans appears limited to roof runoff and therefore would exclude runoff from residential driveways, landscaping, and frontage, if implemented in strict accordance with code. In our interpretation, this provision conflicts with the requirement for public street design to include 20 feet of the adjacent private lots in the catchment delineation (Bend Design Standards and Specification, 6.2.1). Although technically conflicting, City staff have indicated that residential driveways draining to public streets is always allowed, and therefore this is not a true barrier.

Master planning could be a good solution for providing unified drainage and stormwater management on larger developments that have multiple land use types planned. The City could advertise this flexibility more than it does for master plans with residential land uses. Both minor community master plans and major community master plans may be approved under a Type II review, which is the same type as required for a subdivision. However, master plans may require more preparation by private-sector planners and engineers as well as longer review times. If the City wishes to allow comingling of public and private stormwater from other land uses in master planned developments, the City would need to resolve the limitation in Specification 6.4.1, which prohibits commercial and industrial land uses from conveying runoff to the ROW.

Other existing code provisions allow stormwater runoff to be managed outside of the lot of origin, especially in residential subdivisions, under certain circumstances (BMC 16.15.040.A.4, 6, and 8). We have not discovered why these provisions appear to be used infrequently. The City may lack procedures and criteria for reviewing and approving applications that seek to use the flexibility provided in these standards.

Bend Development Code limits comingling stormwater in UIC facilities, which limits the options for centralizing on-site stormwater management (see BDC 2.7.4150.J.c).

Staff have indicated that differing standards for public and on-site stormwater management in Bend Development Code present a barrier. Planning reviewers do not know how to condition a development when stormwater is comingled because BDC 3.4.500 (public improvement standards for storm drainage) and 3.5.600 (on-site storm drainage standards) have different standards.

Technical standards disallowing use of weep holes for draining private runoff to public streets may present another barrier, according to Bend's engineering community. Weep holes are one way to segregate roof runoff from landscaping runoff.

Procedures and Practices

City staff have described the following limitations arising from typical review practices: the Bend Standards and Specifications allow more flexible stormwater arrangements when first approved in the land division. But, if alternative stormwater management options are not approved in the land division, then the Engineering reviewer cannot approve it. Engineering and Planning staff indicate that applicants generally are not asking to use the more flexible provisions allowed in 16.15.040. For land divisions, the applicant would need to invoke 16.15.040 during land use in order for Engineering to approve an alternative to on-site stormwater management.

We reviewed the forms City uses for Pre-Application Conferences and found that stormwater is not included. Engineering staff indicate that Pre-Application Conferences are not required and are often not used. Planning staff indicate that Pre-Application Conferences are strongly encouraged for Type II land divisions (which include subdivisions) and are used some of the time.

Planning staff indicate that they are loosely defining the term “lot of origin” to mean the parent lot in a land division, which allows for placement of stormwater facilities elsewhere than individual lots. We have not studied how often this interpretation has been used to site stormwater facilities somewhere other than an individual residential lot in a subdivision.

The practice of a developer selling off lots in a subdivision may be a disincentive to centralize stormwater management. Finding room for a stormwater tract could reduce the number of lots or could reduce the size of a handful of lots, potentially reducing the developer's profit associated with selling lots. In addition, the developer then bears the cost of constructing all the stormwater infrastructure, rather than allowing builders to bear the cost of constructing stormwater facilities on each lot.

Our investigation into land use and engineering review procedures has been limited to code review, one workshop with staff, one presentation with feedback from Water Advisory Group, and one site visit with staff. The topic of procedural barriers to centralizing stormwater management may be more complex than what we have been able to discover for this paper.

Funding

Funding may not be a barrier to centralized stormwater facilities when managed by an HOA or commercial business park. These facilities are private, and the development would need to construct stormwater facilities whether centralized or decentralized.

Allowing centralized stormwater management in the ROW or on tracts dedicated to the City presents a funding barrier for the City. The long term cost of operating and maintaining additional public stormwater facilities has not been quantified nor considered in previous stormwater rate studies.

Long-Term Responsibilities and Agreements

City staff and developers in Bend do not have shared expectations around arrangements for ownership and long-term maintenance of centralized stormwater facilities. Because this model has been used infrequently so far, the ownership and maintenance responsibilities have varied. In the Luderman Crossing example, the City owns the facility, and the HOA is responsible for maintaining it. This arrangement has proven unsustainable in other communities we are familiar with. If appropriate maintenance is specified in a municipal permit, for example, then the City risks permit non-compliance if the HOA does not adequately maintain a facility owned by the City. In other examples, the HOA both owns and maintains the centralized facilities. If an HOA does not form, or disbands, however, the City has few options for ensuring the facility is maintained. A third choice is to require all centralized stormwater facilities to be owned and operated by the City. Each facility would need to be located in the ROW, where allowed, or on a stormwater tract dedicated to the City. Impact to the City's stormwater operations and maintenance budget would need to be evaluated.

The City lacks standard practices and template agreements which would facilitate centralization of stormwater infrastructure when the developer and builder are not the same entity, such as establishing responsibility for maintenance during construction and determining a start and end of the warranty bonding period for public stormwater infrastructure.

Centralizing stormwater management on subdivisions and non-residential site developments may require additional easements and covenants as well as the standard maintenance agreement required by the City for private stormwater facilities.

Centralizing stormwater management with other public or quasi-public agencies will require negotiating intergovernmental agreements addressing funding for design and construction, land ownership, easements, and funding for operation, maintenance, repair, and replacement.

Section 4. ROW Comingled Stormwater Management Options

This section will discuss options for increased flexibility to manage private or comingled public/private stormwater in the City's ROW. The lot-scale stormwater pattern which the City currently enforces in development cleanly divides responsibility for managing runoff from public sources, such as public streets, from responsibility for managing runoff from private property. Managing lot runoff in the ROW could include either allowing a development to drain to existing public conveyances and facilities or allowing a development to construct a system in the ROW. Managing lot runoff in the ROW would be a bigger departure from current practice than private centralized on-site stormwater management.

ROW stormwater management options may be most needed for infill that triggers the 5,000 sf impervious surface threshold for providing stormwater management. Residential subdivisions and non-residential site development each have better options for centralized on-site stormwater management. ROW options include techniques other than lot-scale stormwater management that are allowed but infrequently used and techniques that may not currently be allowed.

Infill

Residential infill may result in residences on flag lots, T-courts, or shared courts, and for this paper, we also include individual homesites on vacant lots in areas of existing development.

BMC 16. 15.040.A.4 allows drainage from private property to enter the ROW when the owners of the lots of origin compensate the City for the cost of constructing, operating, and maintaining additional stormwater drainage and treatment capacity. If this option were approvable, then the applicant could construct the stormwater facility in the ROW as part of an infill land division. Facilities would require a ROW permit and would be built to public improvement standards. The City would then own and operate the facilities.

Summary of Options for Managing Comingled Stormwater in the ROW

Table 4. Summary of Options for Managing Comingled Stormwater in the ROW

Development Type	Location of Stormwater Facility	Who is Draining	Facility Owner	Approval Process
Infill	ROW	Lots, potentially comingled with existing public runoff	City	TBD; not currently approvable

Barriers to Options for Managing Private Stormwater in the ROW

We briefly reviewed barriers to the options for managing private or comingled stormwater from infill in the ROW including current codes and standards, technical barriers, procedures, and public funding.

Technical

The feasibility of fitting new stormwater facilities in with existing street trees, utilities and drainage patterns, or up-sizing existing facilities to manage new drainage, may be low in many cases.

Current Code and Standards

Although BMC 16.15.040.A.4 allows drainage from private property to enter the ROW when the City is compensated for the cost of constructing, operating, and maintaining additional stormwater drainage and treatment capacity, we did not find any mechanism the City has established for calculating, charging, collecting, and using such a fee. We located BDC 3.4.160, Payment in Lieu of Sidewalk Construction, which allows the applicant in a particular zone to defer sidewalk construction and pay a fee to the City. Staff have noted that the payment in lieu of sidewalk construction does not work well, but we have not explored the topic further to discover why and whether a stormwater in lieu program could be successful in Bend.

The limitation to using the flexibility provided in 16.15.040.A.4 may include lack of standards for demonstrating the existing system has adequate capacity, lack of permitting options for this flexibility, and land use and engineering review procedures which standardize the maintenance of stormwater runoff and facilities on private property.

Procedures and Practices

See discussion of procedures under Section 3.

In addition, many infill projects go through the MDS review, which is designed to streamline the review process. We did not thoroughly study the MDS review process for this paper and cannot say whether it provides enough flexibility to accommodate less common stormwater management choices.

Funding

The City's funding for stormwater capacity, repair and replacement, operations, and compliance is limited to the stormwater fee charged to developed properties. The City has not established a system development charge or other fees in lieu that could fund the construction or operation of public stormwater systems that manage runoff that would otherwise be managed on a private property.

Perception of fairness for public funding of a private project could also be a barrier to allowing private runoff to be managed in the ROW. The City would need to require a rigorous demonstration of the infeasibility of on-site and centralized on-site options before allowing private runoff to be managed in the ROW.

Agreements

In the case where an infill is permitted to construct a stormwater facility in the ROW, due to infeasibility of doing so on the lot(s), then the City and the developer may need to execute a Public Facilities Improvement Agreement. These are not commonly used for infill and may pose a barrier.

Section 5. Developing Regional Facilities or Regional Stormwater Strategies

The City of Bend is investing in several locations such as Central Core/Midtown with the multiple aims of supporting economic development, improving public safety, providing adequate housing inventory, improving circulation, and beautification. Creation of regional stormwater strategies and/or regional stormwater facilities can support these aims. This section will review advantages, steps, and considerations for regional stormwater facility planning.

In recent years, regional stormwater facilities have been widely used in the Pacific Northwest to meet post-construction requirements for mitigating impacts from stormwater runoff for new development and redevelopment.

A regional stormwater facility is typically described as a large stormwater management solution strategically situated and designed to serve multiple properties, often under varied ownership, over a large area to optimize stormwater management as part of a development project or to facilitate redevelopment.

A regional stormwater strategy is a plan that addresses conveyance, water quantity control, and water quality treatment through a planned set of public, private, and/or public and private stormwater infrastructure. A regional stormwater strategy could include several types of solutions to manage runoff in a coordinated manner as opposed to site-by-site.

Advantages and Disadvantages

Several advantages that make regional stormwater facilities attractive to jurisdictions and developers include:

- **Lower design and construction costs.** One or two large regional stormwater facilities could be much more cost-effective to implement than multiple above-ground lot-scale stormwater facilities. This advantage may be less prominent or even non-existent where infiltration is the primary means of stormwater control.
- **Reduced operation and maintenance costs.** If a large regional facility replaces numerous small facilities, the overall cost of operation and maintenance may be reduced compared to the lot-scale approach. However, the cost to operate and maintain may shift, and the benefit may not be apparent to the owner. Fewer sites also increase the likelihood that maintenance activities are carried out regularly for both public and private operators.
- **Visibility.** Regional stormwater facilities have high visibility due to their size making them more likely to be maintained. This also engages the community to understand the purpose and benefits of the regional stormwater facility, and stormwater management in general.
- **Higher utilization of developable land.** Developers can maximize the developable land by minimizing the land normally set aside for the construction of stormwater facilities. Each stormwater facility may have minimum design requirements for setbacks, maintenance access, or other structural elements that may add to the overall “footprint” of a stormwater facility. This total area, while not providing direct stormwater management functionality, would be not available for developable land. Reducing the total number of stormwater facilities would increase the ratio of potentially buildable land.
- **Integration of stormwater solutions.** Regional stormwater facilities and regional stormwater strategies may solve or improve a variety of stormwater issues, including flooding, water quality concerns, and system repair and replacement.

- **Community benefits.** Well-designed regional stormwater facilities can serve as educational, recreational, ecological, and aesthetic amenities for a community.

Figure 13. Examples of Regional Stormwater Facilities

Alternatively, some potential challenges that may arise when considering regional stormwater facilities include:

- **Size and Siting.** One or several regional stormwater facilities may be difficult to site depending on the size, particularly in infill development.
- **Sequencing and Funding.** Coordinating the regional stormwater facility and related conveyance systems can be complicated depending on the number of property owners and developers involved, as well as the topography.
- **Time and Schedule.** Successfully implemented regional stormwater facilities typically completed rigorous planning, as well as reviewed options for funding, and possible permitting requirements. Additionally, land acquisition or easements must be in place before development can begin.

Building Blocks for Implementation

Discussions with Portland area jurisdictions revealed key lessons learned including the benefits of creating stormwater plans, writing codes that encourage regional facilities, and providing developers with guidelines and minimum standards. Without these building blocks, it can be difficult for a jurisdiction to successfully implement a regional approach for stormwater management. This section discusses some typical building blocks for implementation that we uncovered through studying recent examples of regional stormwater facility or stormwater system implementation.

Typically, jurisdictions that created targeted stormwater master plans for new growth areas or urban revitalization areas were able to work through many of the questions related to regional stormwater management prior to the new development. These plans laid the groundwork for codes and design standards that followed.

The planning effort can require long lead times to prepare and to conduct the various studies that might be needed. For example, the River Terrace development in Tigard, Oregon was a new growth area where the City intended to utilize regional facilities. Table 5 provides a general timeframe for that planning effort.

Table 5. Sample Project Timeline for River Terrace, Tigard

River Terrace Planning – Overall Timeline	
Added to Urban Growth Boundary	2002/2011
River Terrace Community Plan	2012-2014 (adopted)
Stormwater Master Plan	2014 (adopted)
Public Improvement Design Standards – Stormwater Management	2015 (adopted)
Development Start	2015

Planning for Success

Beginning with stormwater planning can help determine general feasibility and provide a transparent public document that describes the road map for achieving stormwater goals. A critical element to be determined early in the process will be the responsibility for operation and maintenance of these assets - the jurisdiction or the developer. If the former, the planning process can indicate that design standards will be developed, the types of components a jurisdiction is able to operate or require the developer to provide manuals and training for operational staff. This will drive several decisions during planning, codes drafting, design standards, and implementation of the projects.

Stormwater plans can also help piece together multiple services into broader vision through a regional stormwater planning approach. For instance, the greenway plan in Reeds Crossing in South Hillsboro is one example. This greenway provided active and passive recreation, wildlife habitat, natural areas to enhance views and aesthetics as well as stormwater management for the development. Creating multi-beneficial infrastructure can often enhance a development, as well as meet multiple stated community goals.

Figure 14 describes the key components to properly assess whether a regional stormwater approach would be feasible and compatible with future development sites.

Determine Options/Understand Site Conditions

- Are regional facilities an option for this site?
- Conduct a GIS analysis to identify low points and other features such as steep slopes, geology/infiltration characteristics and other major characteristics of the study area.
- Locate utilities, railroads, highways and other features that pose significant constraints
- Locate where water quality issues, flooding, or other problematic areas exist.

Develop Stormwater Strategy

- Determine multiple options for siting regional facilities including specific types, locations and estimated size.
- Note open space, park, plazas, streetscapes, or other amenity plans and goals and discuss if integrating those with regional stormwater facility would add benefits for the community
- Estimate construction costs.
- Consider future maintenance and operation access and costs and ownership options.

Prepare for Land Acquisition/Easements

- Identify properties not publicly owned but required for regional stormwater facility.
- Begin discussion with elected officials early about land acquisition and/or easements.
- Secure necessary approvals and budget before reaching out to property owners.
- Prepare solid arguments about why it's in their best interest to sell or allow easements.

Estimate Size/Location

- Begin to estimate how much stormwater needs to be detained to meet regulatory or code requirements and create conceptual designs for the facilities.
- If multiple facilities are required, create conceptual plan for the entire site including temporary facilities and conveyance infrastructure.
- Show community amenities if applicable.

Figure 14. Key Components of Planning for Regional Stormwater Facilities

Funding Regional Facilities

Numerous funding options exist and can generally be divided into revenue generated from private development and public funding raised through bonds or fees or Urban Renewal funds. Many jurisdictions utilize system development charges, fee-in-lieu, capital reserves, or capital financing to fund stormwater infrastructure.

System development charges (SDC) are one-time fees charged to developers to help pay for infrastructure or facilities (such as street and sewer systems) that are required to meet growth-related needs for that jurisdiction. SDCs are paid at the time that a development permit is issued. Geographically limited SDC's could also be created specifically to fund regional stormwater facilities.

Fees-in-lieu are allowed and collected per local codes to allow developments to move forward when physical constraints or other major obstacles prevent them from complying with the code as written. The revenue from these fees typically accrue over time and the amount of funds can vary depending on how quickly the jurisdiction uses those funds for already identified projects. Therefore, using fee-in-lieu for regional facilities may require a specific earmark to ensure the funds can be used for those projects[1].

Stormwater fees are collected under the City's stormwater utility and used specifically for operations, compliance, repairs and upgrades to the storm drainage system, and capacity extensions.

In addition to stormwater fee revenue, capital funding may be raised through municipal bond sales to fund large public infrastructure improvements for example water and wastewater, roads and bridges, and public transit. Bonds would be repaid through stormwater fees.

Urban Renewal is a state-authorized redevelopment finance program which use Tax Increment Financing (TIF) to reinvest or rebuild parts of cities that are physically deteriorated, economically stagnated, or unsafe. Bend has three TIF/Urban Renewal areas which are managed by the Bend Urban Renewal Agency (BURA): Core Area, Juniper Ridge, and Murphy Crossing.

For an example of private financing, a developer can fund a regional facility and negotiate a late-comer fee for other developments to connect to it.

Ultimately, staff will need to review the scope of work, the results from the stormwater planning, cost estimates, and align it with the ultimate vision for the regional stormwater facility. Creating a new funding mechanism may be necessary to facilitate the implementation of a regional facility.

Regional Facility Implementation

Jurisdictions that led with a robust stormwater planning process were more successful at implementing their plans and attracted developers willing to work with the cites to meet stormwater requirements. They were also able to successfully integrate community amenities with the regional stormwater approach.

Once necessary planning, code development, and/or design guidelines have been completed and funding mechanisms are clear, a jurisdiction would typically take the following steps toward implementation:

1. Jurisdiction adopts its stormwater plans and messages to the development community that this approach will reduce/eliminate individual lot-scale stormwater quantity controls in exchange for a regional facility approach.

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[1] Bend does not currently have a stormwater fee-in-lieu program, and the tradeoffs would need to be studied before implementing one to support regional facilities serving urban renewal areas or as an option for infill.

2. An implementation plan may be developed for larger, publicly led projects, or projects that have regulatory compliance and timeline implications.
3. Depending on how many developers are involved in the new growth area or specific development, the jurisdiction will either fund and build the regional stormwater facility or allow the developer to build the facilities as part of their projects.
4. Sequencing can be worked out with developers and allow for temporary facilities, if needed.
5. Developers may construct the adjacent conveyance infrastructure as part of the development project in greenfields or make use of existing public conveyances in the ROW in revitalization districts.

Developer-led implementation could also be successful; however, it may necessitate certain circumstances that allow it to move forward in a well-coordinated manner. Reimbursement districts, local development districts or similar codes would need to be in place to facilitate this type of implementation.

Regional Facility References from Pacific Northwest

Planning for Regional Stormwater Facilities

These plans specifically stated the intent to utilize a regional stormwater management approach in their developments or redevelopment areas and worked to integrate those goals into the larger vision for the community. They also discussed feasibility, sizing, land uses, funding, and the preferred approach.

- Red Rock Creek Regional Stormwater Strategy (2021) is a regional stormwater plan in Tigard, OR, which both supports redevelopment and mitigates existing urban impacts on the creek as discussed in the Tigard Triangle Urban Renewal Plan (2016) (see Appendix A).
- Northeast Redevelopment Area (NERA) Redevelopment Plan and Implementation Strategy, Burien, WA April 2010. Also see the NERA Master Drainage Plan, Appendix Sections 9 through 9e, available on the NERA web page.
- South Hillsboro Community Plan, December 2014
- Beaverton Creekside District Master Plan and Implementation Strategy, November 2014
- River Terrace Stormwater Master Plan, December 2015

Development Code for Regional Stormwater Facilities

Below are some examples of code that speak directly to the implementation of regional stormwater facilities including the Washington County ordinance that authorized the various charges and fees that can be used to fund regional facilities.

Burien Municipal Code, Chapter 13.10. See Section 13.10.280 for stormwater connection fee unique to NERA.

River Terrace Plan District, Chapter 18.640, Tigard Municipal Code

- Ensured regional stormwater facilities were visible drainage features that mimic natural systems.
- Ensured public access around most of the facilities.
- Required landscape and amenity features that integrated the facilities into the open space design of the development.

North Bethany Alternative Partition Standards, Washington County Development Code

- Laid groundwork for property acquisitions critical to implementing regional stormwater facilities
- Once Clean Water Services had this in place, they were able to estimate budget for land acquisition and approach landowners with the assurance that the County would allow and approve the purchase

Clean Water Services, Ordinance 40, 2013

The purpose of this chapter is to authorize charges, rates and fees for construction of, use of, and discharge to, the public surface water management system.

Clean Water Services Rate and Charges, July 1, 2024-June 30, 2025

Refer to Section C, Service Request Fees, sub-sections:

14. Regional Stormwater Management Charge (RSMC).

15. Fee-In-Lieu of Construction of Onsite Stormwater Management Approaches.

16. Reimbursement District Application Processing and Review Fees.

Implementation Plans

Often jurisdictions development implementation plans that follow master plan documents. These provide assurances to city officials and regulators that the design and construction of the project(s) will be well considered and that the schedule will meet any compliance dates or other schedule targets.

Overlake Village Stormwater and Park Facilities Conceptual Design, June 2010

Section 6. Summary and Next Steps

Summary of Options

Options currently exist and additional options could be created for more flexible management of stormwater in development. Adding tools to the toolbox could reduce conflicts between stormwater management and increasing density. Options include techniques other than lot-scale stormwater management that are allowed but infrequently used and techniques that may not currently be allowed. Table 6 summarizes all options discussed in the white paper. Table 7 summarizes the barriers to each option.

Table 6. Summary of Options

Development Type	Location of Stormwater Facility	Who is Draining	Facility Owner Existing Options [Recommended]	Approval Process	Current Status
Centralized On-Site Stormwater Management					
Residential Subdivision, streets and lots managed together	Street, tract, individual lot, or combination	Multiple lots and/or lots and street	Varies, HOA or City **[HOA on tract; City in ROW]** Consider whether collection & conveyance should be treated differently than disposal & treatment	Typically Type II	Allowed, some barriers
Non-Residential Site Development	Lot (e.g. Commercial Business Park)	Lot	Property owner	Typically Type II	Allowed, some barriers
Infill	Private property	Private	Private, could be HOA or individual owners	Typically MDS	Combining runoff from lots in infill allowed; drainage to street allowed but technically difficult and infrequently used
ROW Stormwater Management					
Infill	ROW	Private	City	TBD; not currently approvable	Allowed, significant technical and administrative barriers
Regional Facilities/ Regional Strategy					
Urban Redevelopment Area	TBD; could be ROW, individual lot, or tract	Multiple lots and/or lots and street	Determined during planning	Assume Type III	Unknown

Table 7. Summary of Barriers to Options

Development Type	Location of Stormwater Facility	Barriers			
		Current Codes & Standards	Procedures	Public Funding	Agreements
Centralized					
Residential Subdivision, streets and lots managed together	Street, tract, individual lot, or combination	Allowed via Master Planning, which is a more significant effort for developer and City than typical subdivision Potential lack of knowledge about or understanding of 16.15.040.A.4 and 6	Investigate if procedural barriers exist	If facilities are in ROW or on a tract dedicated to the City, funding for long-term maintenance by the City would be a barrier	Additional easements or covenants may be required.
Non-Residential Site Development	Lot	If street runoff comingles, Specification 6.4.1 only allows residential comingling	Investigate if procedural barriers exist	Public funding barriers are not applicable	N/A
Infill	Private property	MDS does not mention stormwater	Investigate if procedural barriers exist	Public funding barriers are not applicable	Easements or covenants may be required
ROW					
Infill	ROW	A barrier to using the flexibility provided in 16.15.040.A.8 may include lack of standards for demonstrating an existing system has adequate capacity	Investigate if procedural barriers exist	The City has not established a system development charge or fees in lieu that could fund the construction or operation of public stormwater systems that manage runoff that would otherwise be required to be managed on a private property.	Barrier not identified

Development Type	Location of Stormwater Facility	Barriers			
		Current Codes & Standards	Procedures	Public Funding	Agreements
Regional Facilities/ Regional Strategy					
Urban Redevelopment Area	TBD; could be ROW, individual lot, or tract	Current urban renewal ordinances do not codify a regional stormwater strategy	None identified	Options identified; capital planning would be necessary to access funds	None identified

Recommended Next Steps

City staff and developers are calling for more options for managing stormwater in Bend. The current typical lot-scale stormwater pattern has disadvantages. Some alternate options explored in this white paper are allowable but are infrequently used. Other options would require policy updates and minor updates to technical standards.

Centralized on-site stormwater management is allowable under many circumstances, and the policy, procedural, and technical updates needed to support more frequent use of this pattern are relatively minor.

ROW stormwater management is allowable under limited circumstances, but the City lacks a reimbursement mechanism for managing private runoff in the ROW and may lack procedural mechanisms for approving applications.

Tenets for Stormwater Management

City staff have articulated the following overarching tenets for guiding further investigation or implementation of changes to stormwater management policies:

- Public stormwater facilities should be constructed to public improvement standards and provide adequate access for maintenance.
- Stormwater facilities in the ROW should be owned and operated by the City.
- The City should identify adequate resources to maintain a larger inventory of public facilities if any recommendations to allow more public facilities are pursued and implemented.

Evaluate Tradeoffs

- Further evaluate the impacts to funding, operation and maintenance workload, plan review procedures, and staffing if the City wishes to promote the available options for centralized on-site stormwater management and/or increase the options for centralized and ROW stormwater management, especially when options may result in more public stormwater facilities.
- Consider how the two approaches to residential subdivision development impact developers' decisions on stormwater system planning.
- Consider whether centralized on-site stormwater management should be required in some areas where infiltration is poor or where infiltration may be unsafe, such as near steep slopes, or in some situations, such as when lot sizes are too small to accommodate on-site stormwater management.
- Consider whether to explore incentives for centralized on-site stormwater management, such as reduced setbacks or relaxed height limitations.

Policies and Procedures

- More investigation into land use and engineering review procedures may be warranted to assess whether procedures are limiting the use of stormwater options that are allowable in code.
- Consider adding stormwater to pre-application materials to increase awareness among staff and developers early in the land development process of existing options for centralized and ROW stormwater management within BMC 16.15.040A.4, 16.15.040.A.6, and 16.15.040.A.8 and BDC. For example, the Standards and Specification at 6.4.1 allow subdivisions to discharge stormwater to the ROW but only if this arrangement was approved during land use review.

- For infill housing, explore establishing a fee in lieu that would allow runoff to be managed in the ROW in a City-owned facility (BMC 16.15.040.A.4). Before implementing a fee in lieu, set the standard for eligibility, set other technical standards such as classification of the street, and research a fair cost.
- Consider adopting the flexible stormwater options codified in seven master planned developments (BDC 2.7, Figure 7) for residential developments city-wide with a Type II administrative land division.
- Coordinate with other departments and BURA to explore options for developing regional stormwater strategies for the Central Core, including the ongoing public improvements in Midtown, and other areas of City focus on economic development.
- Update Specification 6.4.1 to require facilities meet public improvement standard when private runoff is comingled in a public facility.
- Consider the appropriate division of ownership and responsibility for maintaining centralized on-site stormwater facilities. According to some staff, City ownership with private maintenance, as in the Luderman Crossing development, likely is not sustainable. This model has proven challenging in other cities. Likely the easiest revision to policies and procedures is to encourage HOA ownership and maintenance of centralized stormwater facilities. Another option is to require all centralized stormwater facilities to be owned and operated by the City. Impact to the City's budget would need to be evaluated. Consider the options for enforcing stormwater facility operation and maintenance if the HOA does not form or disbands.
- Evaluate the existing limitation on comingling stormwater in UIC facilities, which limits the options for centralizing on-site stormwater management (see BDC 2.7.4150.J.c).

Technical Standards

- Establish standards for use of deep drywells and stormwater trees on private property and in ROW.
- Propose to add "Not causing instability of slopes, buildings, or roadways" to BMC 16.15.040.A.10, which requires stormwater BMPs to consider public health, safety, and welfare and requires them to prevent flooding, prevent standing water that breeds mosquitoes, prevent attractive nuisances and dangerous conditions based on depth or velocity of water or access to drops, and prevent aesthetic nuisances due to excessive slopes, cuts, fills, vegetation mortality, or other.
- Establish criteria for demonstrating compliance with BMC 16.15.040A.4, 16.15.040.A.6, and 16.15.040.A.8 when centralized or ROW stormwater management options are proposed.
- Consider allowing weep holes from downspouts to the street when centralized on-site stormwater management or ROW stormwater management is used, and consider requiring perforated stub out on downspouts that lead to weep holes.
- Develop technical standards for how to demonstrate that on-site stormwater management was considered before moving on to other options.
- If the City decides to require centralized on-site stormwater management in certain circumstances or locations, develop zones or a map that integrates known geology, slope, infiltration rates and reference in the technical standards.

Promotion

- Promote existing or new options by recording a video and posting to the web site.

Appendix A:

Regional Stormwater Facility References

Red Rock Creek

Regional Stormwater Strategy

Submitted to:

Clean Water Services
2550 SW Hillsboro Hwy
Hillsboro, Oregon 97123

Prepared By:

Otak, Inc.
808 SW Third Avenue, Suite 800
Portland, Oregon 97204
Project No. 18505G

June 2021

Red Rock Creek Regional Stormwater Strategy

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Executive Summary

This Regional Stormwater Strategy was developed and submitted to Clean Water Services (CWS) with the goal of aligning stream corridor enhancements to Red Rock Creek with future development planned for the Tigard Triangle by the City of Tigard (City). The Red Rock Creek sub-basin lies almost entirely within the City of Tigard with the headwater in the City or Portland and is currently drained by a degraded stream channel that needs substantial stream corridor enhancement and localized stabilization. With large transportation and transit projects and new development on the horizon, the creek condition could become worse without a comprehensive strategy and implementation plan. Due to these factors, a Regional Stormwater Strategy was deemed appropriate for this section of Red Rock Creek.

The Regional Stormwater Strategy outlines how Red Rock Creek will benefit from the recommended stream corridor enhancement preferred approach by correcting past issues and accounting for new development and redevelopment in the future. Stream corridor enhancement is a multi-benefit approach that provides for stormwater management, improved stream channel stability and decreased risk to adjacent infrastructure and development, recreation in the form of trails that will be interconnected to the City-wide trail system, and improved riparian and wetland vegetation.

The preferred approach is presented here as an alternative compliance strategy to hydromodification requirements in the CWS D&C Standards. The Regional Stormwater Strategy recommends that the City of Tigard leads the implementation of the stream corridor enhancement projects to ensure that they are sequenced according to best practices and within a reasonable timeframe.

Regional Stormwater Strategy Goals

Once approved, this Regional Stormwater Strategy will provide the stormwater management approach that will address current conditions and support future development and redevelopment within the sub-basin boundary. The Regional Stormwater Strategy has the following goals:

- To provide a defensible justification for an achievable stormwater management approach for Red Rock Creek that may be implemented as an alternative approach to compliance with CWS D&C Standards (i.e., a recognized Regional Stormwater Strategy similar to that used in the River Terrace planning area)
- To protect natural resources against the effects of current and future hydromodification[1]
- To provide a stream channel approach that is resilient to current and future stream power and enhances stream ecosystem function of the stream corridor
- To align the approach with the City's planning efforts for the Tigard Triangle

Overview of Preferred Stormwater Management Approach

The preferred approach was developed by analyzing the erosive forces of peak flow from a 2-yr 24-hour storm under current and future conditions. This analysis included various future implementation scenarios that considered the effects of upland detention, LIDA, stream corridor enhancement, and the ecological benefits to the stream.

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[1] Clean Water Services defines hydromodification as the alteration of runoff volumes, rates, and timing resulting from increased impervious surface. This typically occurs with conversion of land uses from non-urban to urban, or within urban land uses, with a change in development density or type.

It was determined that LIDA and peak-flow matching detention designed per the D&C Standards may not protect Red Rock Creek from further hydromodification due to the degree of its current degradation. In addition, it is very likely that a comprehensive stream corridor enhancement would be necessary regardless of future development projections to provide any community amenities or ecological services. Therefore, the Regional Stormwater Strategy was considered as a candidate for an alternative approach based on stream corridor enhancement as opposed to a series of site-by-site detention facilities that could take years to realize any benefits to the creek, if at all.

The stormwater management approach described below is based on the assessment of the critical reaches and stream-power, as well as considering future built-out scenario of the sub-basin. By designing a stream channel and floodplain approach that will be resilient to current and future stream power, coupled with on-site water quality treatment using LIDA, the stormwater impacts to Red Rock Creek will be minimized and the stream health will be improved.

Therefore, the three main components of the preferred approach are as follows:

1) The preferred approach focuses primarily on enhancing Red Rock Creek's stream corridor and floodplain as the primary way to address hydromodification and flow control in the Strategy Area.
2) On-site water quality treatment using LIDA will continue to be required within the Regional Stormwater Strategy area (Figure 4).
3) Substantially enhancing the stream corridor and floodplain to meet the following CWS hydromodification objectives required for approval:
    - Stabilizes the stream channel and floodplain to safely convey and attenuate stormwater runoff within the sub-basin
    - Improves water quality through reduced in-stream erosion
    - Provides improvement of ecological functions through stream channel complexity and riparian vegetation enhancement
    - Protects sanitary infrastructure near the creek

Anticipated Next Steps

- Sub-basin strategy review and adoption
- Implementation Plan review and approval
- Stakeholder engagement
- Project coordination/land acquisition
- Design and construction

Red Rock Creek, Reach 11

Watershed and Sub-basin Characterization Summary

Red Rock Creek is situated within the Tualatin River watershed and mostly within the City of Tigard, but with its headwaters within the City of Portland. Red Rock Creek flows from the flanks of Mt. Sylvania southwest into Fanno Creek, which is tributary to the Tualatin River (Figure 1). Red Rock Creek's drainage area is 1,042 acres located on the eastern edge of Tigard where commercial/industrial buildings, box stores, office complexes, and three major transportation corridors dominate the landscape (Figure 2). 356 acres of the Red Rock Creek drainage area (east of I-5) is located in the City of Portland and is not part of this Regional Stormwater Strategy.

The 686 acre Regional Stormwater Strategy Area ("Strategy Area") is defined as the portions of the Red Rock Creek sub-basin located within the City of Tigard (Figure 2). The Strategy Area primarily lies within the Tigard Triangle bound by Interstate 5, Highway 217, and Highway 99W. 58% percent of the Strategy Area is presently impervious.

There are no named tributaries flowing into Red Rock Creek and its flow inputs are comprised almost entirely of stormwater discharge. For the purposes of this study the creek was characterized by 14 reaches that are described below. Within the Strategy Area, the creek's elevation change is approximately 175 ft over its 1.86-mile length. The average longitudinal slope of reaches 1-6 is 0.7% and the average longitudinal slope of reaches 7-14 is 3.3%.

Because most of the land within the Strategy Area is paved, large volumes of stormwater runoff are delivered quickly to Red Rock Creek. Additionally, the three major roadways drain into the area and ultimately to the creek. The combined result is a flashy and erosive stream network. The creek has incised significantly in portions of reaches 7-14. With a significant amount of impervious surface directing uncontrolled runoff to the creek, Red Rock Creek water levels rise quickly during typical storms. In heavy rain, the creek has been known to rise 8 to 10 feet in as little as 15 minutes. The effects of these fast, high flows are exacerbated by constriction and alteration of the overbank in some reaches.

Red Rock Creek, Reach 1

In the upper reaches, the creek flows through steep terrain, often in ravines. In contrast, the uplands adjacent to the lower reaches are flatter and the stream gradient is low. Eroded soils from the steep sections are transported downstream and settle out in the flat portions, where they block culverts and fill wetlands.

According to CWS's Hydromodification Planning Tool, Red Rock Creek's reaches have a medium to high risk of erosion. The areas with risk of critical damage from erosion in Red Rock Creek is where the sanitary sewer line is located near the channel. The erosive forces of urban stormwater runoff have carved the creek channel lower than the sewer line. When sections of the streambank fall into the creek due to erosion, the sewer line can become exposed. In the last decade, the sewer line has broken six times. The location where the sewer line is most susceptible to damage is in Reach 7.

Water quality is also a concern in Red Rock Creek as a tributary to Fanno Creek. Fanno Creek is home to native fish including endangered salmonids, and has total maximum daily loads (TMDLs) under the Clean Water Act for phosphorus, bacteria, dissolved oxygen, and temperature. Metals, nutrients, bacteria, and toxic compounds like pesticides are often carried into streams with urban stormwater runoff. Red Rock Creek lacks shade where riparian canopy cover has been reduced or removed. Shade from canopy cover is important to maintain because it effectively cools streams. Warm water can stress or kill cold-water fish such as native salmon and steelhead.

The 2018 Tigard Stormwater Master Plan recommended six Red Rock Creek capital improvement projects (CIPs) that would expand detention capacity in existing natural areas and help prevent erosion that threatens the sanitary sewer pipe by stabilizing the channel bed and banks and improving the floodplain. It also recommended a Tigard Triangle Stormwater Implementation Plan to support redevelopment and transportation improvements while also supporting improvements to water quality and stream condition.

The Implementation Plan proposes to divide the stream channel enhancement work into four priorities. Each priority will have a design and construction project to be sequenced using best practices to minimize impacts to Red Rock Creek. The CIPs recommended in the Stormwater Master Plan will be replaced with the Regional Stormwater Strategy's preferred approach in the Implementation Plan. The implementation plan will include conceptual designs, cost estimates, project completion plan, coordination plan for trails and parks, recommended code changes, and phasing and sequencing plans.

Future Build-out and Land-use Assumptions

Future zoning and land use for the Tigard Triangle is outlined in the 2019 update of the Tigard Triangle Plan District. Generally, the commercial area on the western edge of the Triangle will remain commercial use and the eastern side will become mixed use, transit-oriented development. A new transportation network with new roads and trails is planned for the area by the City, as well as TriMet's planned Southwest Corridor expansion of the light rail system.

Currently, the Strategy Area is 58% impervious distributed throughout the sub-basin within big box commercial lots and lower density residential areas. The future condition assumes that the lower density areas will be redeveloped, as will vacant and under-developed lots, and that impervious cover will increase to a maximum of 95% within the Tigard Triangle exclusive of open spaces and LIDA facilities. Open space will be preserved along the creek and one or two parks are currently being planned in the upland areas. As new roads and transportation infrastructure is built out, it is likely that drainage and conveyance catchments will change slightly overtime.

Vegetated Corridor

CWS's D&C Standards define "vegetated corridor" as measured from the edge of the Water Quality Sensitive Area (i.e. stream channel) upland through the riparian zone between 25 feet and 200 feet on both sides of the stream. The required width varies depending on topography, existing development, and other conditions per the D&C Standards.

The vegetated corridor for Regional Stormwater Strategy is represented as a 60 ft buffer on each side of the proposed 2-yr top width or the surrounding wetland areas for descriptive purposes to generally show the extent of the vegetated corridor. The 60 ft buffer is intended to allow for a multi-use trail to be incorporated within the Vegetated Corridor limits. This designation is not based on a site-specific survey, which will be required as part of project design.

Any development undertaken prior to the approval of this Regional Stormwater Strategy must comply with CWS D&C Standards for vegetated corridor. In some cases, the City may approach landowners and developers about acquiring land or an easement along the vegetated corridor as part of the preferred approach. The vegetated corridor is shown in Figure 4 below.

Description of Critical Reaches

A site visit was conducted to determine the critical reaches that are representative of the various conditions in Red Rock Creek. Red Rock Creek's headwaters and upper reach are located within the City of Portland and not included in this sub-basin strategy. The reaches within the City of Tigard were assessed during field visits conducted in February 2020, and they can be grouped into four characteristic areas as follows, beginning at the downstream end. In general Reaches 1-6 are relatively flat and do not exhibit significant erosional degradation while Reaches 7-14 are steep and have shown significant erosion of the native silty materials in the form of channel incision and bank failure. A map of the reaches is shown in Figure 3.

1. **Reaches 1- 3** are low gradient with beaver activity. The downstream reaches have a wide, accessible floodplain and the upstream reach is confined in a narrow channel by industrial buildings on both side of SW Hunziker Street. Beaver dams occur periodically with a drop of 12-18 inches at low flows. There is minimal evidence of erosion.

2. **Reaches 4-6** include the Knez wetland and major crossings at Hwy 217 and SW Dartmouth Street. Between Hwy 217 and SW Dartmouth Street (Reach 5) the channel is meandering and the downstream half of the floodplain is forested wetland. Upstream of the SW Dartmouth (Reach 6) culvert has ponding and sediment accumulation, likely due to decreased capacity of the SW Dartmouth Street culvert crossing and downstream channel from sediment accumulation from upstream erosion.

3. **Reaches 7-9** are characterized by a long culvert under the theater parking lot as reach 8, with channel incision ranging from 2 ft to 9 ft in reaches 7 and 9 with the deepest incision occurring at the upstream end of reach 7 at the outfall of the culvert the crosses the cinema access and parking lot. Upstream of the culvert a series of tree roots is stabilizing the channel from incision, although there is a constructed grade control at one location

4. **Reaches 10-14** upstream of SW 72nd St. include a damaged culvert under SW 68th St. Channel incision in these reaches ranged from 1 ft to 7 ft with the deepest incision occurring in the middle of reach 13. Reach 11 is a constructed grade control that is approximately 8 ft high in total through a series of drops ranging from 0.5 ft to 1.0ft that has prevented deeper incision of upstream reach 12. Reach 14 is downstream of the I-5 culvert and has been armored with riprap with a maximum diameter of approximately 2 ft.

Stream Power and Velocity Assessment

The TRUST hydrologic model was used to calculate peak flows for existing conditions, more details on the technical analysis is available in the Red Rock Creek Regional Stormwater Strategy Technical Analysis (Otak, 2021). The 2-yr peak flow was used to calculate the unit stream power and velocity for each reach to estimate the erosive power of the stream as energy is dissipated against the bed and bank of the stream. Unit stream power is a function of the flow, slope, and top width of the stream. Velocity is a function of flow, slope, hydraulic radius, and Manning's n. The inputs are estimated from the following:

- Flow: TRUST modeling of the Red Rock Creek Basin
- Slope: upper and lower reach elevations taken from LiDAR divided by reach length

- Top Width: field measurements averaged by reach
- Hydraulic Radius: Assumed rectangular cross section to calculate from top width in Manning's equation
- Manning's n: estimate from field conditions as 0.055 for reaches 1 to 6 where the 2-yr flow can generally access the vegetated floodplain and as 0.045 for reaches 7-14 where the 2-yr flow is largely contained within the incised channel.

The existing 2-yr unit stream power and velocity by reach is summarized in Table 1. Reaches 1-6, where erosion is not a major issue, are characterized by unit stream power of less than 10, ranging from 1.4 to 7.8 and velocity of less than 5.0 ft/sec, ranging from 2.1 ft/sec to 4.2 ft/sec. Reaches 7-14, where erosion is a major issue, are characterized by unit stream power of greater than 10, ranging from 12.3 to 51.9 and velocity of more than 5.0 ft/sec, ranging from 5.3 ft/sec to 8.5 ft/sec. Note that reach 12 has a unit stream power and velocity of 6.6 and 4.6 ft/sec respectively because it has been stabilized by the downstream constructed grade control that comprises reach 11.

Table 1: Existing Conditions Unit Stream Power and Velocity by Reach

Reach	Description	Unit Stream Power	Stream Velocity (ft/s)
1	Fanno Creek confluence to railroad. Accessible floodplain with beaver dams.	2.8	3.0
2	Railroad to Hunziker Street. Accessible floodplain with beaver dams. Variable bank width.	3.6	3.2
3	Upstream of Hunziker Street. Straight and narrow through industrial buildings; no floodplain access. Beaver dam at upstream end.	1.5	2.1
4	Knez Wetland downstream of Hwy 217. Accessible floodplain with beaver dams.	1.4	2.5
5	Hwy 217 to Dartmouth Street. Accessible floodplain with meandering channels and beaver dams.	7.8	4.0
6	Upstream of Dartmouth Street. Ponded area with accessible floodplain. Sediment deposits from upstream erosion. Beaver dam at upstream end.	5.2	3.4
7	Babies R Us location. Beaver dam to theater culvert. Deeply incised channel with no floodplain access. Wide greenway surrounds the reach.	14.5	5.7
8	300 ft long 48" diameter culvert under movie theater parking lot	18.2	5.8
9	Theater to 72nd St. Straight, narrow channel through narrow riparian corridor. No	12.3	5.1

Reach	Description	Unit Stream Power	Stream Velocity (ft/s)
	floodplain. Channel incision and exposed tree roots acting as grade control.		
10	Immediately upstream of 72nd St. floodplain is wide and accessible. Farther upstream channel is incised with vertical banks in some areas and densely packed clay soils.	13.7	5.5
11	Short reach where engineered rock grade control was previously constructed over a 5 ft drop, with sandbags stabilizing banks.	14.8	5.7
12	Downstream of 68th St. Incised channel with undercut banks, some gravel deposits, and no floodplain access.	6.6	4.5
13	Sediment deposits have damaged the upstream end of the 68th St. culvert. Reach contains rock and gravel deposits, has accessible floodplain. Upstream end is incised with vertical banks.	14.5	5.7
14	Rock armoring of bed and slope is intact, except at end of reach where there is an approximate 3-ft drop and the armoring is undermining	51.9	8.3

Stormwater Approach

According to the CWS Hydromodification Planning Tool, Red Rock Creek has both high risk reaches and moderate risk reaches for hydromodification. The reaches of Red Rock Creek within Tigard have a moderate risk level. The high-risk level reaches are within the City of Portland east of I-5 and are not considered part of this Regional Stormwater Strategy risk levels are defined by CWS as follows:

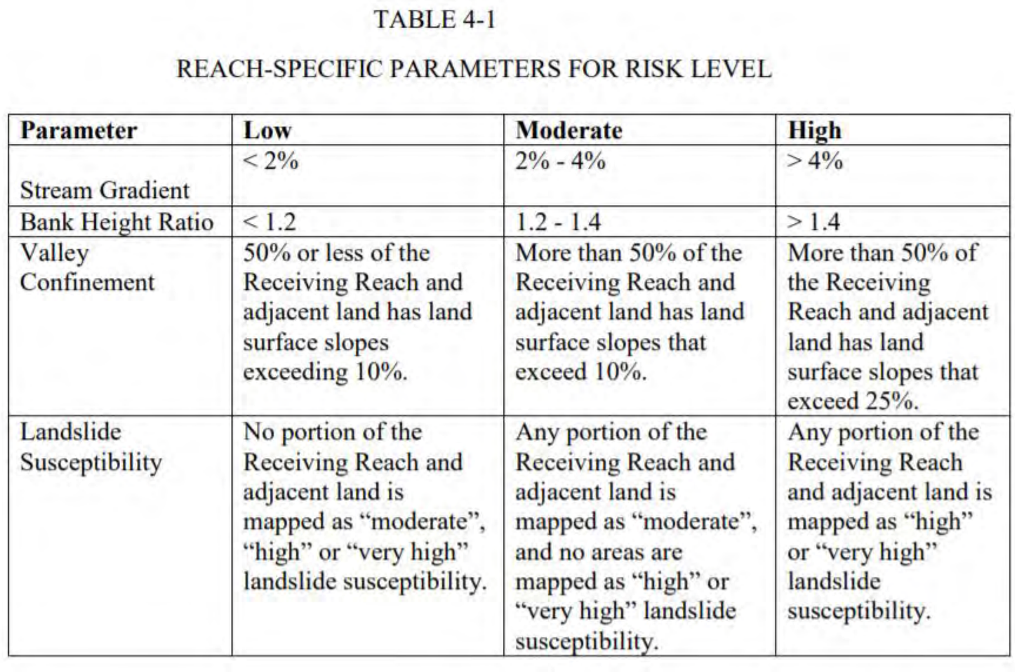


TABLE 4-1

REACH-SPECIFIC PARAMETERS FOR RISK LEVEL

Parameter	**Low**	**Moderate**	**High**
Stream Gradient	< 2%	2% - 4%	> 4%
Bank Height Ratio	< 1.2	1.2 - 1.4	> 1.4
Valley Confinement	50% or less of the Receiving Reach and adjacent land has land surface slopes exceeding 10%.	More than 50% of the Receiving Reach and adjacent land has land surface slopes that exceed 10%.	More than 50% of the Receiving Reach and adjacent land has land surface slopes that exceed 25%.
Landslide Susceptibility	No portion of the Receiving Reach and adjacent land is mapped as “moderate”, “high” or “very high” landslide susceptibility.	Any portion of the Receiving Reach and adjacent land is mapped as “moderate”, and no areas are mapped as “high” or “very high” landslide susceptibility.	Any portion of the Receiving Reach and adjacent land is mapped as “high” or “very high” landslide susceptibility.

Per the D&C Standards, moderate risk reaches require either LIDA or Peak-Flow matching detention, or any combination thereof to meet hydromodification requirements.

It is anticipated that development would consist largely of moderate to large sites (>12,000 SF) that would typically require large detention facilities. These are harder to locate in dense areas with significant trade-offs between costs, space-efficiency, and opportunities for multiple benefits. These constraints can make it difficult to meet the flow control standards.

LIDA and peak-flow matching detention designed per the D&C Standards may not protect Red Rock Creek from further hydromodification due to the degree of its current degradation. In addition, it is very likely that a comprehensive stream corridor enhancement would be necessary regardless to provide any community amenities, or ecological services. Therefore, the Regional Stormwater Strategy will be used as a candidate for an alternative approach grounded in stream stabilization and stream corridor enhancement as opposed to a series of site-by-site detention facilities that could take years to realize any benefits to the creek, if at all.

The stormwater management approach described below is based on the assessment of the critical reaches and stream-power, as well as considering future built-out scenario of the sub-basin. By designing a stream channel and floodplain approach that will be resilient to current and future stream power, coupled with on-site water quality treatment using LIDA, the stormwater impacts to Red Rock Creek will be minimized and the stream health will be improved.

Based on the Regional Stormwater Strategy characteristics and the stated the goals for the Tigard Triangle, the preferred stormwater management approach is to provide stream corridor enhancement that will improve the stability and ecological function of the stream and will be designed to be stable with the contributing flows. On-site stormwater quality treatment using low impact development approaches (LIDA) will be required, but private property owners within the Strategy Area that pay a fee in-lieu to support the instream work will not be required to provide detention facilities to meet hydromodification requirements. The stormwater management approach is shown in Figure 4.

Hydrology

Peak flows were determined using the TRUST hydrology model for existing conditions within the Red Rock Creek watershed and for proposed conditions assuming full build-out of the Tigard Triangle (**Error! Reference source not found.**2). Full build-out assumed that within the Tigard Triangle areas other than proposed open spaces would be developed to 95% impervious area and 5% landscaping.

LIDA was assumed to replace 6% of the impervious area, resulting in a total of 89% impervious area, not including open spaces. This results in a total proposed impervious area within the Tigard Triangle of approximately 79%. LIDA was assumed to use a flow-through configuration, have a 6-inch depth storage and 2 in/hr infiltration rate, consistent with CWS standards. Full development with LIDA does decrease the peak flows in the upper reach when compared to existing conditions because the existing basins is already mostly impervious without water quality or flow control facilities, see Appendix A, Technical Analysis, Table 5. In the lower reach for the 10-yr and 100-yr flows full development with LIDA increases the flows when compared to existing, likely due to peak flows resulting from the LIDA facilities and the downstream storage being coincident.

Table 2: Existing and Proposed TRUST Peak Stream Flows

Location	Reaches	Existing Peak Flows (cfs)			Proposed Peak Flows (cfs)		
		2-yr	10-yr	100-yr	2-yr	10-yr	100-yr
I-5	12, 13, 14	59.7	79.7	98.2	57.3	74.9	90.1
68th	10, 9, 8	68.4	90.6	110.9	63.8	82.7	98.9
72nd	7	73.3	94.7	112.9	66.3	85.6	102.0
Atlanta St	6	91.4	117.6	139.8	75.5	101.9	130.0
Dartmouth	5	117.8	149.9	176.8	101.2	145.4	202.1
Hwy 217	3, 4	97.0	111.3	123.4	90.8	125.7	177.2
Hunziker	1, 2	140.2	166.7	191.9	131.3	186.8	268.5

Regional detention options were considered as part of the approach by identifying three potential contributing storm catchments in the upper reaches were the main stream corridor problem is erosion caused by undetained flows. The detention facilities were modeled in TRUST and the resulting flow reduction was minimal because most of the flow generated in the upper basin is coming from the City of Portland and there are limited regional detention options due to smaller distributed pipe catchments and limited potential locations for providing regional detention due to existing development. Therefore, detention would have minimal impacts on reducing stream power and velocity. This means that the stream corridor rehabilitation design is likely to be similar whether regional detention is also incorporated or not the use of regional detention is not recommended for the preferred approach at this time. If it is impractical to design and implement a stream corridor rehabilitation design that can handle the increased runoff that occurs under full development, then regional detention options should be considered and implemented to ensure that flows do not exceed the capacity of the stream rehabilitation. The regional detention analysis is discussed in more detail in the Red Rock Creek Regional Stormwater Strategy Technical Analysis (Otak, 2021).

Stream Corridor Rehabilitation Design Goals

Stream corridor enhancement projects will be designed for reaches 1 to 13 as described in Table 5. The proposed unit stream power and velocity was taken from planning level analysis, and a full analysis of velocity and stability should be performed during design. There may be localized high velocity areas within a reach that will require a unique design. The stream corridor enhancement projects can be described based on two main sections, Reaches 1-6 where erosion is not a major problem, and Reaches 7-13 where erosion is a major problem and will be addressed as described below.

Cross sections should be designed to improve ecological function by incorporating large wood and providing benches for vegetation establishment outside of the main channel portion of the cross sections. The cross sections should also be stable at peak flows as determined by the latest hydrologic modeling. The channel portion of the cross section should be designed to contain ½ of 2-yr peak flow and in some cases the 2-yr peak flow.

Due to the highly erodible nature of the native soil in reaches 7-14 a stable cross section should be designed to contain the 100-yr peak flow. In the lower reaches 1-6 the existing overbank should be accessed by flows greater than the 2-yr peak flow, except to provide retaining walls necessary to protect adjacent buildings.

Specifically, the project description and goals for Reaches 1-6 include:

- Improve the ecological condition of the stream by incorporating in-channel large wood and floodplain benches/alcoves if opportunities exist.
- Riparian vegetation enhancement and management
- Channel and bank stability suitable in relation to adjacent infrastructure
- Maintain existing longitudinal slope and existing beaver dam and tree root grade controls
- Clear aggraded sediment obstructions from channel to convey half-2 yr to 2-yr flow in-channel, higher flows should access the existing overbank / floodplain.
- If the floodplain is constrained by nearby development then retaining walls should be used to contain the 100-yr flood, or land acquisition for floodplain restoration should be pursued

Typical top widths for the channel sections in these reaches shown are shown in Table 3.

Table 3: Typical top widths and Manning's n for proposed reaches 1-6

Peak Flow	Top width (ft)	Manning's n	Manning's n description
½-2-yr	10	0.045	Straight channel with periodic beaver dams, flow accesses riparian fringe vegetation.
2-yr	15	0.055	Same as above but with more interaction with riparian vegetation
100 yr with retaining wall	30	0.15	Dense shrubs and ground cover on low riparian area bordered by a retaining wall that will contain the 100-yr flow
100 yr Existing Floodplain	N/A	0.15	Dense shrubs and ground cover on accessible floodplain

Specifically, the project description and goals for Reaches 7-13 include :

- Improve the ecological condition of the stream by incorporating in-channel large wood and overbank areas accessible to flow
- Riparian vegetation enhancement and management
- Channel and bank stability suitable in relation to adjacent infrastructure
- Reduce channel longitudinal slope between grade control drops and add stable in-channel large wood and coarse bed material to dissipate energy and increase roughness to reduce flow velocities and increase permissible velocities and stream power.
- Reconstruct longitudinal slope using structural grade controls that meet fish passage with vertical drops of not more than six inches. Longitudinal channel slopes between drops should result in 2-yr unit stream power of less than 10 and 2-yr velocity of less than 5 ft/sec. This analysis assumes that the longitudinal channel slope between drops is 1.5%.
- Shape channel bed to provide a low-flow channel while spreading peak flows to reduce flow depth and shear stress
- 100-yr flood conveyance should be contained within the channel cross sections.
-

Typical top widths for the channel sections in these reaches are shown in Table 4.

Table 4: Typical top widths and Manning's n for proposed reaches 7-12, and reach 12 shown in brackets

Peak Flow	Top Width (ft)	Manning's n	Manning's n description
½-2-yr	10 (6)	0.045	Large wood and coarse stable bed material, relatively straight channel along existing alignment, little vegetation establishment
2-yr	20 (12)	0.045	Same as above
10 yr	30 (18)	0.1	Riparian vegetation with ground cover, shrubs, and trees
100 yr	40 (24)	0.15	Riparian vegetation with ground cover, shrubs, and dense trees

Table 5: Existing (EX) and Proposed (PR) Stream Design Approaches, and Unit Stream Power, and Velocity for the 2-yr peak flow

Reach	Stream Corridor Enhancement Approach	Unit Stream Power		Velocity (ft/s)	
		EX	PR	EX	PR
1	Add large wood to channel and clear obstruction caused by sediment accumulations. Create lowered floodplain benches where possible. Riparian vegetation enhancement.	2.8	2.4	3.0	2.9

Reach	Stream Corridor Enhancement Approach	Unit Stream Power		Velocity (ft/s)	
		EX	PR	EX	PR
2	Add large wood to channel and riparian vegetation enhancement. Protect existing beaver dams. Potential land acquisition at start and end of reach to widen floodplain, otherwise retaining walls may be required for riparian vegetation and flood conveyance	3.6	2.9	3.2	3.2
3	Add large wood to channel and riparian vegetation enhancement. Potential land acquisition to widen floodplain, otherwise retaining walls may be required for riparian vegetation and flood conveyance	1.5	0.6	2.1	1.8
4	Protect beaver dam in Knez wetland. Add large wood to channel and create lowered floodplain benches where possible. Riparian vegetation enhancement	1.4	1.9	2.5	2.7
5	Clear channel obstructions caused by sediment accumulation, especially downstream of SW Dartmouth Street culverts. Add large wood to channel, protect existing tree root and beaver dam grade controls or use beaver dam analogs where needed.	7.8	2.1	4.0	2.8
6	Clear channel obstructions caused by sediment accumulation. Add large wood to channel. Riparian vegetation enhancement.	5.2	1.6	3.4	2.6
7	Reconstruct incised stream corridor by raising bed/lowering floodplain with a channel section that contains the 100-yr flow. Install structural grade controls to maintain channel stability and install coarse bed materials and large wood to dissipate energy and reduce velocities. Riparian vegetation enhancement.	**14.5**	3.5	**5.7**	3.8
8	Daylight culvert and reconstruct incised stream corridor by raising bed/lowering floodplain with a channel section that contains the 100-yr flow. Install structural grade controls to maintain channel stability and install coarse bed materials and large wood to dissipate energy and reduce velocities	**18.2**	3.1	**5.8**	3.6
9	Construct stream section that will contain the 100-yr floodplain using structural grade controls for stream stability. Riparian vegetation enhancement.	**12.3**	3.1	5.1	3.6

Reach	Stream Corridor Enhancement Approach	Unit Stream Power		Velocity (ft/s)	
		EX	PR	EX	PR
10	Reconstruct incised stream corridor by raising bed/lowering floodplain with a channel section that contains the 100-yr flow. Install structural grade controls to maintain channel stability and install coarse bed materials and large wood to dissipate energy and reduce velocities. Riparian vegetation enhancement.	**13.7**	3.0	**5.5**	3.6
11	Replace/Modify existing grade control structure to reduce drop height, spread out drops, and contain the 100-yr flow. Install coarse bed materials and large wood to dissipate energy and reduce velocities. Riparian vegetation enhancement.	**14.8**	3.0	**5.7**	3.6
12	Reconstruct incised stream corridor by raising bed/lowering floodplain with a channel section that contains the 100-yr flow. Install structural grade controls to maintain channel stability and install coarse bed materials and large wood to dissipate energy and reduce velocities. Riparian vegetation enhancement.	6.6	3.0	4.5	3.6
13	Reconstruct incised stream corridor by raising bed/lowering floodplain with a channel section that contains the 100-yr flow. Install structural grade controls to maintain channel stability and install coarse bed materials and large wood to dissipate energy and reduce velocities. Tie-in to reach 14 armoring with an energy dissipator Riparian vegetation enhancement.	**14.5**	4.4	**5.7**	4.0
14	No action, existing rock armoring protects slope erosion.	51.9	3.6	N/A	N/A

Phasing

The four stream corridor enhancement sections have been prioritized for a phased approach to construction. Stabilizing the upstream reaches first will prevent sedimentation of the downstream reaches after then have been improve. A more detailed discussion of the project phasing and their capacity to provide stormwater management is available in the Red Rock Creek and Tigard Triangle Stormwater Implementation Plan (Otak, May 2021)

1. Reaches 5b-9 (Crystal Lake to 72nd). This is the highest priority section due to the potential for streambank failure that could undermine adjacent infrastructure such as sanitary sewer and parking lots, particularly in Reach 7. This is also the reach that is most likely to redevelop first. Removal of the cinema parking lot culvert in Reach 8 and enhancement of Reach 9 would occur as the cinema property redevelops and could take place after Reach 7 is stabilized. Reach 5b

extends approximately 500 feet downstream of SW Dartmouth Ave and is part the first phase to improve the conveyance downstream of SW Dartmouth Ave which is currently limited due to sediment deposits.

2. Reaches 10-13 (upstream of 72nd). This section is less critical because there is more distance between the steep incised banks and nearby development or utilities. This area is also less likely to develop soon. The reach also requires significant reconstruction of the incised stream channel and structural grade control. Reaches 10, 11, and 12 between 68th and 72nd should be built as a single project since the grade control structure in reach 11 will need to be replaced/modified, potentially impacting the long profile of both Reach 12 upstream and Reach 10 downstream.
3. Reaches 1-3 at the downstream end of Red Rock Creek are in an area with a high potential for redevelopment. Stream corridor enhancement in this section will focus more on habitat quality improvement than stream energy management. Some easement or property acquisition may be required.
4. Reaches 4-5a may be the last section to rehabilitate. The creek already has access to the floodplain, and habitat quality and wetland function can be improved.

Cost Estimates

The following cost estimate is based on the Stormwater Master Plan toolkit costs that have been updated to reflect the stormwater management approach and adjusted for inflation of 4% per year. Land and easement acquisition are included as an approximate range. Design and permitting as a percent of cost of construction and contingency is also included. More information is provided in the Red Rock Creek and Tigard Triangle Stormwater Implementation Plan (Otak, May 2021)

Table 6: Estimated costs to implement the recommended stream corridor enhancements

Project		Reach		Estimated Cost (2021)	
ID	**Priority**	**Number**	**Description**	**Per Reach**	**Per Priority**
6	1	5b	Crystal Lake to Dartmouth St	$454,800	**$ 5,005,700**
		6	Dartmouth St to Babies r Us Beaver Dam	$695,500	
		7	Babies r Us Beaver Dam to Atlanta St	$1,248,900	
7		8	Theater Culvert, Atlanta St to 74th Ave	$1,444,700	
		9	74th Ave to 72nd Ave	$1,161,800	
8	2	10,11,12	72nd Ave to 68th Pkwy	$2,527,200	**$ 4,188,300**
9		13	68th Pkwy to Existing Channel Armoring	$1,661,100	
2	3	2	Hunziker St to Railroad	$2,931,200	**$ 4,973,400**
3		3	Hunziker St to Knez Wetland	$1,411,400	
1		1	Fanno Creek to Railroad	$630,800	
4	4	4	Knez Wetland	$499,600	**$ 954,400**
5		5a	Hwy 217 to Crystal Lake	$454,800	
				TOTAL	**$ 15,121,800**

Project Design Considerations

Under the preferred approach, the following could become a risk to costs and schedule and should be fully considered during the development of the Implementation Plan and/or design phase:

1. Materials

Cross sections should be designed to improve ecological function by incorporating large wood and providing benches for vegetation establishment outside of the main channel portion of the cross sections. Design analysis should ensure that the design will be stable under proposed flows

2. Land Acquisition and Easements

Once the Implementation Plan is complete, the extent to which acquisition and easement will be necessary will be made clear. The stream channel survey will identify where the preferred approach will implement stream channel enhancement area and where that overlaps with tax lots along the creek.

3. Contaminated Site Assessments

At a minimum, a Level 1 Site Assessment is recommended during the Implementation Plan or early design phase to confirm the presence of any contaminated soils within the scope area of the preferred approach. Further testing could be necessary based on the Level 1 results.

4. Permitting Considerations

While final permitting requirements cannot be confirmed in the Regional Stormwater Strategy, the nature of the work could require the following permits, reviews, and approvals:

- Section 10, Army Corp of Engineers
- Section 404, Army Corps of Engineers
- National Marine Fisheries Services, either SLOPES V or a formal consultation
- 401 Water Quality Certification, Oregon Department of Environmental Quality (DEQ)
- Remove-Fill Permit, Department of State Lands
- 1200-C Construction Permit, DEQ
- City of Tigard Land Use Application/Sensitive Land Review
- Additional submittals and approvals may be needed if hazardous materials or historic/cultural resources could be present in the project area

5. Other utilities and infrastructure

Other utility and infrastructure work planned in the Strategy Area include repairs to a sanitary sewer located within the vegetated corridor. New and reconstructed roadways, and potential new light rail is also planned and could have an impact on the preferred approach depending upon the need for new outfalls or new or improved creek crossings.

6. New outfall locations

This would be determined in the implementation phase or design phase. All public and private improvements would be encouraged to use existing outfalls but, in some cases, may need to construct new outfalls that discharge to the stream. Energy dissipation at newly constructed outfalls, using vegetation and other naturalized materials or structures, should be incorporated into the design.

7. Culvert or Bridge Roadway Crossings

The preferred approach projects along the stream corridor should consider future conditions for roadway improvements that may impact culverts or bridge crossings. This work may not be included in the scope of the preferred approach projects but should be considered as part of the stream corridor design.

8. Beaver Management

The presence of beavers has been confirmed along Red Rock Creek. The Implementation Plan and design phase should ensure that a compatible design/approach is considered. The preferred approach will not rely on beaver activity to create stability but the design should try to accommodate beaver activity by creating flat areas around culverts so that beaver activity is directed away from the culverts to avoid clogging.

9. Construction Access

Access to the construction site should be assessed during design. It should be made safe and available for all necessary personnel, vehicles and equipment. Designs should incorporate access paths/roads to accommodate loading requirements for all necessary vehicles. In the preferred approach, there are no major obstacles for construction access. There are some access points that require easements through private property, and in some cases permanent easement or acquisition may be needed to ensure the full project scope and benefits are realized.

10. Maintenance Access

In some cases, construction access can be made permanent as maintenance access once completed, or additional maintenance access can be planned as part of the final design. In the case of the preferred approach, floodplain maintenance will be necessary for replanting, debris and litter removal, and other necessary activities. Access to outfalls, culverts and other structures in and near the creek should also be considered during design.

Opportunities to Coordinate with Existing Plans & Projects

As mentioned above, the Red Rock Creek stream corridor has been identified as both an important natural resource but also a community resource for passive and active recreation such as walking and biking trails. Tigard's vision is also to link existing open space, parks, and other bike infrastructure to Red Rock Creek to advance the goal of a more walkable and multi-modal city. Several opportunities are in conceptual, planning, or design stages. As the implementation plan is developed and the design phase begins, the following opportunities to co-locate, link, and coordinate within the Strategy Area could be expanding wetland areas, additional LIDA in bike/pedestrian paths, or other urban greening efforts to connect the existing and new open spaces in the Tigard Triangle.

Specifically, the following efforts are ongoing or underway that either directly relate to Red Rock Creek's proposed enhancement or intersect this part of the City:

Transportation/Transit Projects:

- TriMet Southwest Corridor
- New roadways identified in the Tigard Triangle Plan District
- 72nd Avenue Planned Roadway Improvement

On-going Initiatives or CIPs:

- Culvert Replacements
- Roadway Improvements
- Parks Master Plan
- Sanitary Master Plan

- Red Rock Creek Trail Master Plan

Additionally, there are several private parcels directly adjacent to Red Rock Creek that could be opportunities for easements or acquisition for the vegetated corridor or expanded floodplain as part of the Regional Stormwater Strategy, such as:

- Regal Tigard cinema site
- Oregon Educational Association
- SW 74th Ave TriMet park and ride site
- Former Babies-R-Us
- WinCo Foods
- Costco
- Wal-Mart
- Portland Community College

Recommended Policies or Code Changes

The preferred approach as described above will recommend a series of stream corridor enhancements to absorb current and future stormwater flows to Red Rock Creek. All current codes and policies will remain in effect, and no changes to code or policy are being proposed in the Regional Stormwater Strategy approach.

Potential Funding Alternatives

The City has already allocated some capital funding for the CIPs identified in the 2018 Stormwater Master Plan, which will likely provide the initial funding for the preferred approach. The following could provide other sources of funding:

- Regional Stormwater Management Charge
    - A CWS Regional Stormwater Management Charge was established for North Bethany and can be utilized for this project.
- Hydromodification Fee In Lieu
- Tigard Utility Fees
- Public Partnerships, such as:
    - TriMet SW Corridor Project
    - ODOT Hwy 217 Widening Project

In addition, the City could explore the following funding sources to off-set project costs:

- Economic Development Grants
- Urban Renewal Tax Increment Financing (TIF)
- Infrastructure Bonds
- Metro Parks & Nature Grants

Stakeholder Communication, Outreach, & Engagement Plan

The City will lead stakeholder outreach and engagement with CWS support. Outreach graphics, including typical sections and plans and profiles for each reach are included in the Red Rock Creek and Tigard Triangle Stormwater Implementation Plan (Otak, May 2021). The outreach plan will include standard components as typical for public engagement for large projects, such as:

1. Identification of key stakeholders
    - Large property owners adjacent to Red Rock Creek
    - Developers
    - TriMet/ODOT
    - Tualatin Riverkeepers
    - Tualatin Watershed Council
    - Wetland Conservancy (land trust)
2. Information and graphics for public and stakeholder meetings
    - Maps of the total stream corridor enhancement with future development and transportation/transit projects
3. Graphics showing stream enhancement projects
    - CIP fact sheets (with costs and phasing information)

References

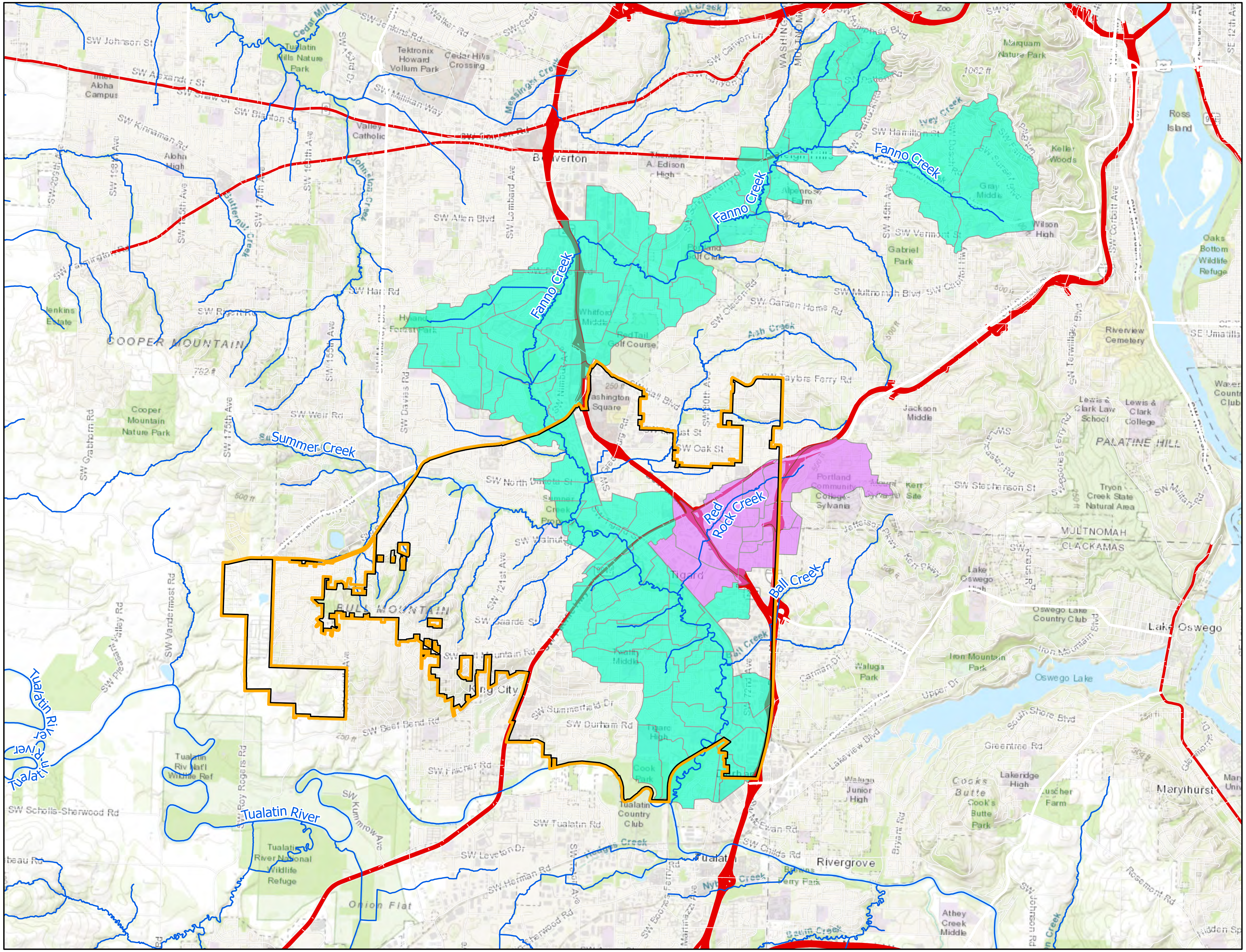
Otak (May 2021), Red Rock Creek and Tigard Triangle Stormwater Implementation Plan, prepared for City of Tigard.

Otak (June 2021), Red Rock Creek Regional Stormwater Strategy Technical Analysis, prepared for Clean Water Services.

Figures

Watersheds

FIGURE 1



RED ROCK CREEK REGIONAL STORMWATER STRATEGY

CLEANWATER SERVICES

CITY OF TIGARD | OREGON

6/8/2021

Legend

▢ City Limit

— Streams

Watersheds

🟩 Fanno Creek Watershed

🟪 Red Rock Creek Watershed

N

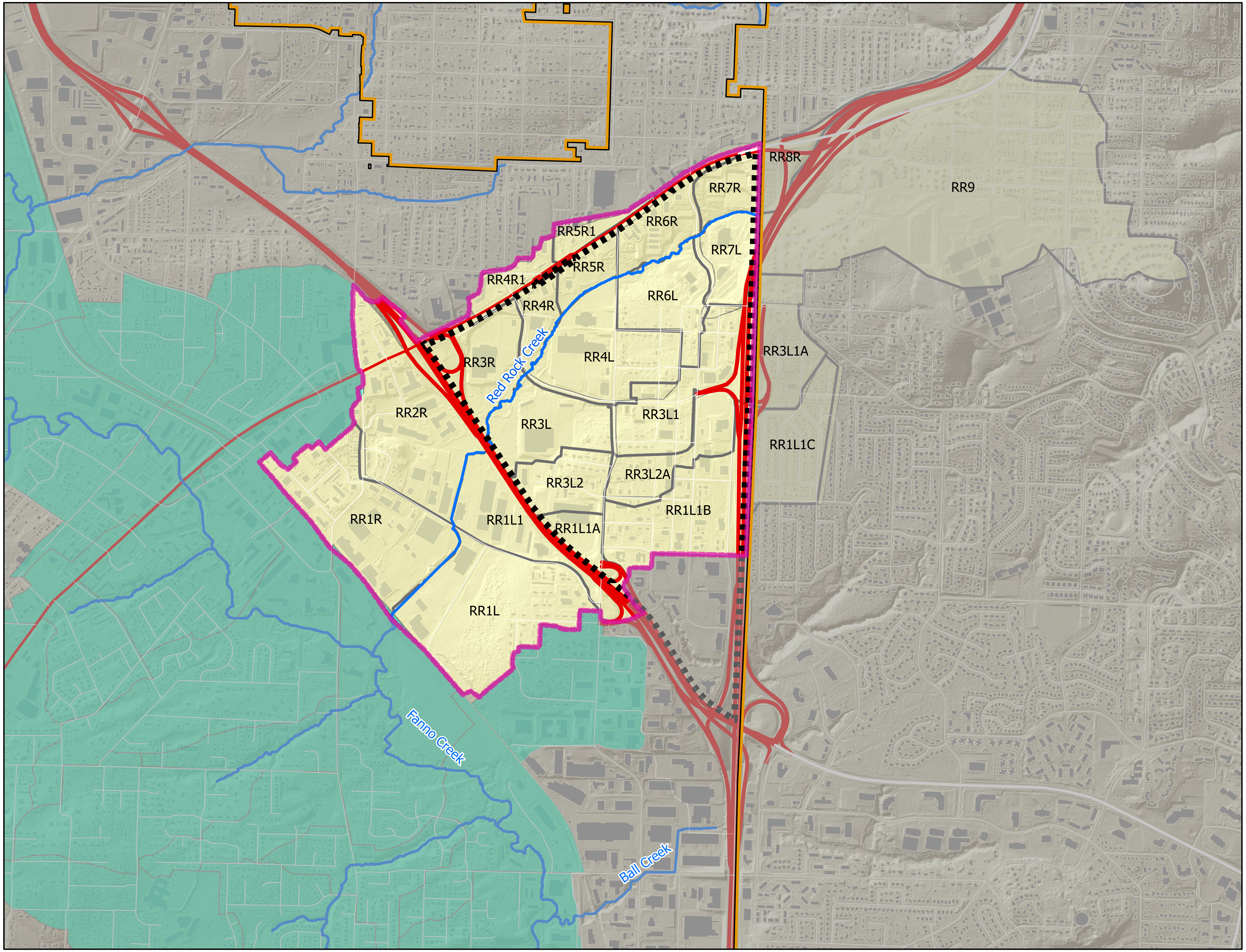
Miles

0 1

Otak

Regional Stormwater Strategy Area & TRUST Model Basins

FIGURE 2



RED ROCK CREEK REGIONAL STORMWATER STRATEGY

CLEANWATER SERVICES

CITY OF TIGARD | OREGON

6/8/2021

Legend

- ▪▪▪▪ Tigard Triangle
- ▭ Subbasin Strategy Area
- ▭ City Limit
- ― Streams
- 🟩 Fanno Creek Watershed
- 🟨 Red Rock Creek Watershed
- ▭ TRUST Subbasins
- ⬛ Buildings

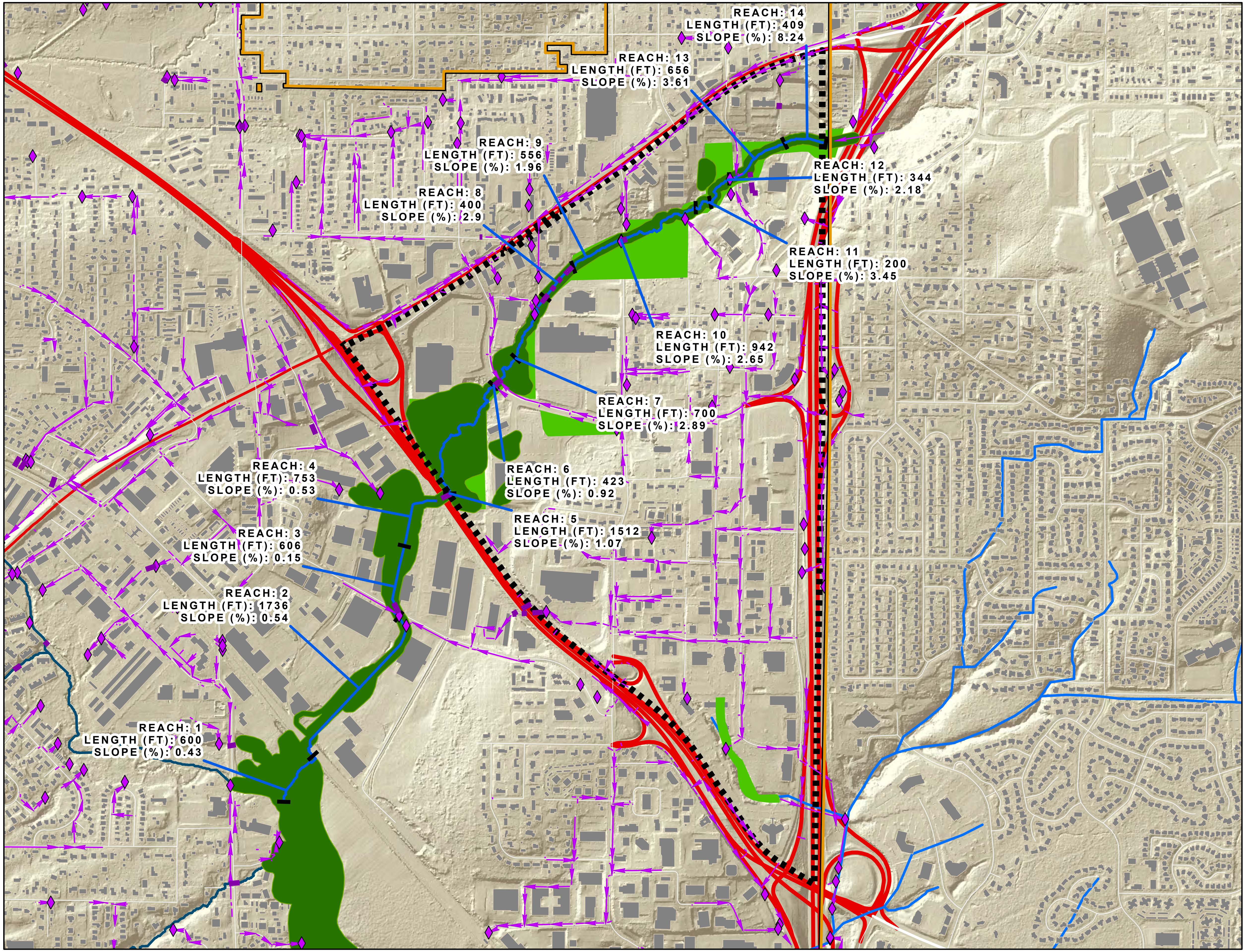
N

Miles
0 0.25

Otak

STREAM REACHES

FIGURE 3



RED ROCK CREEK REGIONAL STORMWATER STRATEGY

CLEANWATER SERVICES
CITY OF TIGARD | OREGON
6/8/2021

Legend

- ☐ CITY LIMIT
- ─┃ STREAM REACHES
- ▪▪▪ TIGARD TRIANGLE
- 🟩 VEGETATED CORRIDOR (50 FT FROM TOB)
- 🟩 PROPOSED GREENWAY
- ▪▪ STORMWATER CULVERTS
- ♦ STORMWATER OUTFALLS
- → STORMWATER MAINS

N

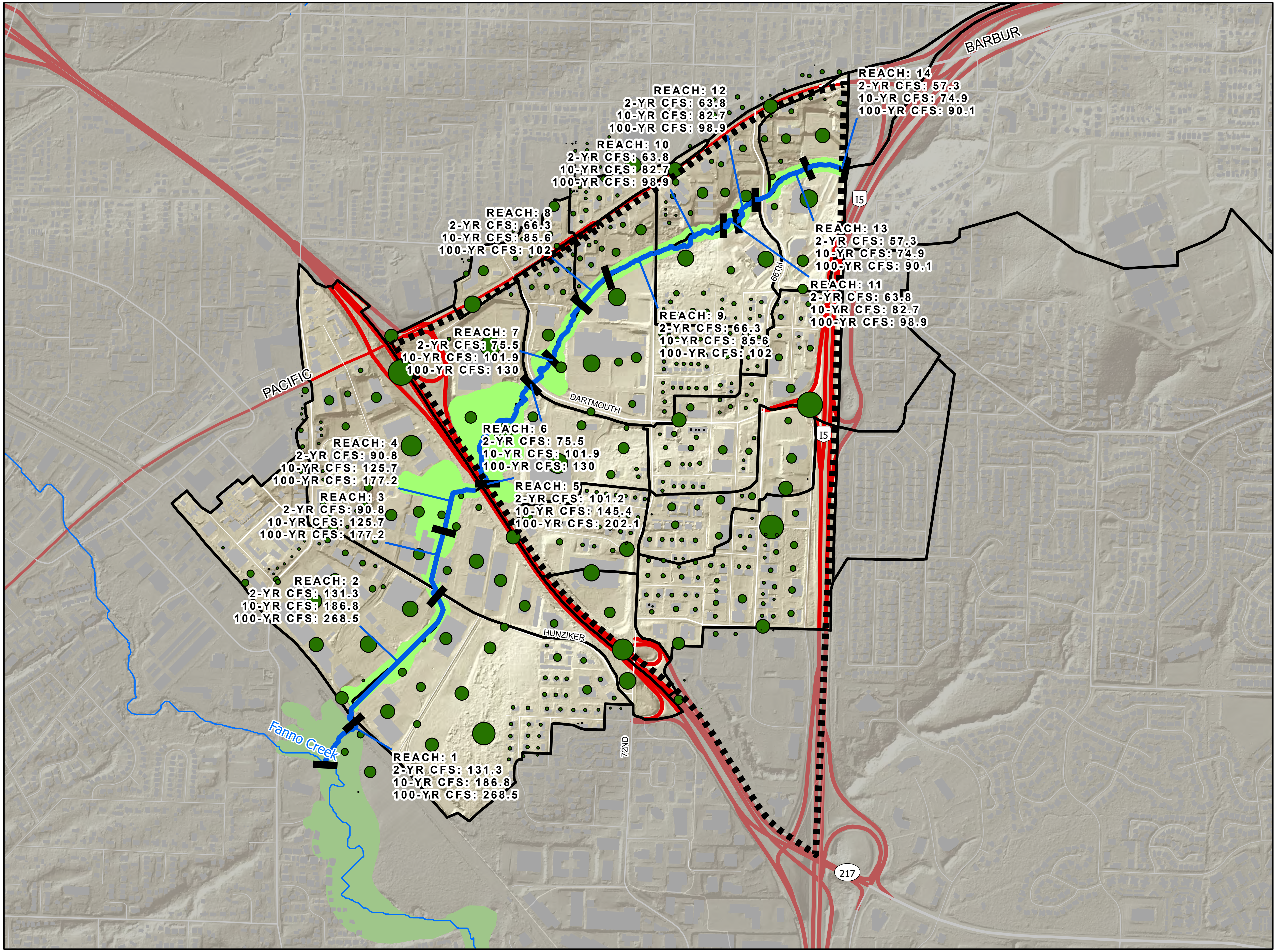
Miles
0 0.25

Otak

DISCLAIMER: THE INFORMATION SHOWN IN THIS MAP IS ASSEMBLED GIS DATA CREATED AND ACQUIRED BY OTAK INC. THIS DATA IS NOT TO SURVEY ACCURACY AND IS MEANT FOR PLANNING PURPOSES ONLY.
NOTE: BASEMAP DATA IS PROVIDED BY ESRI INC.

STORMWATER MANAGEMENT PREFERRED APPROACH: WATER QUALITY LIDA, STREAM CORRIDOR REHABILITATION, NO DETENTION

FIGURE 4



RED ROCK CREEK REGIONAL STORMWATER STRATEGY

CLEANWATER SERVICES
CITY OF TIGARD | OREGON
6/8/2021

Legend

- ▪▪▪▪ Tigard Triangle
- ━┃ Project Reaches
- ● Onsite LIDA (6% of Impervious Area)
- ☐ TRUST Subbasins
- 🟩 Estimated Vegetated Corridor

N

Scale
0 500 1,000 1,500 2,000 Feet

Otak

DISCLAIMER: THE INFORMATION SHOWN IN THIS MAP IS ASSEMBLED GIS DATA CREATED AND ACQUIRED BY OTAK INC. THIS DATA IS NOT TO SURVEY ACCURACY AND IS MEANT FOR PLANNING PURPOSES ONLY.
NOTE: BASEMAP DATA IS PROVIDED BY ESRI INC.

JANUARY 2021

Tigard Triangle
URBAN RENEWAL PLAN

Adopted by the City of Tigard | December 13, 2016 | Ordinance No. 16-24

Approved by Voters
May 16, 2017


Red Rock Creek Commons affordable housing development, the first project to receive Tigard Triangle TIF funding.

LIST OF PARTICIPANTS

Mayor
John L. Cook

Tigard City Council
Council President Jason Snider

Councilor John Goodhouse

Councilor Marland Henderson

Councilor Marc Woodard

Planning Commission
Calista Fitzgerald, President
Brian Feeney, Vice President
Michael Enloe, Alternate
Y-Kang Hu
Gary Jelinek
Bret Lieuallen
Brian McDowell
Chris Middaugh
Matthew Muldoon
Tom Mooney, Alternate
Don Schmidt

City Manager
Marty Wine

City Attorney
(Jordan Ramic, PC)
Dan Olsen
Shelby Rihala

Community Development Director
Kenny Asher

Finance Director
Toby LaFrance

Senior Planner
Susan P. Shanks

Associate Planner
Cheryl Caines

Project Planning Assistant
Hannah Holloway

Citizen Advisory Council
John Boren
Calista Fitzgerald
John Goodhouse
Scott Hancock
Gary Jelinek
Jim Long
Cathy Olson
Katen Patel
Elise Shearer
Veronica Smith
David Walsh
Dustin White

Technical Advisory Committee
Celina Baguiao, PCC
Kelly Betteridge, TriMet
Joshua Brooking, ODOT
Buff Brown, City of Tigard Planning
Cheryl Caines, City of Tigard Planning
Rachael Duke, CPAH
Lori Faha, City of Tigard Engineering
Sean Farrelly, City of Tigard Community Development
Cara Fitzpatrick, City of Tigard Finance
Chris Ford, Metro
Steve Kelley, Washington County
Allen Kennedy, TVFR
Kate Lyman, TriMet Alternate
Mike McCarthy, City of Tigard Engineering
Debi Mollahan, Tigard Chamber of Commerce
David Moore, TTSD
Carrie Pak, TVWD
Jeffrey Raker, Metro Alternate
Damon Reische, CWS
Ryan Smith, TVWD Alternate
Cassandra Ulven, TVFR Alternate
Phil Wentz, TTSD Alternate
Shannon Wilson, CPAH Alternate
Jessica Woodruff, REACH

Consultant Team
Elaine Howard and Scott Vanden Bos
of Elaine Howard Consulting, LLC

Nick Popenuk of Tiberius Solutions, LLC

Ali Danko and Rob Wyman of ECONorthwest

Alex Dupey and Jon Pheanis of MIG, Inc.

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TIGARD TRIANGLE
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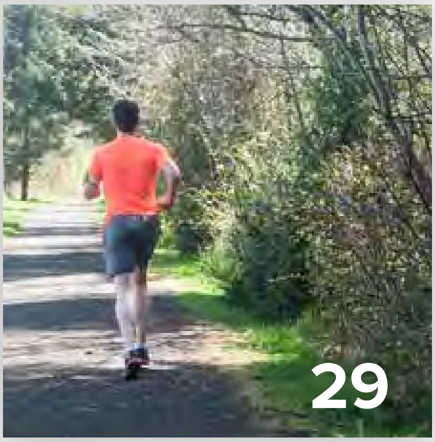
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I. DEFINITIONS

"Agency" means the Tigard Urban Renewal Agency. This Agency is responsible for administration of the urban renewal plan. In Tigard, the Agency is the City Center Development Agency (CCDA).

"Area" means the properties and rights-of-way located with the Tigard Triangle urban renewal boundary.

"Blight" is defined in ORS 457.010(1)(A-E) and identified in the ordinance adopting the urban renewal plan.

"Board of Commissioners" means the Washington County Board of Commissioners. "City" means the City of Tigard, Oregon.

"City Council" or **"Council"** means the Tigard City Council.

"Comprehensive Plan" means the City of Tigard comprehensive land use plan and its implementing ordinances, policies, and standards.

"County" means Washington County, Oregon.

"Fiscal year" means the year commencing on July 1 and closing on June 30.

"Frozen base" means the total assessed value including all real, personal, manufactured, and utility values within an urban renewal area at the time of adoption. The county assessor certifies the assessed value after the adoption of an urban renewal plan.

"Increment" means that part of the assessed value of a taxing district attributable to any increase in the assessed value of the property located in an urban renewal area, or portion thereof, over the assessed value specified in the certified statement.

"Maximum indebtedness" means the amount of the principal of indebtedness included in a plan pursuant to ORS 457.190 and does not include indebtedness incurred to refund or refinance existing indebtedness.

"ORS" means the Oregon revised statutes and specifically Chapter 457, which relates to urban renewal.

"Planning Commission" means the Tigard Planning Commission.

"Revenue sharing" means sharing tax increment proceeds as defined in ORS 457.470.

“Tax increment financing (TIF)” means the funds that are associated with the division of taxes accomplished through the adoption of an urban renewal plan.

“Tax increment revenues” means the funds allocated by the assessor to an urban renewal area due to increases in assessed value over the frozen base within the area.

“Urban renewal area” means a blighted area included in an urban renewal plan or an area included in an urban renewal plan under ORS 457.160.

“Urban renewal plan” or **“Plan”** means a plan, as it exists or is changed or modified from time to time, for one or more urban renewal areas, as provided in ORS 457.085, 457.095, 457.105, 457.115, 457.120, 457.125, 457.135 and 457.220.

“Urban renewal project” or **“Project”** means any work or undertaking carried out under ORS 457.170 in an urban renewal area.

“Urban renewal report” or **“Report”** means the official report that accompanies the urban renewal plan pursuant to ORS 457.085(3).

“Tigard Park System Master Plan” means the Park System Master Plan adopted by the Tigard City Council.

“Tigard Transportation System Plan (TSP)” means the Transportation System Plan adopted by the Tigard City Council.

II. INTRODUCTION

The Tigard Triangle Urban Renewal Plan (Plan) was developed for the Tigard City Council (City Council) with cooperative input from a Citizen Advisory Council (CAC) and Technical Advisory Committee (TAC) that were formed for this purpose. The Plan also includes input from the community received at a public open house and several public meetings and hearings before the Planning Commission, City Council, and Washington County Board of Commissioners. Pursuant to the Tigard City Charter, this Plan will go into effect when it has been adopted by City Council and approved by Tigard voters at a public election.

A. Plan Overview

The Tigard Triangle is located in the northeast corner of the city. Its triangular shape is the result of the three state highways that surround it, namely OR 99W, OR 217, and Interstate 5 . The long-range land use and development vision for the Tigard Triangle is outlined in the Tigard Comprehensive Plan and further defined in the recently completed Tigard Triangle Strategic Plan (TT Strategic Plan). The latter was developed with extensive public engagement and technical analysis in 2015.

The TT Strategic Plan generally describes the desired scale and design of development for the Area. It also specifically identifies the need for pedestrian amenities, multimodal transportation improvements, public spaces, and certain kinds of uses, such as housing and neighborhood-scale goods and services. Additionally, the TT Strategic Plan identifies barriers to development and how they might be overcome through specific regulatory actions, public-private partnerships, and investment strategies. Urban renewal is listed as one such strategy because it has the ability to remove barriers to development and build projects that implement the vision by utilizing tax increment financing (TIF) as a source of funding.

The purpose of this Plan, therefore, is to implement the land use and development vision for the Area and support its transformation into an active, urban, multimodal, and mixed-use district that is:

- Attractive to new residents and businesses,
- Connected to the city and the region, and
- Built around its distinguishing natural features.

The Plan Area, shown in Figure 1 below, consists of approximately 547.9 total acres: 383.04 acres of land in tax lots and 164.86 acres of public rights-of-way. It is anticipated that the Plan will take 35 years of tax increment collections to implement. The maximum amount of indebtedness (amount of TIF for projects and programs) that may be issued for the Plan is $188,000,000 (one hundred eighty-eight million dollars.)

FIGURE 1 – Tigard Triangle Urban Renewal Plan Area Boundary

II. INTRODUCTION

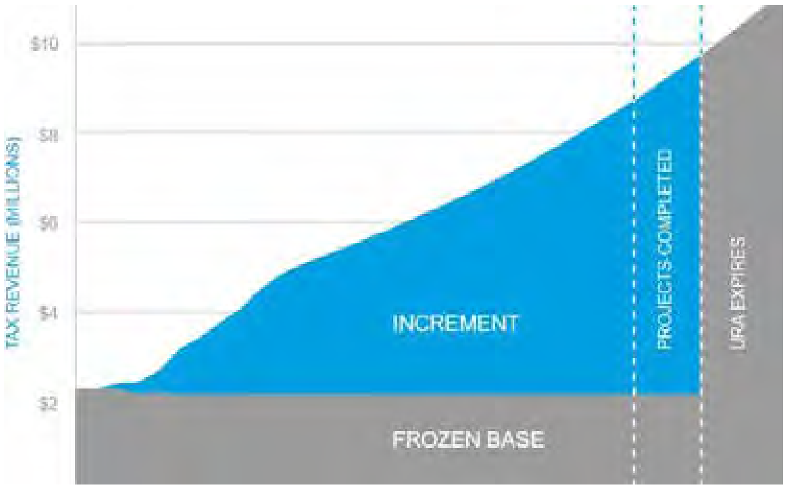
Detailed goals and objectives developed by the community for this Plan are intended to guide TIF investment in the Area over the life of the Plan. The project category descriptions and list of projects are similarly intended to aid future decision makers when considering how best to expend funds generated by TIF. The Plan is to be administered by the city's Urban Renewal Agency, which is currently the Tigard Town Center Development Agency.
Substantial amendments to the Plan must be approved by City Council as outlined in Section IX. All amendments to the Plan are to be listed numerically in this section of the Plan and then incorporated into the Plan document and noted by footnote with an amendment number and adoption date.

In summary, the Plan is designed to implement the goals and policies of the Tigard Comprehensive Plan and the vision of the TT Strategic Plan; advance the city's mission to become the most walkable city in the Pacific Northwest; and, support the area's designation as a regional Town Center.

B. Urban Renewal Overview

Urban renewal allows for the use of TIF, a financing source that is unique to urban renewal, to fund its projects. Tax increment revenues— the amount of property taxes generated by the increase in total assessed values in the urban renewal area from the time the urban renewal area is first established— are used to repay borrowed funds. The borrowed funds are used to pay for urban renewal projects and cannot exceed the maximum indebtedness amount set by the urban renewal plan ***(See graphic).*** In general, urban renewal projects can include construction or improvement of streets, utilities, and other public facilities; assistance for rehabilitation or redevelopment of property; acquisition and re-sale of property (site assembly) from willing sellers; and improvements to public spaces.

The purpose of urban renewal is to improve specific areas of a city that are poorly developed or underdeveloped, called blighted areas in ORS 457. These areas can have old or deteriorated buildings, public spaces that need improvements, streets and utilities in poor condition, a complete lack of streets and utilities altogether, or other obstacles to development. The Tigard Triangle meets the definition of blight due to its infrastructure deficiencies and number of vacant and underdeveloped lots. These blighted conditions are specifically cited in the ordinance adopting the Plan and described in detail in the accompanying Urban Renewal Report (Report).



The Report accompanying the Plan contains the information required by ORS 457.085, including:

- A description of the physical, social, and economic conditions in the area;
- Expected impact of the Plan, including fiscal impact in light of increased services;
- Reasons for selection of the Plan Area;
- The relationship between each project to be undertaken and the existing conditions;
- The estimated total cost of each project and the source of funds to pay such costs;
- The estimated completion date of each project;
- The estimated amount of funds required in the Area and the anticipated year in which the debt will be retired;
- A financial analysis of the Plan;
- A fiscal impact statement that estimates the impact of tax increment financing upon all entities levying taxes upon property in the urban renewal area; and
- A relocation report.

III. GOALS & OBJECTIVES

The goals of the Plan represent its basic intents and purposes. Accompanying each goal are objectives, which generally describe how the Agency intends to achieve each goal. The urban renewal projects identified in Sections IV and V of the Plan are the specific means of meeting the objectives. The goals relate to adopted plans, as detailed in Section X, and were developed with input from the CAC and TAC. The goals and objectives will be pursued as economically as is feasible and at the discretion of the Agency. The goals and objectives are not listed in any order of importance or priority.

GOAL 1

Encourage meaningful involvement by by citizens , interested parties, and affected agencies throughout the life of the urban renewal district to ensure that it reflects the community's values and priorities.

OBJECTIVES:

1. Invite citizens both within and outside of the boundaries of the Area, interested parties, and affected agencies to participate on urban renewal advisory committees and task forces.
2. Invite public comment at all Agency meetings.
3. Hold a public vote as required by the City Charter to use tax increment financing as a method of funding projects in the Area.

GOAL 2

Provide a safe and effective multimodal transportation network that provides access to, from, and within the Area and supports mixed-use and pedestrian-oriented development.

OBJECTIVES:

1. Develop comfortable, interesting, and attractive streetscapes—especially along designated pedestrian streets—that build upon the Area's existing assets, improve the pedestrian experience, and support a variety of commercial and social activities, e.g. cafe seating, outdoor displays, etc.

2. Create more connections within the Area by building new streets and trails so that people of all ages and abilities can enjoy healthy and interconnected lives.

3. Create more access points into and out of the Area by building new overpasses and/or undercrossings and modifying existing intersections and/or interchanges so that the Area is more connected to downtown Tigard, Portland Community College, and other neighboring areas and businesses.

4. Provide transportation choices for all modes of travel, as appropriate, and on-street parking and vegetative stormwater facilities, where feasible, when building new streets and extending and/or modifying existing streets, including but not limited to the following:
   a. Shared bicycle and vehicle travel lanes along low volume streets.
   b. Separate bicycle and vehicle travel lanes along high volume streets.
   c. Sidewalks and pedestrian crossings that connect to transit (e.g. bus) stops.

5. Allow transitional street improvements (i.e. temporary or partial improvements) that further the Area's transportation goals and objectives and support small, incremental development when construction of all permanent street elements is not practicable at the time of development.

6. Provide a reliable transportation system that effectively manages vehicle congestion and safely moves people, goods, and services to, from, and through the Area, with special consideration for the following:
   a. Pedestrian crossings of high volume streets.
   b. Freight trucks to, from, and through the Area.
   c. Transit service (e.g. buses) to, from, and through the Area.

7. Build a multi-use trail for pedestrians and bicyclists along Red Rock Creek that provides an off-street east-west connection parallel to Highway 99W and facilitates the transformation of this natural corridor into a greenway. Identify and build other off-street multi-use trails and connections as opportunities arise.

8. Develop and implement a parking management plan for the Area that supports economic development efforts, the desired land use pattern, and a balanced transportation system, including but not limited to public-private partnerships, public parking facilities, and parking enforcement.

9. Periodically evaluate the functioning of the transportation system to refine project scope and inform project prioritization.

GOAL 3

Provide public utility improvements to support desired development

OBJECTIVES:

1. Develop a stormwater master plan for the Triangle and a greenway plan for Red Rock Creek. Build regional stormwater facilities where practicable.
2. Extend the public sewer system to areas served by private septic systems.
3. Permanently fix compromised sewer lines in Red Rock Creek.
4. Ensure new water mains are constructed as needed and coordinate replacement of existing water mains.
5. Encourage sustainable utility and energy usage practices.

GOAL 4

Create a clear identity for the Area as a fun and diverse place to live, work, shop, eat, and play by building upon existing unique and desirable features.

OBJECTIVES:

1. Build public facilities that support the Area's identity as a mixed-use, multimodal, and pedestrian-oriented district, including but not limited to parks, plazas, public restrooms, recreational facilities, and non-vehicular infrastructure, e.g. bike racks, bike lockers, pedestrian shelters, and wayfinding signage.

2. Use parks, trails, stormwater facilities, and existing natural features—such as wetlands, creeks, trees/tree groves, and view corridors—to create focal points that reinforce the Area's identity as a unique and special place.
3. Apply distinctive and consistent sign, art, gateway, and streetscape treatments to visually distinguish the Area from surrounding areas.
4. Relocate or underground existing utilities as practicable to provide a more aesthetically pleasing pedestrian environment.

The 72nd mixed-use housing development

GOAL 5

Provide financial and technical assistance to new and existing businesses and housing developments that contribute to the Area's diversity and vitality and help it transform into a mixed-use and pedestrian-oriented district.

OBJECTIVES:

1. Support new and existing businesses by providing a variety of financial and technical assistance programs that increase the diversity of goods and services available in the Area and/or contribute to the Area's liveliness and upkeep, including but not limited to façade improvement grants, streetscape improvements, site preparation, permit fee assistance, private utility extensions/upgrades, and business development incentives.
2. Form public-private partnerships and use public investment in infrastructure and public spaces/facilities to spur private development.
3. Support the development of mixed-use buildings that provide a variety of housing types and storefront spaces for a range of community and commercial needs.
4. Assist in the development of affordable and workforce housing.
5. Assemble parcels to enhance development opportunities.
6. Encourage low impact and environmentally sustainable building practices wherever practicable.

IV. URBAN RENEWAL PROJECT CATEGORIES

As an outcome of the goals described in the previous section, the projects within the Area fall into the following categories

- Transportation (Goal 2)
- Public Utilities (Goal 3)
- Public Spaces, Facilities, and Installations (Goal 4)
- Re/Development Assistance and Partnerships (Goal 5)
- Finance Fees and Plan Administration

V. URBAN RENEWAL PROJECTS

Urban renewal projects authorized by the Plan are described below.

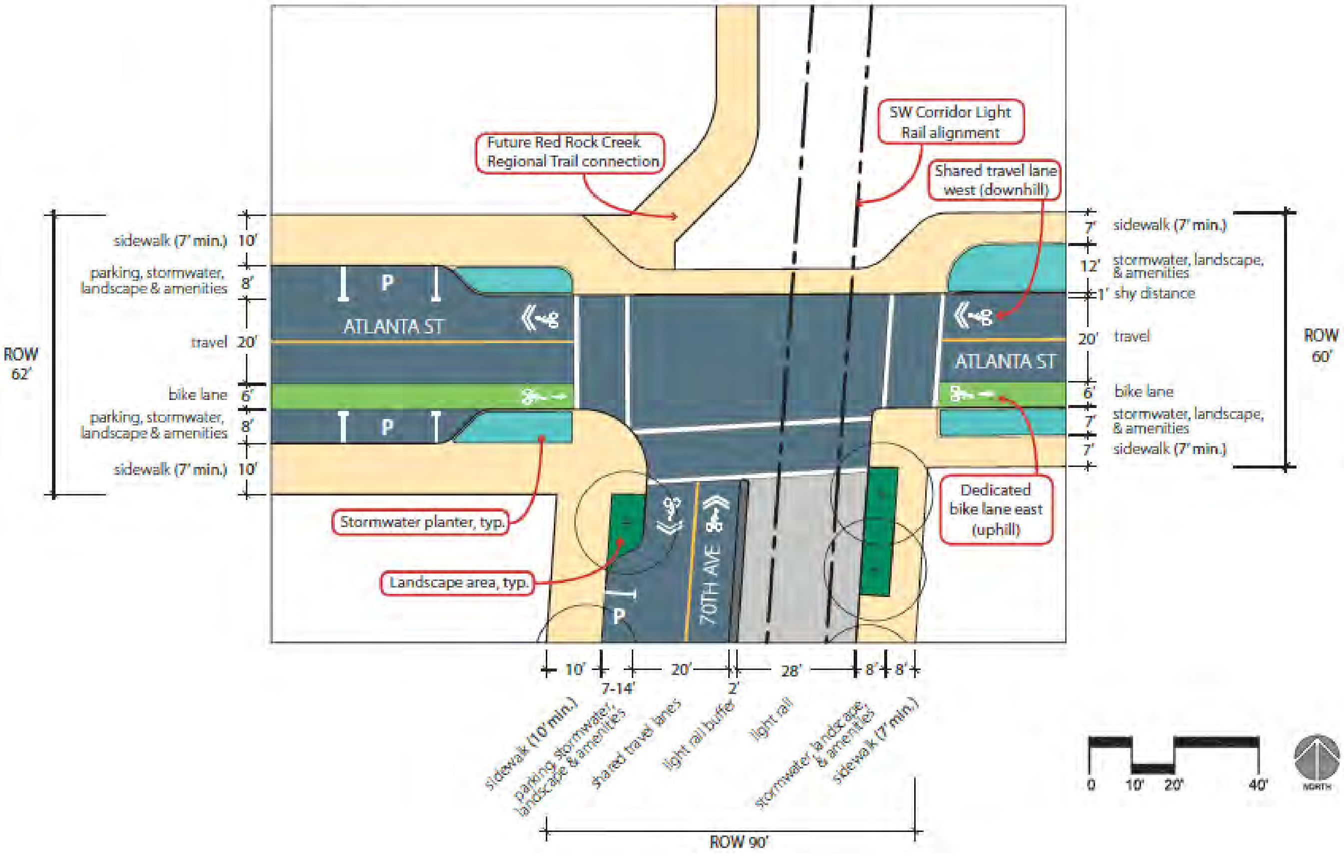
A. TRANSPORTATION

Provide financial and technical assistance to new and existing businesses and housing developments that contribute to the Area's diversity and vitality and help it transform into a mixed-use and pedestrian-oriented district.

TABLE 1 – Transportation Projects

Project #	Project Type	Project Description
1	New Hwy 217 Overpass (Beveland)	Extend Beveland Rd south over Hwy 217 to Hunziker Rd/Wall St area with car, ped, and bike facilities.
2	New Street (74th Ave)	Extend 74th Ave south from 99W to Hermoso Way or Beveland Rd.
3	New Street (Atlanta)	Extend Atlanta St west from 69th Ave to Dartmouth St or future 74th Ave.
4	New Hwy I-5 Overpass (Beveland)	Provide ped/bike bridge across Hwy I-5 from Beveland Rd to Southwood Dr
5	New Hwy I-5 Overpass (Red Rock Creek)	Provide ped/bike bridge across Hwy I-5 between the Triangle and PCC Sylvania around location of Red Rock Creek.
6	Modified Intersection (Atlanta/68th)	Install traffic signal and turn lanes where needed at Atlanta St/68th Ave intersection.
7	Modified Intersection (99W/68th)	Add protected left turn and transit improvements on 68th Pkwy at 99W.
8	Modified Streets	Develop comfortable, interesting, and attractive streetscapes throughout the Area, especially along designated pedestrian streets.
9	New Trail (Red Rock Creek)	Build a new trail along Red Rock Creek parallel to and south of 99W.
10	New Streets	Improve connectivity, circulation, and access throughout the Area with new or extended local streets.

Project #	Project Type	Project Description
11	Modified Street (72nd Ave)	TBD. Improve 72nd Ave corridor, including intersections/interchanges. Dependent on 72nd Ave Corridor Study recommendations
12	Modified Street (99W)	Implement access management strategies and median projects in Hwy 99W Plan, including additional pedestrian crossing locations.
13	Modified Interchange (99W/ Hwy 217)	Add second left turn lane on Hwy 217 northbound ramp to 99W.
14	Modified Signals	Upgrade signals throughout the Area with adaptive signal coordination technology.
15	Parking Management Plan	Develop a plan and implement strategies for managing parking.
16	Transportation Study	Periodically evaluate the functioning of the transportation system to refine project scope and inform project prioritization.
17	Highway 217 Multi-use Path	Provide ped/bike bridge and Red Rock Creek Trail connection across Hwy 217 between SW 72nd Ave and Hunziker Road.



Conceptual rendering of proposed new Atlanta Street intersection

B. PUBLIC UTILITIES

The following public utility projects are intended to address infrastructure deficiencies in the Area. This list includes the development of a stormwater master plan for the Area and a greenway plan for Red Rock Creek that addresses stormwater , sewer, and recreational needs. It also includes construction of new stormwater facilities, repair of existing sewer lines, and extension or enlargement of existing water and sewer lines as needed to support desired development.

TABLE 2 – Public Utility Projects

Project #	Project Type	Project Description
1	Stormwater/Sewer	Develop a stormwater master plan for the Triangle and a greenway plan for Red Rock Creek that addresses stormwater, sewer, and recreational needs
2	Stormwater	Construct approximately three regional stormwater facilities to meet new DEQ regulations for water quantity management.
3	Sewer	Extend public sewer system to areas served by private septic systems.
4	Stormwater/Sewer	Permanently fix compromised sewer lines in Red Rock Creek and restore creek channel and riparian buffer.
5	Water	Install new water mains as needed.

C. PUBLIC SPACES, FACILITIES, AND INSTALLATION

Projects within this category are intended to support the Area's new identity as a fun and diverse place to live and visit by building upon existing unique and desirable features. When considering whether to fund a specific project within this category, the Agency shall evaluate how it meets the goals and objectives of this Plan and whether it will encourage private investment in the Area and increase assessed value over time. The Agency shall also take the city's level of service standards for parks into consideration where applicable. Level of service standards are contained in the Tigard Park System Master Plan.

Projects may include, but are not limited to, the following:

- Parks, such as splash pads, nature play areas, skate parks, pocket parks, linear parks, and neighborhood parks
- Greenways, such as along Red Rock Creek
- Recreational facilities, such as those that serve the immediate needs of Area residents
- Plazas
- Public restrooms
- Public art
- Wayfinding
- Gateway installations
- District signage

As part of its evaluation, the Agency should consider consulting with the private development community to identify the kinds of amenities that would catalyze private sector development, particularly housing and mixed-use development.

Rendering of The Overland mixed use development, which was awarded development assistance. Estimated completion date: 2022.

D. RE/DEVELOPMENT ASSISTANCE AND PARTNERSHIPS

Projects within this category are intended to contribute to the Area's diversity and vitality by providing assistance to new and existing businesses and housing developments. Projects include, but are not limited to, the following:

- Façade improvement grants/loans
- Streetscape improvements
- Technical, code, and/or fee assistance
- Site assembly
- Site clean-up/preparation
- Site acquisition
- Partnerships that facilitate housing and mixed use developments

E. FINANCE FEES AND PLAN ADMINISTRATION

This category allows for repayment of costs associated with implementation of the Plan, including but not limited to ongoing administration and financing costs associated with issuing long- and short-term debt, relocation costs, and other administrative costs.

VI. PROPERTY ACQUISITION & DISPOSITION

The Plan authorizes the acquisition and disposition of property as described in this section. Property includes any and all interests in property, including fee simple ownership, lease, easements, licenses, or other rights to use. If property is acquired it will be identified in the Plan through a Minor Amendment, as described in Section IX. Identification of property to be acquired and its anticipated disposition is required by ORS 457.085(g).

A. Property acquisition for public improvements

The Agency may acquire any property within the Area for the public improvement projects undertaken pursuant to the Plan by all legal means, including use of eminent domain. Good faith negotiations for such acquisitions must occur prior to institution of eminent domain procedures.

B. Property acquisition from willing sellers

The Plan authorizes Agency acquisition of any interest in property within the Area that the Agency finds is necessary for private redevelopment, but only in those cases where the property owner wishes to convey such interest to the Agency. The Plan does not authorize the Agency to use the power of eminent domain to acquire property from a private party to transfer property to another private party for private redevelopment. Property acquisition from willing sellers may be required to support development of projects within the Area

C. Land disposition

The Agency will dispose of property acquired for a public improvement project by conveyance to the appropriate public agency responsible for the construction and/or maintenance of the public improvement. The Agency may retain such property during the construction of the public improvement.

(continued).

The Agency may dispose of property acquired under Subsection B of this Section VI by conveying any interest in property acquired. Property shall be conveyed at its fair reuse value. Fair reuse value is the value, whether expressed in terms of rental or capital price, at which the urban renewal agency, in its discretion, determines such land should be made available in order that it may be developed, redeveloped, cleared, conserved, or rehabilitated for the purposes specified in the Plan. Because fair reuse value reflects limitations on the use of the property to those purposes specified in the Plan, the value may be lower than the property's fair market value.

Where land is sold or leased, the purchaser or lessee must agree to use the land for the purposes designated in the Plan and to begin and complete the building of its improvements within a period of time that the Agency determines is reasonable.

VII. RELOCATION METHODS

When the Agency acquires occupied property under the Plan, residential or commercial occupants of such property shall be offered relocation assistance, as required under applicable state law. Prior to such acquisition, the Agency shall adopt rules and regulations, as necessary, for the administration of relocation assistance. No specific acquisitions that would result in relocation benefits have been identified; however, there are plans to acquire land for infrastructure which may trigger relocation benefits in the future in the Area.

VIII. TAX INCREMENT FINANCING OF PLAN

Tax increment financing consists of using annual tax increment revenues to make payments on debt, usually in the form of bank loans or revenue bonds. The proceeds of the bonds are used to finance the urban renewal projects authorized in the Plan. Bonds may be either long-term or short-term.

Tax increment revenues equal most of the annual property taxes imposed on the cumulative increase in assessed value within an urban renewal area over the total assessed value at the time an urban renewal plan is adopted. (Under current law, the property taxes for general obligation (GO) bonds and local option levies approved after October 6, 2001 are not part of the tax increment revenues.)

A. General description of the proposed financing methods

The Plan will be financed using a combination of revenue sources. These include:

- Tax increment revenues;
- Advances, loans, grants, and any other form of financial assistance from federal, state, or local governments, or other public bodies;
- Loans, grants, dedications, or other contributions from private developers and property owners, including, but not limited to, assessment districts; and
- Any other public or private source.

Revenues obtained by the Agency will be used to pay or repay the costs, expenses, advancements, and indebtedness incurred in (1) planning or undertaking project activities, or (2) otherwise exercising any of the powers granted by ORS Chapter 457 in connection with the implementation of this Plan.

B. Tax increment financing and maximum indebtedness

The Plan may be financed, in whole or in part, by tax increment revenues allocated to the Agency, as provided in ORS Chapter 457. The ad valorem taxes, if any, levied by a taxing district in which all or a portion of the Area is located, shall be divided as provided in Section 1c, Article IX of the Oregon Constitution, and ORS 457.440. Amounts collected pursuant to ORS 457.440 shall be deposited into the unsegregated tax collections account and distributed to the Agency based upon the distribution schedule established under ORS 311.390.

The maximum amount of indebtedness that may be issued or incurred under the Plan, based upon good faith estimates of the scope and costs of projects in the Plan and the schedule for their completion is $188,000,000 (one hundred and eighty-eight million dollars). This amount is the principal of such indebtedness and does not include interest or indebtedness incurred to refund or refinance existing indebtedness or interest earned on bond proceeds. It does include initial bond financing fees and interest earned on tax increment proceeds, separate from interest on bond proceeds.

C. Plan Evaluation

During the fifteenth (15th) year of the Plan, the Agency shall undertake a financial analysis of the Plan, including updated projections for tax increment finance revenues, and evaluate the ability of the Plan to achieve its maximum indebtedness by the anticipated expiration date in fiscal year 2052-53. The Agency shall consult and confer with affected taxing districts regarding the results of this financial update and will consider revenue sharing if revenues are exceeding projections.

D. Plan Duration

The Agency intends that it not collect tax increment revenues for the Area after FYE 2053. The Agency shall not initiate any urban renewal projects in the Area unless the Agency reasonably projects it will be able to pay for those projects from the proceeds of indebtedness issued on or before FYE 2053, and from other funds available to the Agency. Except as provided in the next sentence, all indebtedness that is secured by the tax increment revenues of the Area shall mature no later than FYE 2053, and the Agency shall structure all its indebtedness so that it can be paid in full from the tax increment revenues of the Area that the Agency reasonably projects it will receive on or before FYE 2053. The Agency may issue refunding indebtedness that matures after FYE 2053, only if issuing that refunding indebtedness is necessary to avoid a default on previously-issued indebtedness.

IX. AMENDMENTS TO PLAN

The Plan may be amended as described in this section.

A. Substantial Amendments

Substantial Amendments, in accordance with ORS 457.085(2)(i), shall require the same notice, hearing, and approval procedure required of the original Plan, under ORS 457.095, including public involvement, consultation with taxing districts, presentation to the Agency, the Planning Commission, and adoption by the City Council by non-emergency ordinance after a hearing.

Notice of such hearing shall be provided to individuals or households within the City of Tigard, as required by ORS 457.120. Notice of adoption of a Substantial Amendment shall be provided in accordance with ORS 457.095 and 457.115.

Substantial Amendments are amendments that:[1]

1. Add land to the urban renewal area, except for an addition of land that totals not more than 1% of the existing area of the urban renewal area; or
2. Increase the maximum amount of indebtedness that can be issued or incurred under the Plan.

Revenues obtained by the Agency will be used to pay or repay the costs, expenses, advancements, and indebtedness incurred in (1) planning or undertaking project activities, or (2) otherwise exercising any of the powers granted by ORS Chapter 457 in connection with the implementation of this Plan.

B. Amendments Requiring Concurrence

Amendments requiring written concurrence of taxing districts imposing at least 75% of the amount of taxes imposed under permanent rate limits in the urban renewal area are amendments that:.

1. Increase the maximum amount of indebtedness that can be issued or incurred under the Plan.

   Increasing the maximum indebtedness is also a substantial amendment, as defined above and must also meet the requirements of Section IX (A) of this Plan.

2. Extend the duration provision as defined in Section VIII (D) of the Plan.

   In addition to obtaining concurrence, extending the duration of the Plan requires approval of the Agency and City Council by resolution.

C. Minor Amendments

Minor Amendments are amendments that are not Substantial Amendments as defined in ORS 457 or Amendments Requiring Concurrence as defined in this Plan. Minor Amendments require approval of the Agency by resolution.

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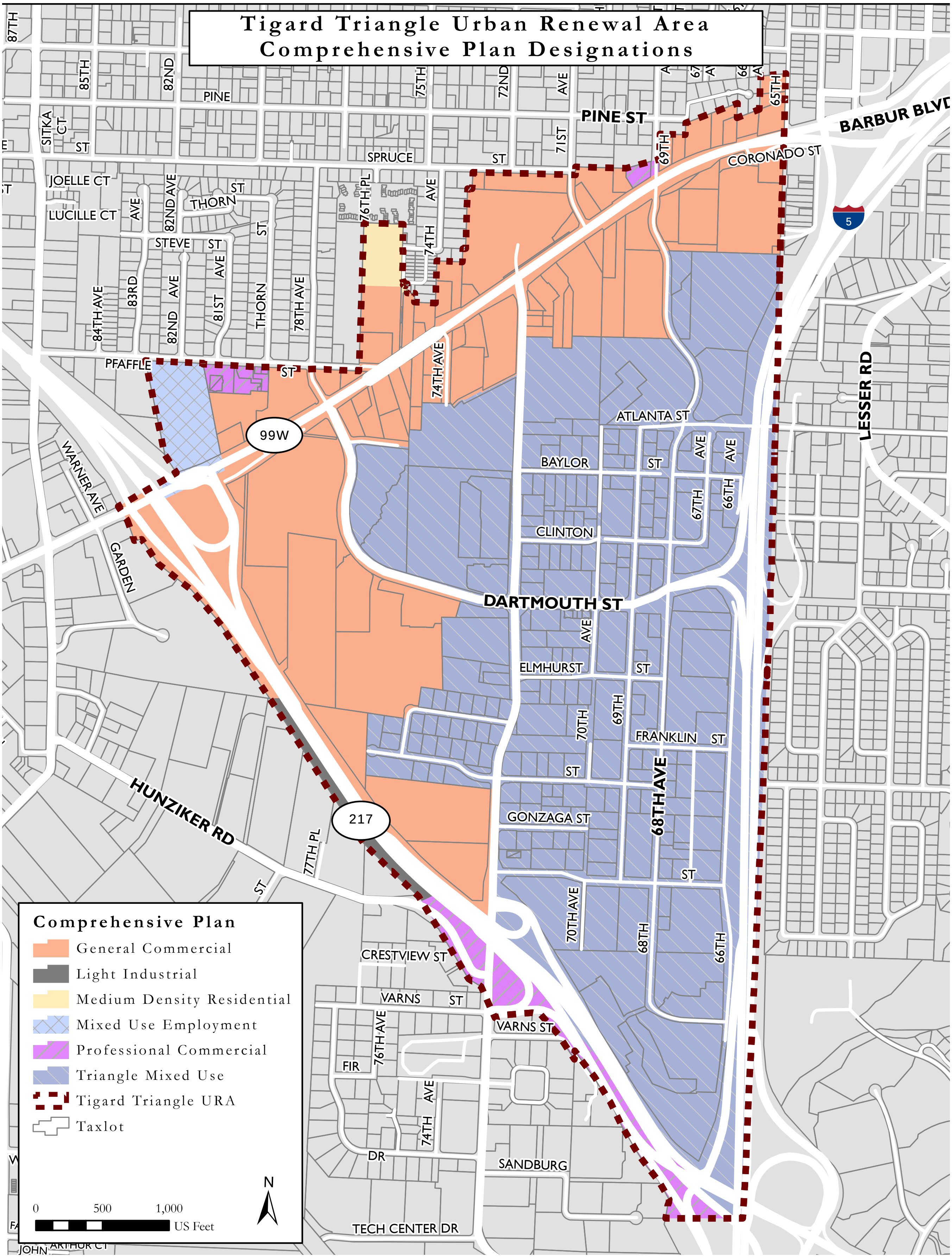
[1] Unless otherwise permitted by state law, no land equal to more than 20 percent of the total land area of the original Plan shall be added to the urban renewal area by amendments, and the aggregate amount of all amendments increasing the maximum indebtedness may not exceed 20 percent of the Plan's initial maximum indebtedness, as adjusted, as provided by law.

FIGURE 2 – Tigard Triangle Urban Renewal Plan Area Comprehensive Plan Designations



X. RELATIONSHIP TO LOCAL OBEJECTIVES

ORS 457.085 requires that the Plan conform to local objectives. This section provides that analysis. Relevant local planning and development objectives are contained within the Tigard Comprehensive Plan, Tigard Community Development Code Chapter 18.500 Zoning Districts, Tigard Transportation System Plan, and Tigard Park System Master Plan. The following section describes the purpose and intent of these plans, the main applicable goals and policies within each plan, and an explanation of how the Plan relates to the applicable goals and policies.

The numbering of the goals and policies within this section reflects the numbering that occurs in the original document. Italicized text is text that has been taken directly from an original document.

Comprehensive Plan designations for all land in the Area are shown in Figure 2. All proposed land uses conform to Figure 2. Maximum densities and building requirements for all land in the Area are contained in the Tigard Community Development Code.

A. Tigard Comprehensive Plan

Citizen Involvement

Goal 1.1: *Provide citizens, affected agencies, and other jurisdictions the opportunity to participate in all phases of the planning process.*

Policies:

3. *The City shall establish special citizen advisory boards and committees to provide input to the City Council, Planning Commission, and City staff.*
4. *The City shall provide staff and financial support to the Committee for Citizen Involvement and any other appointed board or committee.*
5. *The opportunities for citizen involvement provided by the City shall be appropriate to the scale of the planning effort and shall involve a broad cross-section of the community.*

Citizen Involvement *(continued)*

Goal 1.2: *Ensure all citizens have access to:.*

A) Opportunities to communicate directly to the City; and
B) Information on issues in an understandable form.

Policies:

1. *The City shall ensure pertinent information is readily accessible to the community and presented in such a manner that even technical information is easy to understand.*
2. *The City shall utilize such communication methods as mailings, posters, newsletters, the internet, and any other available media to promote citizen involvement and continue to evaluate the effectiveness of methods used.*
3. *The City shall work to maximize citizen involvement through education and accessibility.*
4. *The City shall ensure citizens receive a timely response from policy-makers regarding recommendations made through the citizen involvement program.*
5. *The City shall seek citizen participation and input through collaboration with community organizations, interest groups, and individuals in addition to City sponsored boards and committees.*
6. *The City shall provide opportunities for citizens to communicate to Council, boards and commissions, and staff regarding issues that concern them.*

The Plan conforms to Citizen Involvement Goals 1.1 and 1.2, as a Citizen Advisory Council (CAC) was formed to help develop the Plan. The CAC included representatives from neighborhood organizations, the business and development community, and standing city advisory committees on land use, transportation, etc. They met four times to review the boundary, goals and objectives, finances, and draft Plan and Report. There was also an open house where citizens were given information on the proposed Plan and public meetings and hearings before the Planning Commission and City Council where citizens had the opportunity to comment on the proposed Plan. The Plan was voted on by the citizens of Tigard in May of 2017.

Parks, Recreation, Trails, and Open Spaces

Goal 8.1: *Provide a wide variety of high quality park and open spaces for all residents, including both:*

A) Developed areas with facilities for active recreation; and
B) undeveloped areas for nature-oriented recreation and the protection and enhancement of valuable natural resources within the parks and open space system.

Policies:

1. *Tigard shall acquire, develop, and maintain a diverse system of parks, trails, open space, and recreational facilities that are safe, functional, and accessible to all of its population.*
2. *The City shall preserve, and where appropriate, acquire and improve natural areas located within a half mile of every Tigard resident to provide passive recreational opportunities.*

3. *The City shall seek to achieve or exceed the ideal park service level standard of 11.0 acres of parkland per thousand population.*
4. *The City shall endeavor to develop neighborhood parks [or neighborhood park facilities within other parks, such as a linear park] located within a half mile of every resident to provide access to active and passive recreation opportunities for residents of all ages.*
5. *The City shall develop other parks, including linear parks, special use facilities, urban plazas, skate parks, and pet arenas, consistent with the descriptions and standards contained in the park system master plan.*
9. *The City shall integrate green concepts into park and open space design, maintenance, and operations.*
20. *The City shall continue to improve access to neighborhood parks and other facilities in order to serve all citizens, regardless of ability.*

Goal 8.2: *Create a Citywide network of interconnected on- and off-road pedestrian and bike trails.*

Policies:

1. *The City shall create an interconnected regional and local system of on- and off-road trails and paths that link together neighborhoods, parks, open spaces, major urban activity centers, and regional recreational opportunities utilizing both public property and easements on private property.*

The Plan conforms to Parks, Recreation, Trails, and Open Space Goals 8.1 and 8.2, as there are projects in the Plan to develop plazas, parks, greenways, and public restrooms in the Area. There are also plans for the development of a trail system along Red Rock Creek parallel to and south of 99W.

Economy

Goal 9.1: *Develop and maintian a strong, diversified, and sustainable local economy.*

Policies:

5. *The City shall promote well-designed and efficient development and redevelopment of vacant and underutilized industrial and commercial lands.*

Goal 9.2: *Make Tigard a center and incubator for innovative businesses, including those that focus on environmental sustainability*

1. *The City shall institute appropriate land use regulations to accommodate a contemporary mix of economic activities.*

Goal 9.3: *Make Tigard a prosperous and desirable place to live and do business. Policies:*

1. *The City shall focus a significant portion of future employment growth and high-density housing development in its Metro-designated Town Center (Downtown); Regional Center (Washington Square); High Capacity Transit Corridor (Hwy 99W); and the Tigard Triangle.*
3. *The City shall commit to improving and maintaining the quality of community life (public safety, education, transportation, community design, housing, parks and recreation, etc.) to promote a vibrant and sustainable economy.*

The Plan conforms to Economy Goals 9.1, 9.2 and 9.3, as there are projects in the Plan to provide financial and technical assistance to new and existing businesses and housing developments to help with the development of vacant and underutilized lands in the Area. Development assistance will include, but is not limited to, façade improvement grants/loans, streetscape improvements, technical assistance, site assembly, site clean-up/preparation, site acquisition, and/or partnerships that facilitate housing and mixed-use developments. The Plan was developed with the guidance of a Technical Advisory Committee, comprised of partners from various organizations including the Tigard Chamber of Commerce.

Housing

Goal 10.1: *Provide opportunities for a variety of housing types to meet the diverse housing needs of current and future City residents.*

Policies:

1. *The City shall adopt and maintain land use policies, codes, and standards that provide opportunities to develop a variety of housing types that meet the needs, preferences, and financial capabilities of Tigard's present and future residents.*
3. *The City shall support housing affordability, special-needs housing, ownership opportunities, and housing rehabilitation through programs administered by the state, Washington County, nonprofit agencies, and Metro.*
5. *The City shall provide for high and medium density housing in the areas such as town centers (Downtown), regional centers (Washington Square), and along transit corridors where employment opportunities, commercial services, transit, and other public services necessary to support higher population densities are either present or planned for in the future*

Goal 10.2: *Maintain a high level of residential livability.*

1. *The City shall adopt measures to protect and enhance the quality and integrity of its residential neighborhoods.*
2. *The City shall provide multi-modal transportation access from residential neighborhoods transit stops, commercial services, employment, and other activity centers.*
5. *The City shall encourage housing that supports sustainable development patterns by promoting the efficient use of land, conservation of natural resources, easy access to public transit and other efficient modes of transportation, easy access to services and parks, resource efficient design and construction, and the use of renewable energy resources.*

The Plan conforms to Housing Goals 10.1 and 10.2, as there are projects in the Plan to facilitate workforce and affordable housing and transit-oriented and mixed-use development. The Plan was developed with the guidance of a Technical Advisory Committee, comprised of partners from various organizations including Community Partners for Affordable Housing and REACH Community Development.

Transportation

Goal 12.1: *Develop mutually supportive land use and transportation plans to enhance the livability of the community.*

1. *The City shall plan for a transportation system that meets current community needs and anticipated growth and development.*
2. *The City shall prioritize transportation projects according to community benefit, such as safety, performance, and accessibility, as well as the associated costs and impacts.*
3. *The City shall maintain and enhance transportation functionality by emphasizing multi- modal travel options for all types of land uses.*
4. *The City shall promote land uses in transportation investments that promote balanced transportation options.*
5. *The City shall develop plans for major transportation corridors and provide appropriate land uses in and adjacent to those corridors.*
6. *The City shall support land use patterns that reduce greenhouse gas emissions and preserve the function of the transportation system.*
9. *The City shall coordinate with private and public developers to provide access via a safe, efficient, and balanced transportation system.*
10. *The City shall require all development to meet the adopted transportation standards or provide appropriate mitigations.*

Goal 12.2: *Develop and maintain a transportation system for the efficient movement of goods.*

2. *The City shall manage the transportation system to support desired economic development activities.*
3. *The City shall design streets to encourage a reduction in trip length by improving arterial, collector, and local street connections.*
4. *The City shall design arterial routes, highway access, and adjacent land uses in ways that facilitate the efficient movement of people, goods and services.*
6. *The City shall develop and maintain an efficient arterial grid system that provides access within the City, and searched through traffic in the City.*
9. *The City shall require the provision of appropriate parking in balance with other transportation modes.*
11. *The City shall design the transportation system to provide connectivity between Metro designated centers, corridors, employment and industrial areas.*

Goal 12.3: *Provide an accessible, multi-modal transportation system that meets the mobility needs of the community.*

3. *The City shall design and construct transportation facilities to meet the requirements of the Americans with Disabilities Act.*
4. *The City shall support and prioritize bicycle, pedestrian, and transit improvements for transportation disadvantaged populations who may be dependent on travel modes other than private automobile.*
5. *The City shall develop and maintain neighborhood and local connections to provide efficient circulation in and out of the neighborhoods.*
6. *The City shall require development adjacent to transit routes to provide direct pedestrian accessibility.*
7. *The City shall develop and implement public street standards that recognize the multi- purpose nature of the street right-of-way.*
8. *The City shall design all projects on Tigard city streets to encourage pedestrian and bicycle travel.*
9. *The City shall require sidewalks to be constructed in conjunction with private development and consistent with adopted plans.*
10. *The City shall require and/or facilitate the construction of off-street trails to develop pedestrian and bicycle connections that cannot be provided by a street.*
11. *The City shall require appropriate access to bicycle and pedestrian facilities for all schools, parks, public facilities, and commercial areas.*

Transportation (continued)

Goal 12.4: *Maintain and improve transportation system safety.*

1. *The City shall consider the intended uses of street during the design to promote safety, efficiency, and multi-modal needs.*
2. *The City shall ordinate with appropriate agencies to provide safe, secure, connected, and desirable pedestrian, bicycle, and public transit facilities.*
3. *The City shall require new development to provide safe access for all modes to and from a publicly dedicated street.*
5. *The City shall prioritize intersection improvements to address safety deficiencies.*
9. *The City shall require new transportation facilities to meet adopted lighting standards.*

Goal 12.6: *Fund an equitable, balanced, and sustainable transportation system that promotes the well-being of the community.*

2. *The City shall seek to invest in capital projects that leverage other infrastructure investments.*
3. *The City shall seek opportunities for transportation investments that support transportation goals of efficiency, multi-modal access, and safety.*

The Plan conforms to Transportation Goals 12.1, 12.2, 12.3, and 12.4, as there are projects in the Plan to improve the transportation system for all modes of travel and to create better access to, from, and within the Area. The specific projects include modifying existing streets, constructing new streets, providing better pedestrian and bicycle access, intersection improvements, overpass connections, parking solutions for vehicles and bicycles, and trail development along Red Rock Creek. The Plan was developed with the guidance of a Technical Advisory Committee, comprised of partners from various agencies including Metro, TriMet, Washington County, and the Oregon Department of Transportation.

B. Tigard Community Development Code

The land uses in the Area will conform to the zoning designations in the community development code, including maximum densities and building requirements, and are incorporated by reference herein. The following zoning districts are present in the Area.

C-G: General commercial district. The C-G zoning district applies to roughly half of the land in the Area. This zoning district is designed to accommodate a full range of retail, office and civic uses with a citywide and regional trade area. Except where nonconforming, residential uses are limited to single-family residences that are located on the same site as a permitted use. A wide range of uses, including but not limited to adult entertainment, automotive equipment repair and storage, mini-warehouses, utilities, heliports, medical centers, major event entertainment, and gasoline stations, are permitted conditionally.

MUE: Mixed-use employment. The MUE zoning district applies to roughly half of the land in the Area and is the city's only regional mixed-use employment district. This zoning district permits a wide range of uses including major retail goods and services, business/professional offices, civic uses and housing; the latter includes multi-family housing at a maximum density of 25 units/acre, equivalent to the R-25 zoning district. A wide range of uses, including but not limited to community recreation facilities, medical centers, schools, utilities and transit-related park-and-ride lots, are permitted conditionally. Although it is recognized that the automobile will accommodate the vast majority of trips to and within the Triangle, it is still important to: (1) support alternative modes of transportation to the greatest extent possible, and (2) encourage a mix of uses to facilitate intra-district pedestrian and transit trips even for those who drive.

R-12: Medium-density residential district. The R-12 zoning district is designed to accommodate a full range of housing types at a minimum lot size of 3,050 square feet. A wide range of civic and institutional uses are also permitted conditionally.

B. Tigard Community Development Code (continued)

C-P: Professional/administrative commercial district. The C-P zoning district is designed to accommodate civic and business/professional services and compatible support services, e.g., convenience retail, personal services, and restaurants in close proximity to residential areas and major transportation facilities. Residential uses at a minimum density of 32 units/net acre, i.e., equivalent to the R-40 zoning district, are permitted in conjunction with a commercial development. Heliports, medical centers, religious institutions and utilities are permitted conditionally. Development in the C-P zoning district is intended to serve as a buffer between residential areas and more-intensive commercial and industrial areas.

C. Transportation System Plan

Goal 1: *Land use and transportation coordination– develop mutually supportive land use and transportation plans to enhance the livability of the community. The city shall plan for a transportation system that meets current community needs and anticipated growth and development.*

Goal 2: *Transportation efficiency – develop and maintain a transportation system for the efficient movement of people and goods.*

Goal 3: *Multi-modal transportation system – provide an accessible, multi-modal transportation system that meets the mobility needs of the community.*

Goal 4: *Safe transportation system – maintain and improve transportation system safety.*

Goal 5: *Inter-agency coordination – coordinate planning, development, operation and maintenance of the transportation system with appropriate agencies.*

Goal 6: *Transportation funding – fund and equitable, balanced and sustainable transportation system that promotes the well-being of the community.*

In addition to the above applicable goals, the Tigard Triangle is identified as one of three special areas within the city with significant growth opportunities and transportation challenges.

The Tigard Triangle is a priority opportunity for community development and economic activity. The triangle has long been a retail and commercial hub within the city. Today, the triangle is zoned for commercial and mixed-use development and is identified as an area of significant future growth in housing and jobs.

Although the area is bordered by three major regional roadways, in many ways those roadways function as barriers to access the triangle. Travel to and from the Tigard Triangle is funneled from Pacific Highway via 72nd Avenue, Dartmouth Street and 68th Parkway; the Highway 217/72nd Avenue interchange; the northbound I-5 interchange with Haines Street; and the southbound I-5 interchange with Dartmouth Street.

Access to and from the Tigard Triangle area is, and will remain, a critical issue to the success of the Tigard Triangle area. The majority of employees and customers traveling to the area on city streets access the Tigard Triangle area off of Pacific Highway. There is considerable congestion on Pacific Highway in the vicinity of the Tigard Triangle and this congestion is forecast to worsen with future development and regional growth.

A second issue with the Tigard Triangle relates to non-auto mobility/circulation to/from and within the area. The triangle area as a whole is generally sloping downward from Pacific Highway and I-5 to Highway 217. The topography makes pedestrian and bicycle transportation more difficult. These conditions are worsened by incomplete bicycle and pedestrian systems within the Triangle. At the broadest level, options for improving access to the Tigard Triangle area fall into the following categories:

- *Provide additional intersection and roadway capacity improvements to improve traffic operations at the boundary streets.*
- *Minimize additional roadway capacity infrastructure investment and focus on travel demand management (TDM) programs.*
- *Provide better facilities for alternative modes (transit, bicycles, pedestrians, etc.).*
- *Create a mix of critical additional capacity and implementing TDM programs.*

C. Transportation System Plan *(continued)*

The Plan conforms to the Transportation System Plan goals and recommendations, as there are projects in the Plan to improve the transportation system for all modes of travel and to create better access to, from, and within the Area. The specific projects include modifying existing streets, constructing new streets, providing better pedestrian and bicycle access, intersection improvements, overpass connections, parking solutions for vehicles and bicycles, and trail development along Red Rock Creek. The Plan was developed with the guidance of a Technical Advisory Committee, comprised of partners from various agencies including Metro, TriMet, Washington County, and the Oregon Department of Transportation.

D. Tigard Parks System Master Plan

Goal 1: *Provide a wide variety of high quality park and open spaces for all residents, including both: 1) Developed areas with facilities for active recreation; and 2) Undeveloped areas for nature-oriented recreation and the protection and enhancement of valuable natural resources within the parks and open space system*

Goal 2: *Create a citywide network of interconnected on- and off-road pedestrian and bicycle trails.*

Goal 3: *Provide Tigard residents with a broad range of recreational, cultural and educational activities.*

The Plan conforms to the Park System Master Plan, as there are projects in the Plan to develop plazas, parks, greenways, and public restrooms in the Area. There are also plans for the development of a trail system along Red Rock Creek parallel to and south of 99W.

XI. APPENDIX A: LEGAL DESCRIPTION

Tigard Triangle Urban Renewal Area
Tigard, Oregon
Area = 548 Acres

A tract of land, including road rights-of-way, located in the Northeast One-Quarter, the Southeast One-Quarter, and the Southwest One-Quarter of Section 36, Township 1 South, Range 1 West and the Northwest One-Quarter, the Northeast One-Quarter, and the Southeast One-Quarter of Section 1, Township 2 South, Range 1 West, Willamette Meridian, City of Tigard, Washington County, Oregon, and being more particularly described as follows:

Beginning at the southeast corner of Lot 1 of the plat of “Villa Ridge No. 2”, being on the Willamette Meridian, the easterly line of Washington County, in the Northeast One-Quarter of Section 31, Township 1 South, Range 1 West, Willamette Meridian, in the City of Tigard, Washington County, Oregon (Assessor’s Map 1S 1 36AD):

1. Thence along the Willamette Meridian, being the easterly line of Washington County, Southerly 8,592 feet, more or less, to its intersection with the easterly extension of the south line of Lot 2 of the plat of “Salem Freeway Subdivision” (Assessor’s Map 2S 1 01DD);
2. Thence along said easterly extension, Westerly 585 feet, more or less, to the southwesterly right-of-way line of State Highway 217 (Assessor’s Map 2S 1 01DD);
3. Thence along said southwesterly right-of-way line, Northwesterly 1,471 feet, more or less, to the west line of Lot 3 of the plat of “Varns Acres” (Assessor’s Map 2S 1 01DA);
4. Thence along said west line, Southerly 65 feet, more or less, to the southwesterly right-of-way line of State Highway 217, also being the north line of Lot 9 of the plat of “72nd Business Center” (Assessor’s Map 2S 1 01DA);
5. Thence along said southwesterly right-of-way line, Northwesterly 773 feet, more or less, to the easterly right-of-way line of SW 72nd Avenue (Assessor’s Map 2S 1 01DB);
6. Thence crossing SW 72nd Avenue, Northwesterly 258 feet, more or less, to the intersection of the westerly right-of-way line of SW 72nd Avenue and the southwesterly right-of-way line of SW Hunziker Street (Assessor’s Map 2S 1 01DB);
7. Thence along said southwesterly right-of-way line, Northwesterly 549 feet, more or less, to Engineers Station ‘H’ 453+50, 80 feet right, as shown on Washington County Survey Number 25355 (Assessor’s Map 2S 1 01DB);
8. Thence Northwesterly 285 feet, more or less, to the intersection of the northeasterly right-of-way line of SW Hunziker Street and the southwesterly right-of-way line of State Highway 217 (Assessor’s Map 2S 1 01AC);
9. Thence along said southwesterly right-of-way line, Northwesterly 3,627 feet, more or less, to the intersection of the southeasterly right-of-way line of SW Pacific Highway and the southwesterly right-of-way line of State Highway 217 (Assessor’s Map 2S 1 01BB);
10. Thence crossing said SW Pacific Highway, Northwesterly 128 feet, more or less, to the intersection of the northwesterly right-of-way line of SW Pacific Highway and the southwesterly right-of-way line of State Highway 217 (Assessor’s Map 1S 1 36CC);
11. Thence crossing said State Highway 217 along the northeasterly extension of the northwesterly right-of-way line of SW Pacific Highway, Northeasterly 505 feet, more

or less, to the intersection of the northwesterly right-of-way line of SW Pacific Highway and the northeasterly right-of-way line of State Highway 217 (Assessor's Map 1S 1 36CC);

12. Thence along said northeasterly right-of-way line of State Highway 217, Northwesterly 155 feet, more or less, to the west line of Document Number 2016-13886 (Assessor's Map 1S 1 36CC);
13. Thence along said west line, Northwesterly 727 feet, more or less, to the southerly right-of-way line of SW Pfaffle Street (Assessor's Map 1S 1 36CC);
14. Thence along said southerly right-of-way line, Easterly 1,609 feet, more or less, to the southerly extension of the east line of Document Number 2016-18082 (Assessor's Map 1S 1 36CA);
15. Thence along said southerly extension and the east line thereof, Northerly 1,113 feet, more or less, to the south line of the plat of "Tigard Woods, A Condominium Community" (Assessor's Map 1S 1 36CA);
16. Thence along said south line, Easterly 296 feet, more or less, to the west line of the plat of "White Oak Village" (Assessor's Map 1S 1 36CA);
17. Thence along said west line, Southerly 198 feet, more or less, to the north line of Tract 'A' of said plat (Assessor's Map 1S 1 36CA);
18. Thence along said north line, Easterly 4 feet, more or less, to the northeast corner thereof (Assessor's Map 1S 1 36CA);
19. Thence along the east line of said Tract 'A', Southeasterly 304 feet, more or less, to the northwest corner of Lot 26 of said plat (Assessor's Map 1S 1 36CA);
20. Thence along the west line of said Lot 26, Southerly 69 feet, more or less, to the southwest corner thereof (Assessor's Map 1S 1 36CA);
21. Thence along the south line of said Lot 26 and the south line of Lot 27, Easterly 58 feet, more or less, to the southeast corner of said Lot 27 and the west line of Document Number 2001-29328 (Assessor's Map 1S 1 36DB);
22. Thence along the west line of said Deed, Southerly 65 feet, more or less, to the south line of said Deed (Assessor's Map 1S 1 36DB);
23. Thence along said south line, Easterly 160 feet, more or less, to the west line of Document Number 2000-00576 (Assessor's Map 1S 1 36DB);
24. Thence along said west line and the west line of Document Number 2007-115624, Northerly 319 feet, more or less, to the south line of Partition Plat Number 2009-027 (Assessor's Map 1S 1 36DB);
25. Thence along said south line, Easterly 192 feet, more or less, to the southeast corner thereof (Assessor's Map 1S 1 36DB);
26. Thence along the east line of said plat, Northerly 100 feet, more or less, to the south line of Document Number 2000-14791 (Assessor's Map 1S 1 36DB);
27. Thence along said south line, Easterly 21 feet, more or less, to the west line of Document Number 2001-49756 (Assessor's Map 1S 1 36DB);
28. Thence along said west line, Northerly 451 feet, more or less, to the south line of the plat of "Metzger Acre Tracts" (Assessor's Map 1S 1 36AC);
29. Thence along said south line, Easterly 34 feet, more or less, to the west line of Document Number 2001-49756 (Assessor's Map 1S 1 36AC);
30. Thence along said west line, Northerly 126 feet, more or less, to the southerly rightof-way line of SW Spruce Street (Assessor's Map 1S 1 36AC);

31. Thence along said southerly right-of-way line and the easterly extension thereof, Easterly 769 feet, more or less, to the easterly right-of-way line of SW 71st Avenue (Assessor's Map 1S 1 36AD);
32. Thence along said easterly right-of-way line, Northerly 58 feet, more or less, to the north line of Document Number 2016-75996 (Assessor's Map 1S 1 36AD);
33. Thence along said north line, Easterly 380 feet, more or less, to the northwest corner of Document Number 2016-64828 (Assessor's Map 1S 1 36AD);
34. Thence along the north line of said Deed and the northeasterly extension thereof, Northeasterly 258 feet, more or less, to the easterly right-of-way line of SW 69th Avenue (Assessor's Map 1S 1 36AD);
35. Thence along said easterly right-of-way line, Northerly 189 feet, more or less, to the south line of Document Number 2005-78796, being a line parallel to and 88 feet southerly of the north line of Lot 1, Block 1 of the plat of "Villa Ridge" (Assessor's Map 1S 1 36AD);
36. Thence along said parallel line, Easterly 190 feet, more or less, to the west line of Document Number 2008-19233 (Assessor's Map 1S 1 36AD);
37. Thence along said west line, Northerly 88 feet, more or less, to the northwest corner thereof (Assessor's Map 1S 1 36AD);
38. Thence along the north line of said Deed and the north line of Document Number 2008-74471, Northeasterly 416 feet, more or less, to the west line of Document Number 85-51861 (Assessor's Map 1S 1 36AD);
39. Thence along said west line, Southerly 110 feet, more or less, to the southwest corner of said Deed (Assessor's Map 1S 1 36AD);
40. Thence along the south line of said Deed and the south line of Deed Book 794, Page 602, Northeasterly 179 feet, more or less, to the west line of Document Number 93-07010 (Assessor's Map 1S 1 36AD);
41. Thence along said west line, Northerly 249 feet, more or less, to the south line of the plat of "Villa Ridge No. 2" (Assessor's Map 1S 1 36AD);
42. Thence along said south line, Northeasterly 194 feet, more or less, to the Point of Beginning.

The above described tract of land contains 548 acres, more or less.

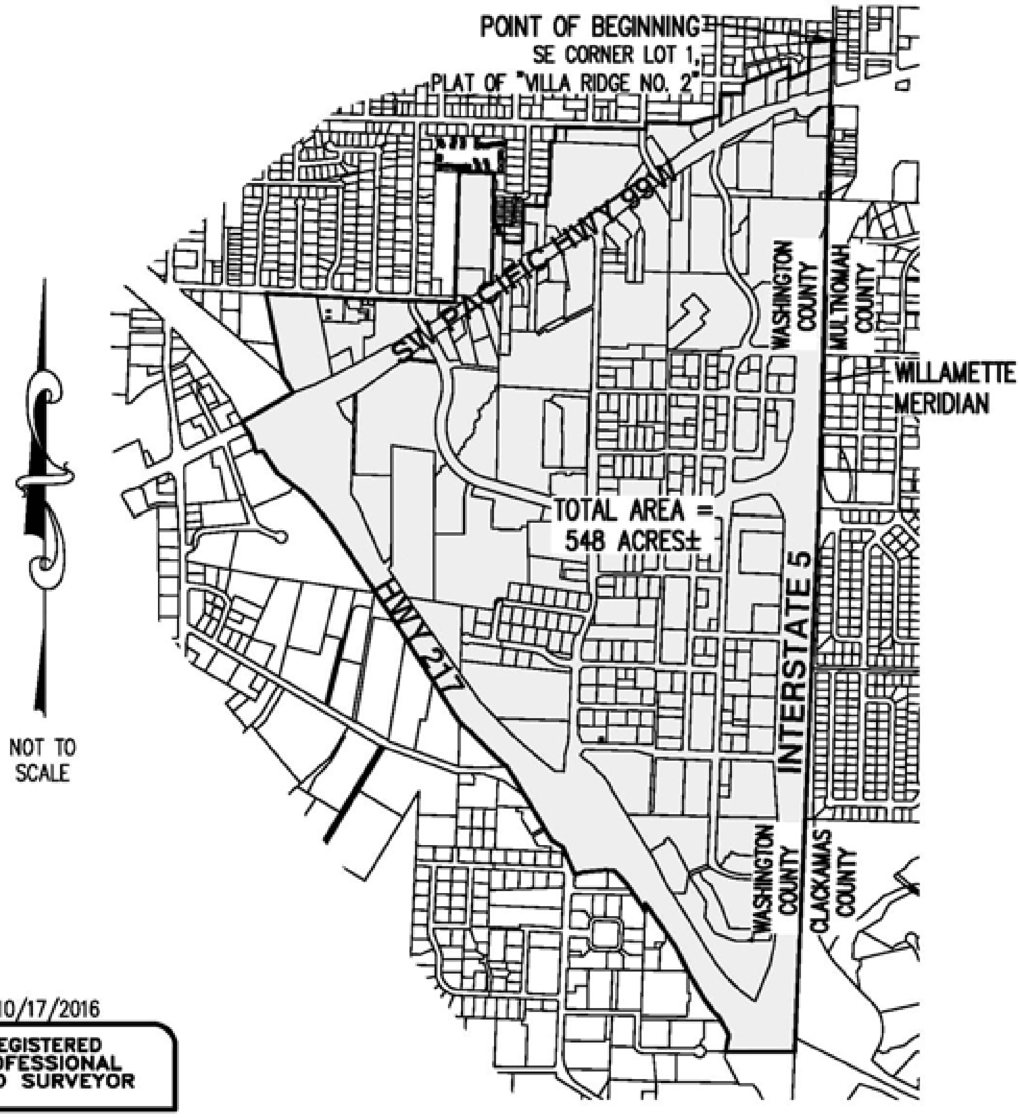
10/17/2016

REGISTERED
PROFESSIONAL
LAND SURVEYOR

OREGON
JANUARY 12, 2016
MICHAEL S. KALINA
89558PLS
RENEWS: 6/30/17

SHEET 1 OF 9

MAP OF URBAN RENEWAL AREA
A TRACT OF LAND, INCLUDING ROAD RIGHTS-OF-WAY, LOCATED IN THE NE 1/4, THE SE 1/4, AND THE SW 1/4 OF SEC. 36, T1S, R1W, AND THE NW 1/4, THE NE 1/4, AND THE SE 1/4 OF SEC. 1, T2S, R1W, W.M., CITY OF TIGARD, WASHINGTON COUNTY, OREGON



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JANUARY 12, 2016
MICHAEL S. KALINA
89558PLS
RENEWS: 6/30/17

PREPARED FOR
CITY OF TIGARD
13125 SW HALL BLVD
TIGARD, OR 97223

TIGARD TRIANGLE
URBAN RENEWAL AREA

AKS ENGINEERING & FORESTRY, LLC
12965 SW HERMAN RD, STE 100
TUALATIN, OR 97062
P: 503.563.6151 F: 503.563.6152 aks-eng.com

AKS

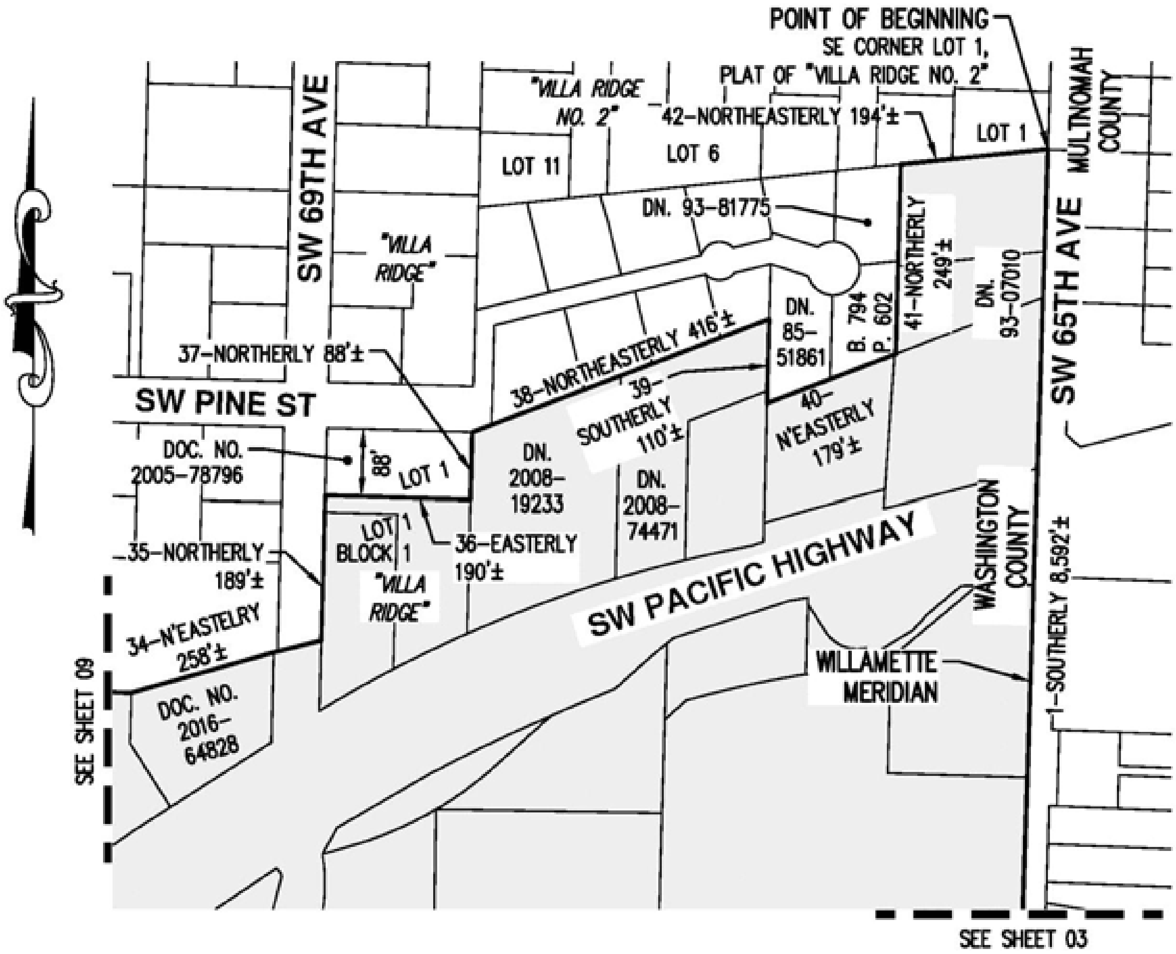
EXHIBIT
B

DRWN: MSK
CHKD: NSW
AKS JOB:
5570

DWG: 5570 COT UR-01 | 01

SHEET 2 OF 9

MAP OF URBAN RENEWAL AREA
A TRACT OF LAND, INCLUDING ROAD RIGHTS-OF-WAY, LOCATED IN THE NE 1/4, THE SE 1/4, AND THE SW 1/4 OF SEC. 36, T1S, R1W, AND THE NW 1/4, THE NE 1/4, AND THE SE 1/4 OF SEC. 1, T2S, R1W, W.M., CITY OF TIGARD, WASHINGTON COUNTY, OREGON



10/17/2016

SCALE 1" = 200 FEET

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TUALATIN, OR 97062
P: 503.563.6151 F: 503.563.6152 aks-eng.com

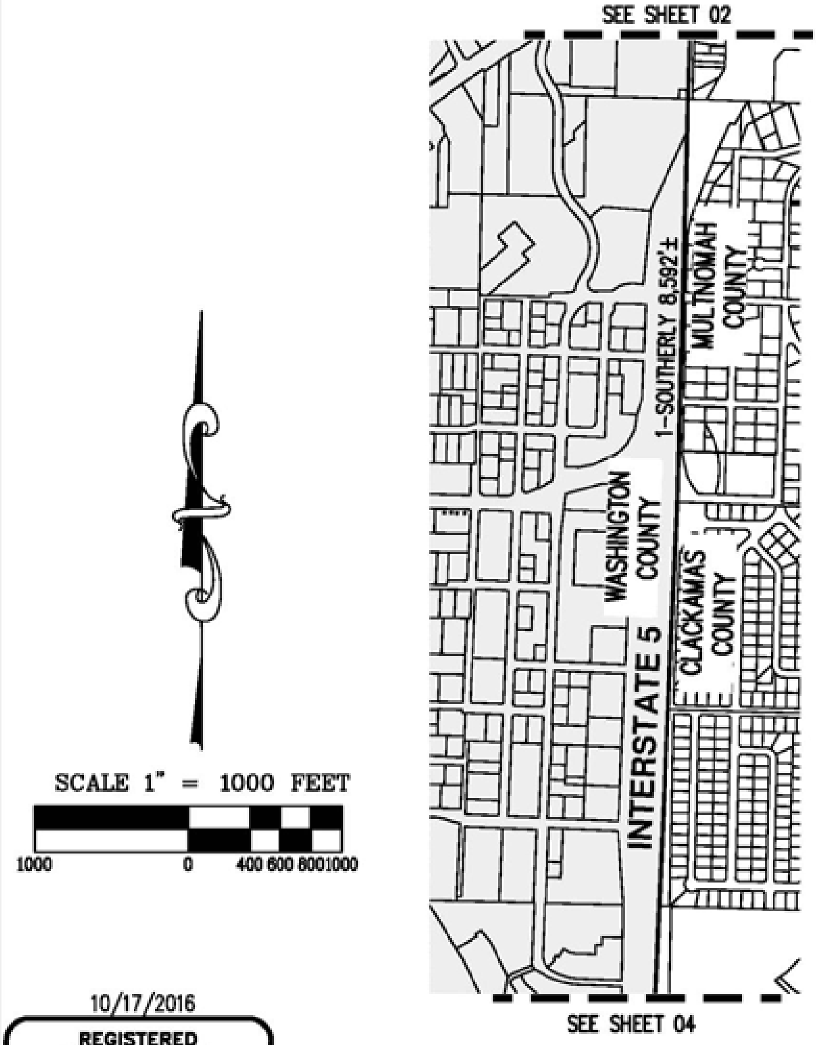
AKS

EXHIBIT
B
DRWN: MSK
CHKD: NSW
AKS JOB:
5570

DWG: 5570 COT UR-02 | 02

SHEET 3 OF 9

MAP OF URBAN RENEWAL AREA
A TRACT OF LAND, INCLUDING ROAD RIGHTS-OF-WAY, LOCATED IN THE NE 1/4, THE SE 1/4, AND THE SW 1/4 OF SEC. 36, T1S, R1W, AND THE NW 1/4, THE NE 1/4, AND THE SE 1/4 OF SEC. 1, T2S, R1W, W.M., CITY OF TIGARD, WASHINGTON COUNTY, OREGON



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TIGARD, OR 97223

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URBAN RENEWAL AREA

AKS ENGINEERING & FORESTRY, LLC
12965 SW HERMAN RD, STE 100
TUALATIN, OR 97062
P: 503.563.6151 F: 503.563.6152 aks-eng.com

AKS

EXHIBIT
B

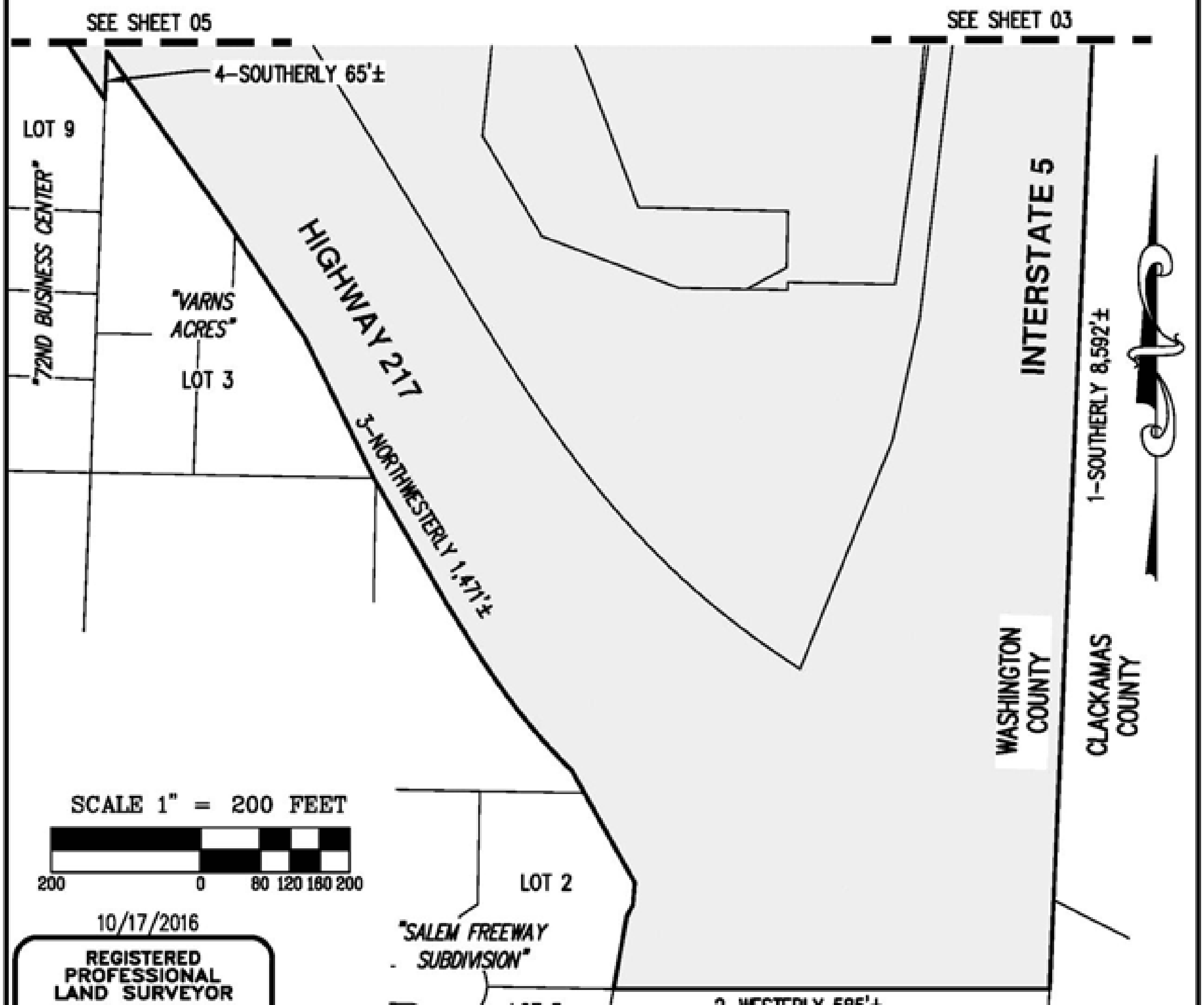
DRWN: MSK
CHKD: NSW
AKS JOB:
5570

DWG: 5570 COT UR-03 | 03

SHEET 4 OF 9

MAP OF URBAN RENEWAL AREA

A TRACT OF LAND, INCLUDING ROAD RIGHTS-OF-WAY, LOCATED IN THE NE 1/4, THE SE 1/4, AND THE SW 1/4 OF SEC. 36, T1S, R1W, AND THE NW 1/4, THE NE 1/4, AND THE SE 1/4 OF SEC. 1, T2S, R1W, W.M., CITY OF TIGARD, WASHINGTON COUNTY, OREGON



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REGISTERED PROFESSIONAL LAND SURVEYOR

Michael Kalina

OREGON
JANUARY 12, 2016
MICHAEL S. KALINA
89558PLS
RENEWS: 6/30/17

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13125 SW HALL BLVD
TIGARD, OR 97223

TIGARD TRIANGLE URBAN RENEWAL AREA

AKS ENGINEERING & FORESTRY, LLC
12965 SW HERMAN RD, STE 100
TUALATIN, OR 97062
P: 503.563.6151 F: 503.563.6152 aks-eng.com

AKS

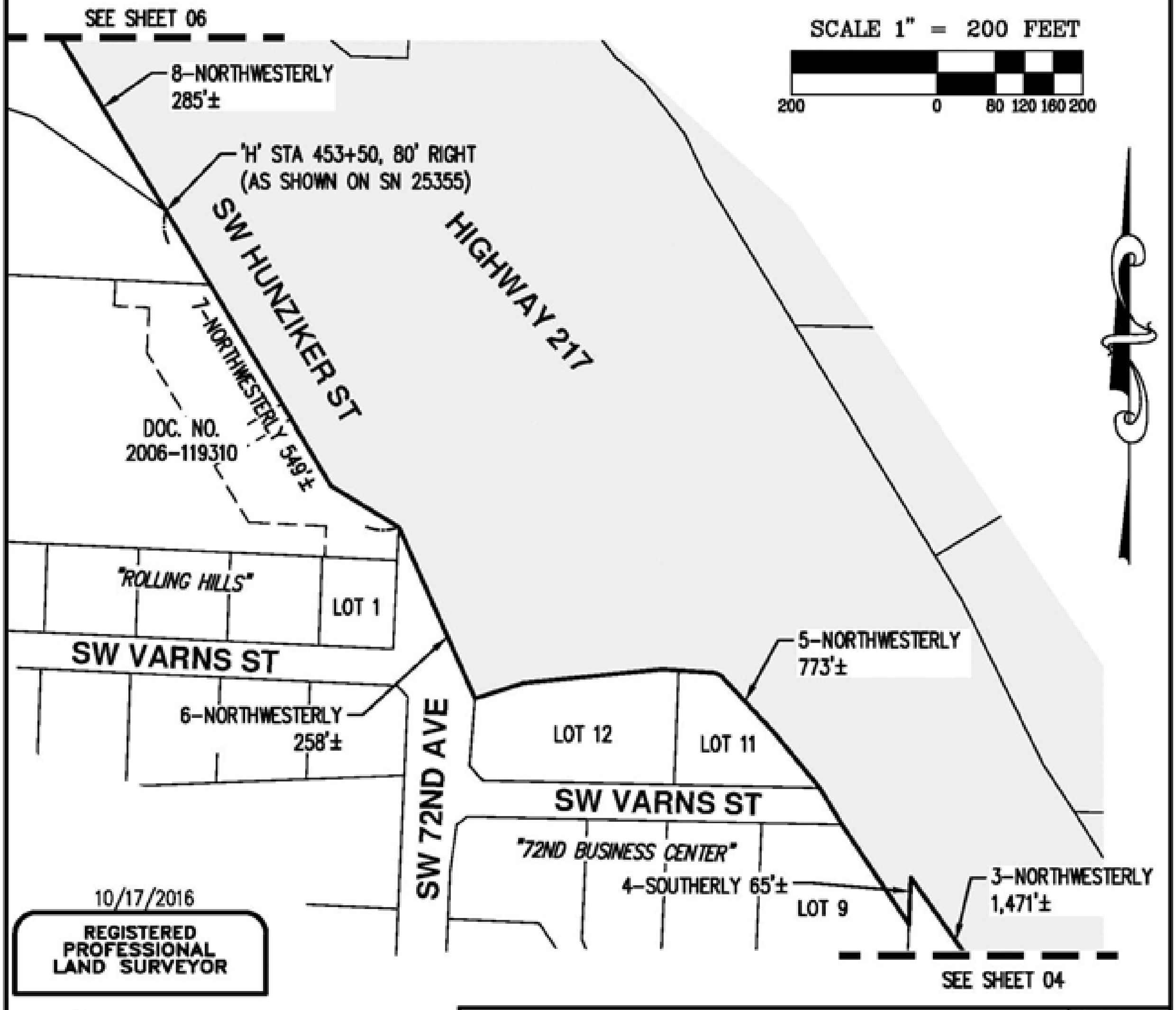
EXHIBIT B
DRWN: MSK
CHKD: NSW
AKS JOB: 5570

DWG: 5570 COT UR-04 | 04

SHEET 5 OF 9

MAP OF URBAN RENEWAL AREA

A TRACT OF LAND, INCLUDING ROAD RIGHTS-OF-WAY, LOCATED IN THE NE 1/4, THE SE 1/4, AND THE SW 1/4 OF SEC. 36, T1S, R1W, AND THE NW 1/4, THE NE 1/4, AND THE SE 1/4 OF SEC. 1, T2S, R1W, W.M., CITY OF TIGARD, WASHINGTON COUNTY, OREGON



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TIGARD, OR 97223

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12965 SW HERMAN RD, STE 100
TUALATIN, OR 97062
P: 503.563.6151 F: 503.563.6152 aks-eng.com

EXHIBIT
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DRWN: MSK
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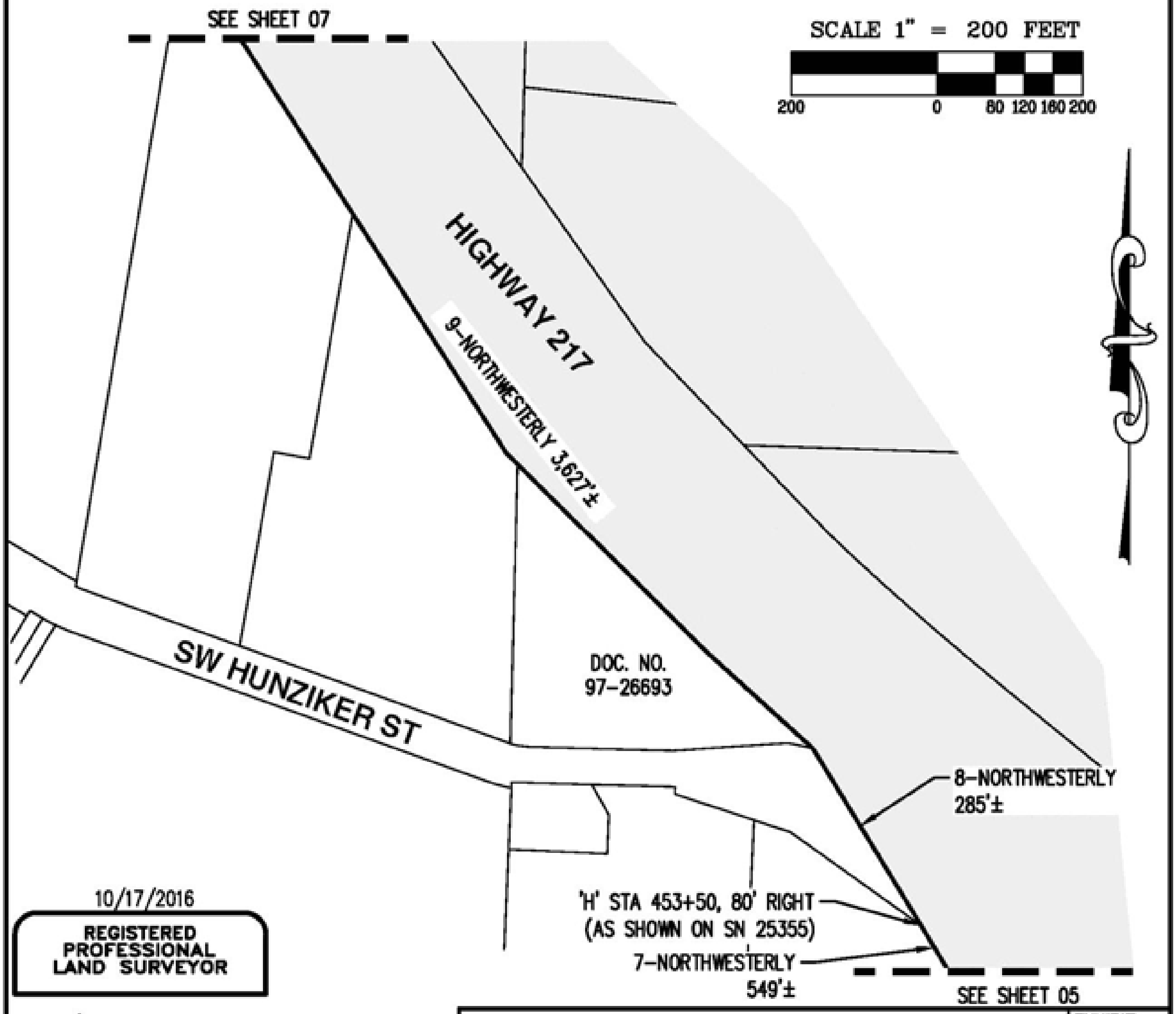
AKS JOB:
5570

DWG: 5570 COT UR-05 | 05

SHEET 6 OF 9

MAP OF URBAN RENEWAL AREA

A TRACT OF LAND, INCLUDING ROAD RIGHTS-OF-WAY, LOCATED IN THE NE 1/4, THE SE 1/4, AND THE SW 1/4 OF SEC. 36, T1S, R1W, AND THE NW 1/4, THE NE 1/4, AND THE SE 1/4 OF SEC. 1, T2S, R1W, W.M., CITY OF TIGARD, WASHINGTON COUNTY, OREGON



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MICHAEL S. KALINA
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RENEWS: 6/30/17

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TIGARD, OR 97223

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URBAN RENEWAL AREA

AKS ENGINEERING & FORESTRY, LLC
12965 SW HERMAN RD, STE 100
TUALATIN, OR 97062
P: 503.563.6151 F: 503.563.6152 aks-eng.com

EXHIBIT
B

DRWN: MSK
CHKD: NSW
AKS JOB:
5570

DWG: 5570 COT UR-06 | 06

SHEET 7 OF 9

MAP OF URBAN RENEWAL AREA

A TRACT OF LAND, INCLUDING ROAD RIGHTS–OF–WAY, LOCATED IN THE
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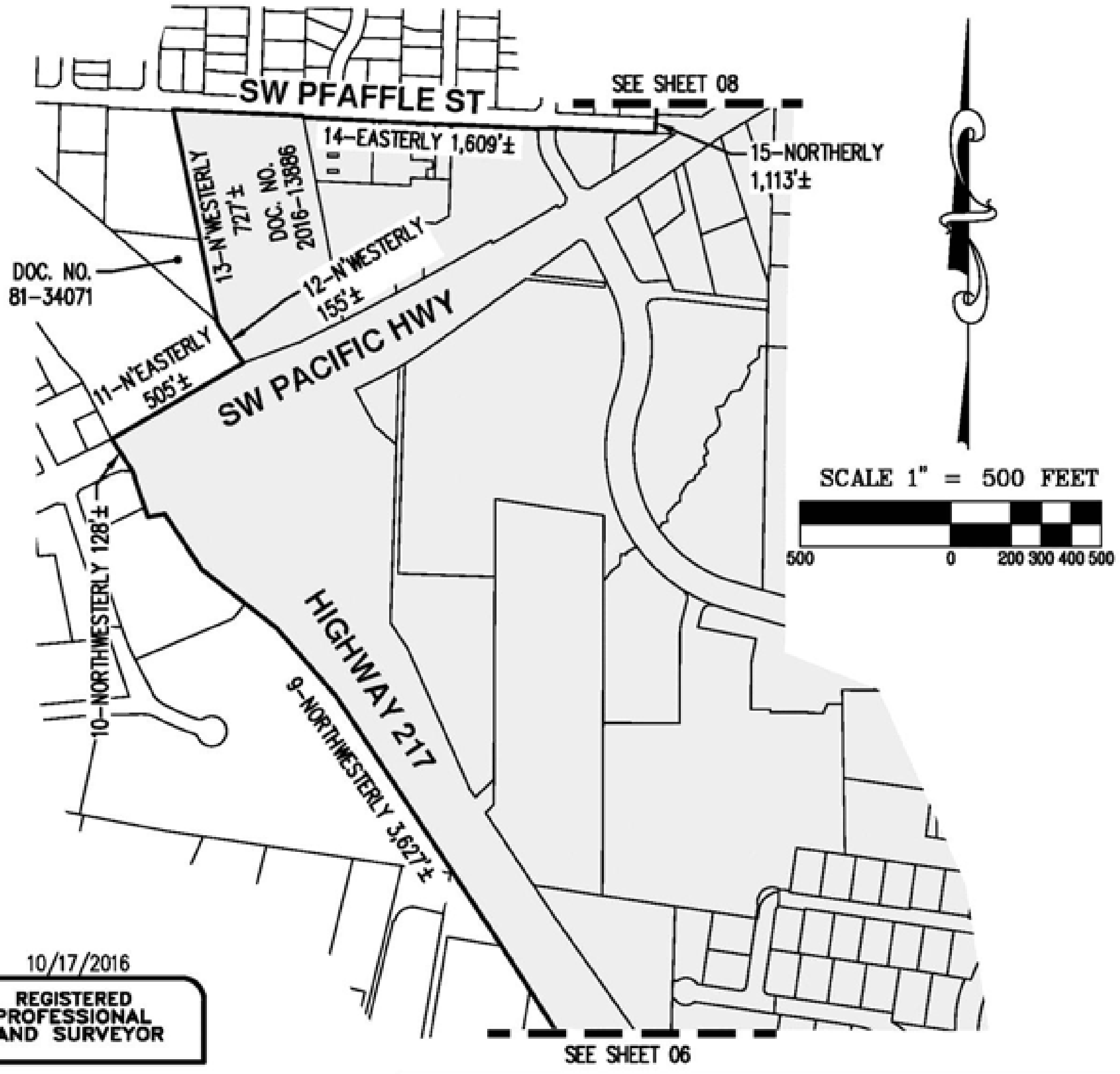

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TIGARD, OR 97223

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AKS ENGINEERING & FORESTRY, LLC
12965 SW HERMAN RD, STE 100
TUALATIN, OR 97062
P: 503.563.6151 F: 503.563.6152 aks–eng.com

AKS

EXHIBIT
B

DRWN: MSK
CHKD: NSW
AKS JOB:
5570

DWG: 5570 COT UR–07 | 07

SHEET 8 OF 9

MAP OF URBAN RENEWAL AREA

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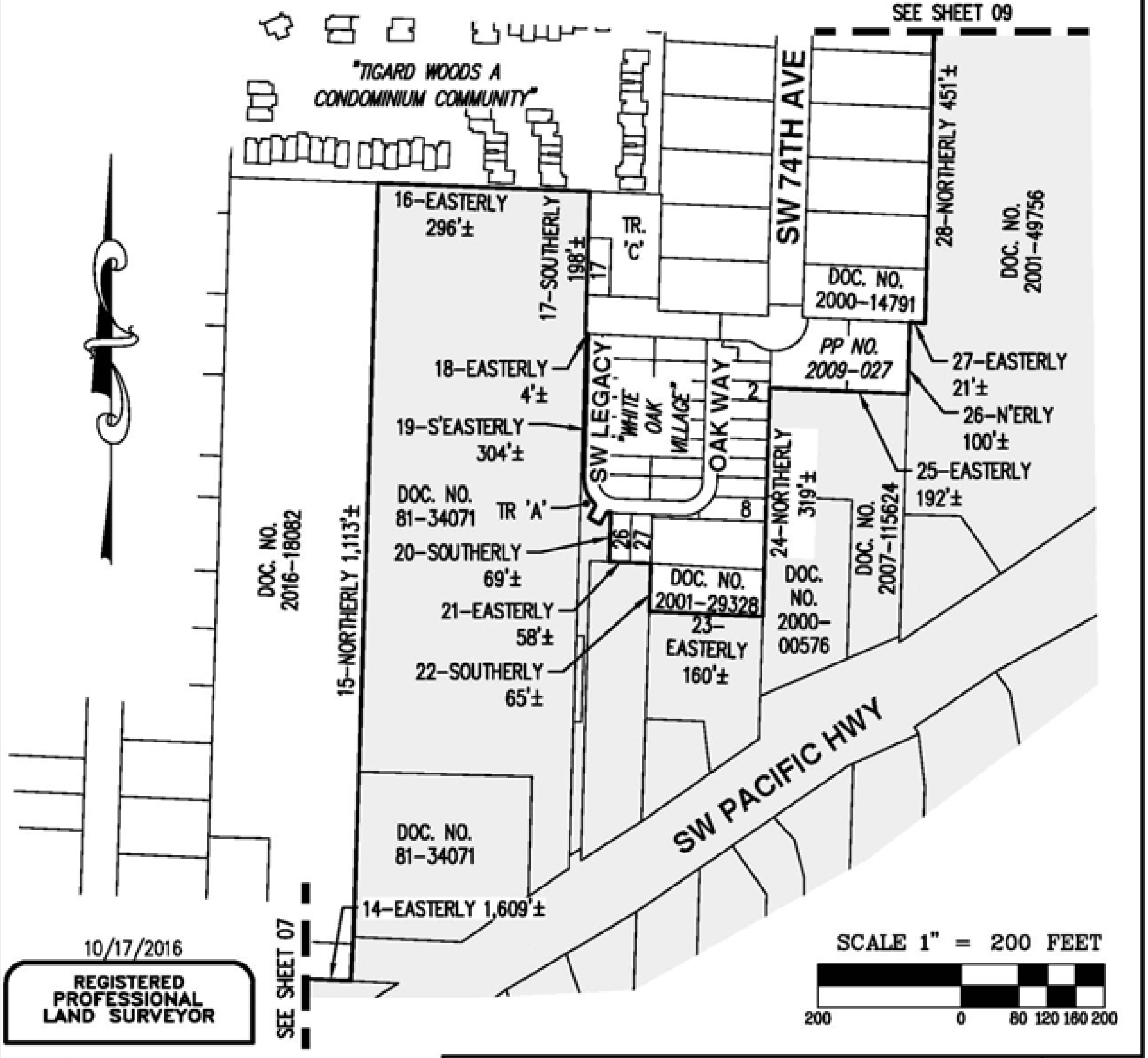

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TUALATIN, OR 97062
P: 503.563.6151 F: 503.563.6152 aks–eng.com

AKS

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DRWN: MSK
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5570

DWG: 5570 COT UR–08 | 08

SHEET 9 OF 9

MAP OF URBAN RENEWAL AREA

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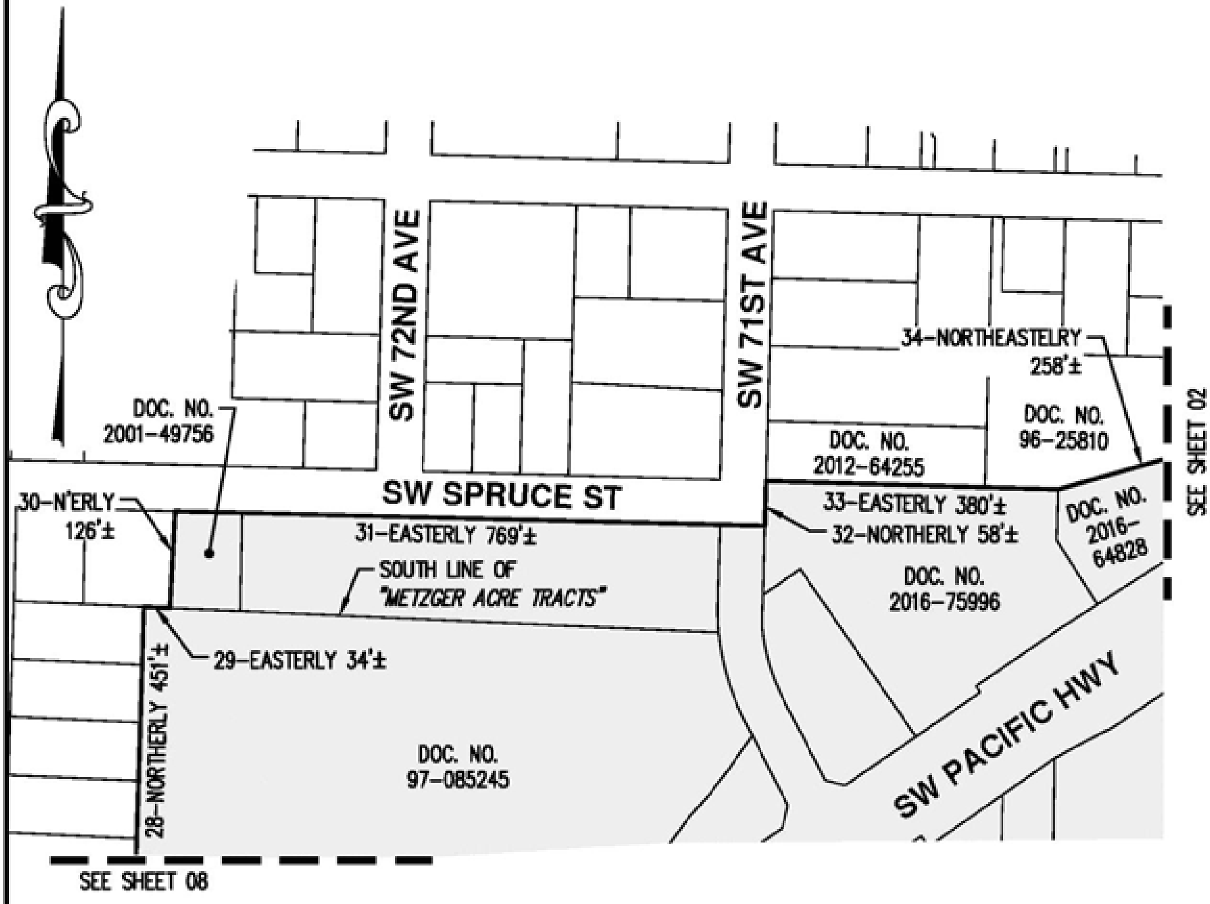

SCALE 1" = 200 FEET

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10/17/2016

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RENEWS: 6/30/17

PREPARED FOR
CITY OF TIGARD
13125 SW HALL BLVD
TIGARD, OR 97223

TIGARD TRIANGLE
URBAN RENEWAL AREA

AKS ENGINEERING & FORESTRY, LLC
12965 SW HERMAN RD, STE 100
TUALATIN, OR 97062
P: 503.563.6151 F: 503.563.6152 aks-eng.com

AKS

EXHIBIT
B

DRWN: MSK
CHKD: NSW
AKS JOB:
5570

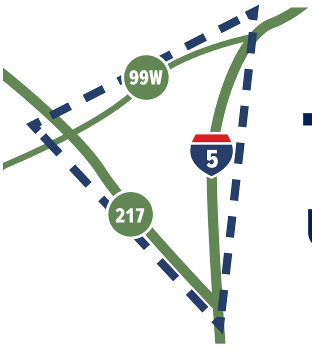
DWG: 5570 COT UR-09 | 09

XII. APPENDIX B

Amendments to the Tigard Comprehensive Plan and/or Tigard Community Development Code

Amendments to the Tigard Comprehensive Plan and/or Tigard Community Development Code that affect the Plan and/or the Area shall be incorporated automatically within the Plan without any separate action required by the Agency or City Council.

Tigard Triangle Urban Renewal Plan Amendments	
The following are amendments to the adopted Tigard Triangle Urban Renewal Plan.	
AMENDMENT NUMBER: 1	**PURPOSE:** Add a multi-use path over Highway 217 to the list of urban renewal projects under Transportation: Table 1.
RESOLUTION NUMBER: TCDA 20-01	
EFFECTIVE DATE: May 19, 2020	



Tigard Triangle

URBAN RENEWAL PLAN

TIGARD®

Memorandum

To:	Austin Somhegyi (City of Bend)
From:	Tim Seed, Trista Kobluskie (Otak)
Copies:	File
Date:	August 22, 2025
Subject:	Level of Service for Bend's Stormwater Program
Project No.:	20359

Introduction

The City of Bend (City) is updating its 2014 Stormwater Master Plan. The Stormwater Master Plan (SMP) Update will provide direction for the City's stormwater system upgrades, repair and replacement, operations and maintenance, and stormwater policy considerations. In this update, the City hopes to begin discussions that will establish a target Level of Service (LOS) for key aspects of the stormwater utility. Identifying a baseline and target LOS are foundational steps in asset management.

Purpose & Goals

Defining LOS targets helps guide investment decisions, optimize operations, communicate service expectations, and manage performance trade-offs. These targets can range from broad, strategic goals at the agency level to specific performance standards for individual assets or components. LOS is not static and may evolve according to changes in customer demands, regulatory requirements, system condition, and fiscal constraints. A well-structured LOS framework will enable the City's stormwater utility to balance service delivery, affordability, and long-term sustainability, ensuring that the right level of service is delivered at the right cost with an acceptable level of risk.

This paper will document and assess the current level of service for Bend's stormwater system and recommend target levels of service which will be evaluated in a cost of services study and used in a stormwater rate study to understand the potential impacts on the City's Stormwater Fund. The cost of service study and rate study will be performed at a later date.

Existing Program Summary

The objective of this review is to document existing activities, services, staffing, and funding, considering regulatory requirements and existing commitments. This analysis will allow the City to identify areas where new or enhanced activities are needed. The analysis is based on data and documents received from the City as well as a workshop with City staff.

Stormwater Assets

Due to Bend's unique geology, the drainage system within the City consists of a centralized municipal separate storm sewer system (MS4) which discharges into the Deschutes River as well as a large, decentralized network of Class V underground injection controls (UICs), consisting of drywells and drillholes, across the entire City. As Bend's population grows, so does its stormwater system. Table 1 summarizes the City's public stormwater assets.

Table 1 Bend's Stormwater Asset Inventory

Type of Asset	Quantity of Asset*
Catch Basin	9,908
Drywell	6,083
Drillhole	933
Stormwater Quality Facility	299
Storm Distribution Box	79
Storm Pipe Segment	12,731
Storm Filter Vault	18
Sedimentation Manhole	1,495
Outfall to Deschutes River	36
Swale	290

**City-owned and active assets retrieved from GIS*

Regulatory Requirements

The City of Bend has an NPDES Phase II Permit for its MS4. This Permit was issued in January 2021 and will expire in December 2026. The Permit requires the City to maintain minimum measures for public education and outreach, public involvement and participation, illicit discharge detection and elimination (IDDE), construction site runoff control, post-construction site runoff for new development and redevelopment, and pollution prevention and good housekeeping for municipal operations. Activities are tracked in the City's 2023 Integrated Stormwater Management Plan (ISWMP) and Annual Reports submitted to DEQ.

The City was issued a Water Pollution Control Facilities Permit (WPCF) for its Class V UICs. The WPCF requires that the City properly operate and maintain all UICs and was most recently issued in 2013. However, DEQ is currently in the process of finalizing an updated WPCF permit, expected to be issued in 2025. The City does not expect significant changes in requirements from the new permit.

Stormwater Fund and Annual Budget

The stormwater utility was formed in 2007 and developed a billing system that charges per Equivalent Residential Unit (ERU) once per month. The ERU is based on the average impervious surface coverage for residential lots calculated at the time of implementation, which is 3,800 square feet. Residential properties are billed one ERU. Nonresidential properties are billed based on measured impervious surface coverage at the ERU rate. There are exemptions and credit processes available. The stormwater utility rate was $4.00 per ERU in 2007. The stormwater utility rate at the time of writing is $7.55 per ERU.

The Stormwater Fund is an enterprise fund and the sole revenue mechanism for the stormwater utility. No general funds are used for the stormwater utility. The fund provides the resources to implement regulatory requirements and capital improvements. Table 2 provides a summary of the proposed 2025-2027 Biennial Budget.

Table 2 2025-2027 Proposed Biennial Stormwater Budget

Revenue	
Beginning Working Capital	$15,779,300
Charges for Services	$14,247,700
Miscellaneous	$1,880,200
Debt Proceeds	$9,525,000
TOTAL RESOURCES	**$41,432,200**
Expenditures	
Infrastructure Program	$22,062,600
Interfund Transfers	$5,497,700
Debt Service	$3,391,700
Contingency	$2,173,000
Reserves Future Construction	$6,465,700
Reserves Debt Services	$1,841,500
TOTAL REQUIREMENTS	**$41,432,200**

Organization

Stormwater utility operations and program management staff are organized under the Water Services Department. In the FY 2023-25 budget there are 11 full-time equivalent (FTE) employees authorized by the Stormwater Fund, which includes eight approved FTE paid fully by the utility. Most stormwater functions are spread between the Field Operations, Environmental Resources, and Assistant City Engineer (Stormwater) divisions. Stormwater support functions are also carried out by the Utility Business Management group but are not diagrammed (Figure 1). Additional stormwater-related staffing resources include capital project delivery in the Engineering Department and street sweeping staff in the Transportation and Mobility Department. The stormwater fund supports approximately 40% of the cost of the citywide street sweeping program.

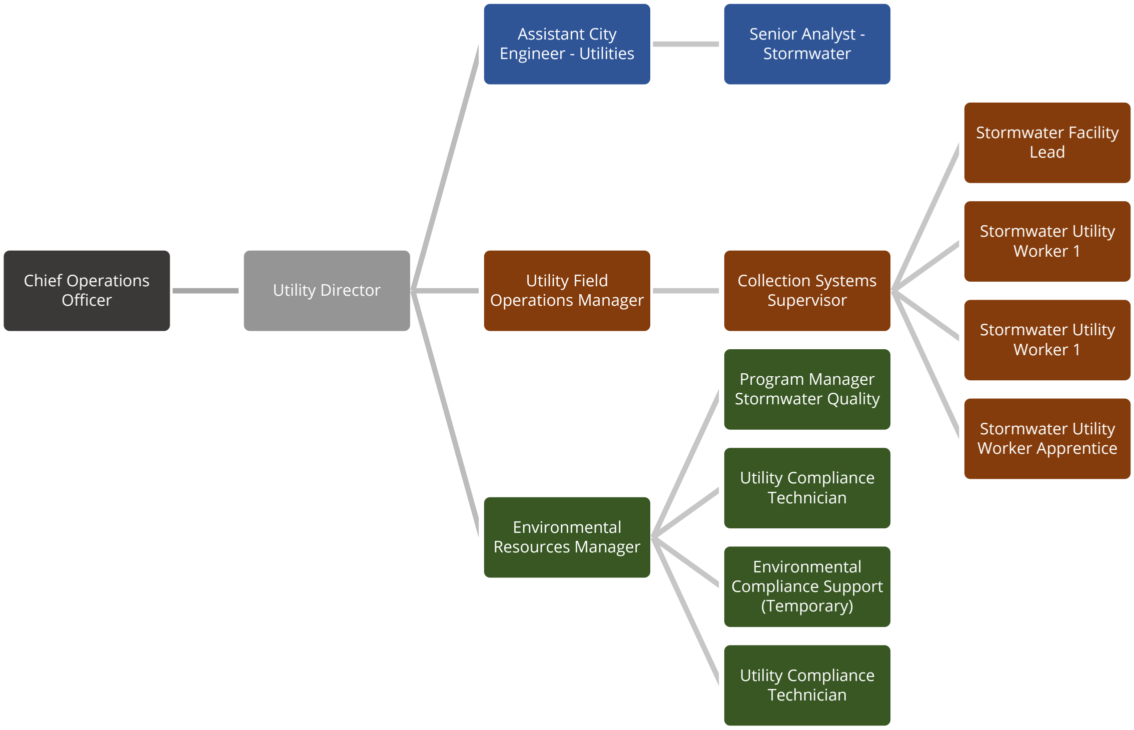


Figure 1. Organization Chart of the Stormwater Functions in the Water Services Department

Future Program Needs

Program Accomplishments & Challenges

Bend's stormwater utility currently complies with regulatory requirements and maintains a robust capital improvements schedule. The City has explored and implemented process improvements across the utility and is proactive in the planning process.

Sustained rapid growth over the last 20 years has strained the limited resources of the stormwater utility. Maintenance staff noted that since 2008, the City's stormwater system has grown significantly, but the FTE allocated to maintain and operate the system has not grown accordingly. While the utility is successful in implementing capital improvements and complying with regulations, costs to maintain the existing inventory of assets and regulatory requirements are increasing, putting greater pressure on field operations staff to maintain current levels of service.

Regulatory Requirements

Set to be issued in 2026, a new Individual Phase II MS4 Permit will require the City to expand the current LOS for MS4 permit compliance phased over the lifecycle of the Permit, which may impact LOS for other categories. It is not expected that the new WPCF UIC permit, to be issued in 2025, will significantly impact current practices.

Stormwater Rate Analysis

Stormwater rates have increased over the last 10 years at percentages that are at or above the increases to the water and sewer rates, but the overall dollar amount remains relatively low per ERU. Compared to cities of comparable size, Bend's stormwater utility rate is lower (Table 3). Further financial analysis is planned to establish a future utility rate.

Table 3. Comparison of Stormwater Utility Rates

City	Population Est. (2024)*	2025 Stormwater Utility Rate (Residential)
Bend, OR	104,089	$7.55 per ERU
Gresham, OR	115,233	$19.48
Hillsboro, OR	111,006	$17
Medford, OR	88,585	$8.29 to $8.77
Redmond, OR	37,146	$6.10 to $8.69
Eugene, OR	177,155	$12.84 to $18.61
Beaverton, OR	98,843	$14
Corvallis, OR	60,408	$11.20
Salem, OR	177,560	$20.65 to $22.61

**Certified population estimates from the Population Research Center at Portland State University*

Level of Service Analysis

A workshop with City staff included a multi-disciplinary group from the Water Services and Engineering Departments, including roles in finance, field operations, environmental resources, and engineering. The group explored the City's current levels of service for categories of service within the stormwater utility. Eleven categories were selected from conversations with staff and actions that have regulatory mandates. The LOS for each category was assessed subjectively on a scale of low, moderate, and high. Categories that ranked as "low" are reactive services with limited investment or capacity. "Moderate" indicates a balanced service with funding that meets permit requirements or performance goals. "High" indicates proactive or preventative services with increased investment that does or may exceed regulatory mandates. The result of a subjective analysis is detailed in Table 4.

Inventory Increases

Several categories will experience an increase in inventory as the City's stormwater system expands. The future workload is therefore also expected to increase corresponding to inventory growth. Current LOS may trend up or down as inventories increase and can be mitigated by additional FTE for the stormwater utility and/or introducing processes that prioritize efficiency.

Level of Service Increase

Categories not classified as having a high level of service currently have the potential for more proactive activities and practices. In several of the categories, the City wishes to improve upon the current LOS. Increasing LOS can be measured through introducing new actions or improving upon key performance metrics, often the frequency of actions specific to each category.

Table 4. Level of Service for Priority Categories

Category	Current LOS	Target	Regulatory Requirements	Recommendations
A. Drainage Complaint Immediate Response	High	Respond to drainage complaints within 72 hours.	N/A	▪ Maintain LOS ▪ Continue current activities ▪ Explore process improvements
B. Inspection & Maintenance of Underground Facilities	High	Inspect underground facilities (excluding pipes) once per year	MS4 Permit (A.3.f.ii.) ISWMP BMP OM-2	▪ Maintain LOS ▪ Continue current activities; ▪ Implement process improvements
C. Inspection of Storm Pipes	Low	Inspect the entirety of the City's storm pipe system.	MS4 Permit (A.3.f.ii.) ISWMP BMP OM-2	▪ Increase LOS ▪ Establish a percentage of storm pipe system to be inspected per year ▪ Pursue implementation planning for pipe inspections
D. Inspection of Aboveground Water Quality Facilities	High	Inspect water quality facilities at least once per year	MS4 Permit (A.3.e.) ISWMP BMP PC-3	▪ Maintain LOS ▪ Continue current activities ▪ Explore process improvements for efficiency
E. Maintenance of Aboveground Water Quality Facilities	Low	Maintain water quality facilities to ensure function.	MS4 Permit (A.3.e.) ISWMP BMP PC-3	▪ Increase LOS ▪ Improve capacity for in-house vegetation management for ROW facilities ▪ Establish a maintenance checklist that addresses vegetation management, sedimentation buildup, irrigation performance, and effects of roadway applications such as deicers and cinders
F. Ground Water Quality Protection Retrofit Projects	Low	Yearly progress in completing UIC retrofits	WPCF Permit ISWMP BMP PL-2	▪ Increase LOS ▪ Implement drillhole retrofit strategy ▪ Complete 17 priority drillhole retrofits in five years
G. Capital Project Implementation	Moderate	Plan, fund, and construct stormwater capital	MS4 Permit (A.3.f.x.)*	▪ Maintain LOS

Category	Current LOS	Target	Regulatory Requirements	Recommendations
		improvements, which include drainage and surface water quality retrofit projects, as identified in the utility's CIP.		▪ Maintain or increase pace of project implementation based on prioritized list in 2025 SMP Update; Improve synergy with other City departments. ▪ Ensure surface water quality retrofit projects are implemented per MS4 Permit requirements
H Major Maintenance Program Implementation	Low	Prioritize, fund, and complete major maintenance projects.	N/A	▪ Increase LOS ▪ Monitor utilization of increased budget on identified major maintenance and synergy projects ▪ Prioritize major maintenance projects recommended in the SMP update
I. Street Sweeping	Moderate	Sweep streets within the MS4 area once per quarter.	MS4 Permit (A.3.f.iii.) ISWMP BMP OM-3	▪ Maintain LOS ▪ Collect and manage sweeping data within the MS4 area ▪ Operational changes to achieve goals may be needed in the future
J. Development Regulations for Private Stormwater Infrastructure & Inspections	Moderate	Establish an internal system that identifies and catalogues private stormwater systems and inspection schedules.	MS4 Permit (A.3.e.v.) ISWMP BMP PC-4	▪ Maintain LOS ▪ Monitor and evaluate implementation of emergent activities ▪ Operational changes to achieve goals may be needed in the future
K. Other MS4 Compliance	Moderate	Maintain compliance with all aspects of the MS4 Permit.	MS4 Permit	▪ Maintain LOS ▪ Monitor effectiveness of current compliance activities ▪ Evaluate needs under new Permit in 2026

**Regulatory requirement is to implement a surface water quality retrofit program*

A. Drainage Complaint Immediate Response

The City's stormwater utility responds to public reports of drainage issues. Drainage complaints may reflect flooding or erosion during and after rain events. These complaints are acknowledged and investigated to discover the problem, causes, and potential solutions. Drainage complaints in the right-of-way and other public property are responded to and recorded in a timely manner. This is a current program which is voluntary and is generally not bound by regulatory requirements except when water quality or erosion issues are involved.

Current Level of Service (LOS): High

The current LOS for drainage complaint response is considered high due to the current short turn-around for initial response. Stormwater utility operations staff strive to respond within 72 hours, and complaints are often addressed within the same day. During and after intense rainstorms, crews operate on high alert and have an excellent track record of responding immediately to street flooding and flooding that may damage properties. A comprehensive heat map of drainage complaints was developed to identify problem areas and recurring issues. The high rating for LOS reflects responsiveness to complaints and addressing easily resolvable problems such as drain clearing. Drainage issues that cannot be resolved by the stormwater field crew or that require significant resources are referred to a City Engineering and Stormwater Management Team for potential future major maintenance or capital improvements.

Inventory Increase

Available data is limited to assess patterns in time to fully resolve drainage complaints. Quantifying the exact rate of resolution or complaints received is complicated due to the decentralized manner in which drainage complaints are received. Stormwater utility staff respond to approximately 100-125 drainage complaints per year, which may increase or decrease depending on the frequency of intense storm events.

Recommendations

- Increasing the level of service for drainage complaint immediate response is not recommended at this time. The City is proactive in identifying drainage hotspots and responds to complaints in a timely manner.
- There may be opportunities to develop a reporting process that would improve efficiencies for tracking and provide trackable metrics.
- Continued work on asset management systems to identify, prioritize and track needed major maintenance or capital project actions to address underlying system deficiencies is recommended.

B. Inspection & Maintenance of Underground Facilities (excluding pipes)

Routine inspection of underground infrastructure is necessary to ensure stormwater infrastructure maintains structural integrity and is free of blockages like sediment buildup. Consistent maintenance schedules extend the life of stormwater infrastructure. Inspection, maintenance, and cleaning of the MS4 is mandated by the City's MS4 Permit Schedule A.3.f. (Pollution Prevention and Good Housekeeping for Municipal Operations).

Current LOS: High

Current LOS for inspection and maintenance of underground facilities is high but trending towards moderate. The current high rating reflects the frequency of work. Inspection of catch basins exceeds the minimum requirements of the City's MS4 Permit and BMP OM-2 in the City's ISWMP, both of which call for an inspection once every five years In the 2023-24 Annual Report, the City inspected 70% of its public catch basin network.

The City inspects and maintains its underground assets on routine schedules. Inspections are completed in a zone system throughout the City. When catch basins are flagged for maintenance, downstream UICs and sedimentation manholes are inspected. Service of the City's existing underground infrastructure has recently decreased from annually to every other year due to staffing shortages and pressure from inspecting new construction. Currently, the City does not track inspection and maintenance of underground structures separately. It is developing a field application to track these activities separately and increase efficiency.

Inventory Increase

Since 2015, the City has increased its inventory of catch basins by an average of 173 per year, or a yearly growth rate of 1.9%. Applying the same rate for the next 10 years increases the City's inventory by 1,903 to 3,350 (Figure 2). UICs are prevalent in Bend and are often the preferred method to manage stormwater runoff. Much of the City is not within its MS4 area. As of 2023, the City has 6,589 publicly owned and operated UICs which include drillholes and drywells. Since 2015, the inventory of UICs has grown by an average of 95 per year, or a yearly growth rate of 1.5%. Applying the same rate for the next ten years increases the City's inventory by 1,140 to 1,289, or 17-20% above its current inventory (Figure 3). The City has a small inventory of underground propriety filtration facilities. The inventory is expected to increase as the City completes projects to improve stormwater quality before it enters the Deschutes River or groundwater. There are too few data points to chart a trend. For the purposes of this paper, we assume an increase of one publicly operated underground proprietary filtration vault with 28 filter cartridges per year (Figure 4).

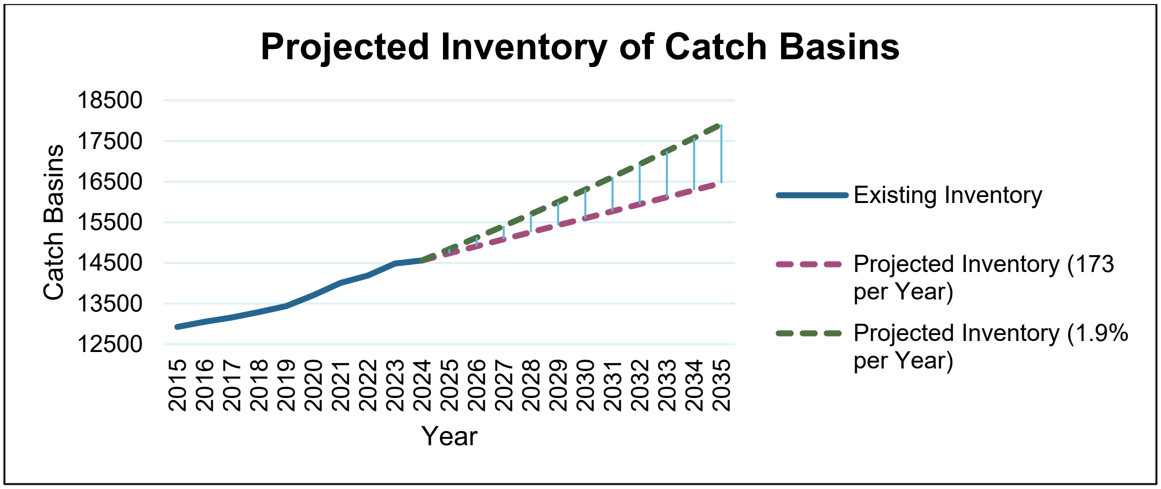


Figure 2. Projected Inventory of Catch Basins, 2024-2035

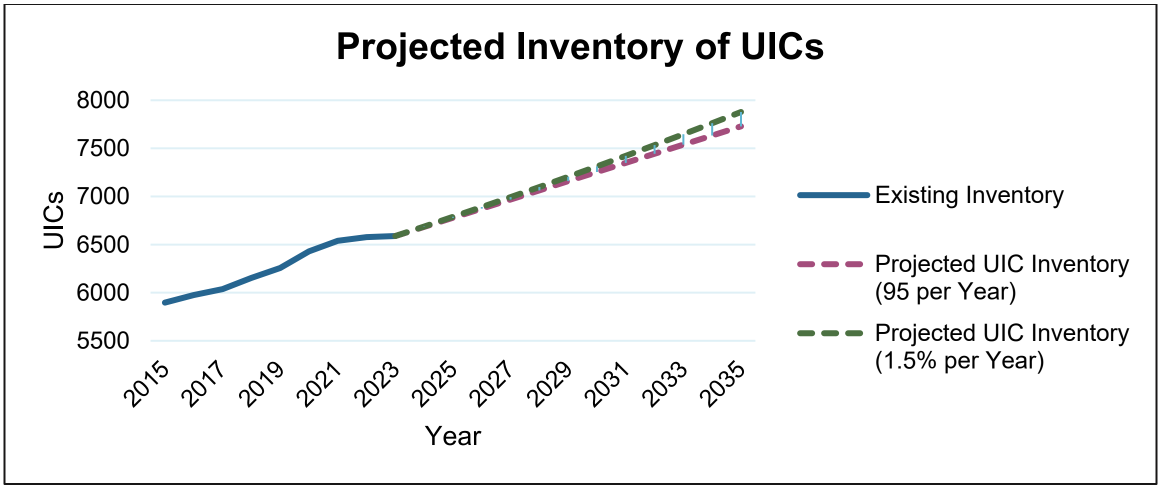


Figure 3. **Projected Inventory of UICs, 2023-2035**

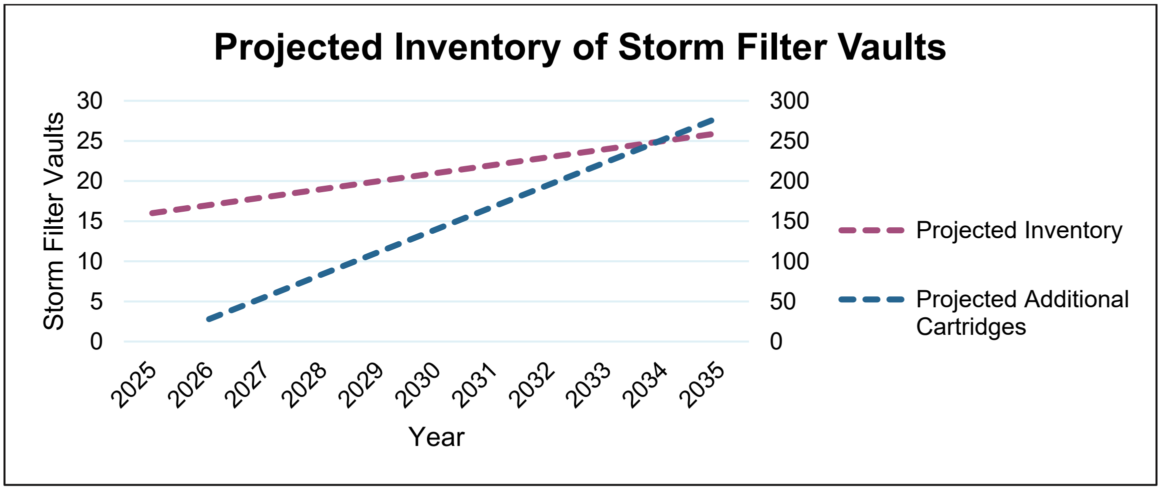


Figure 4. **Projected Inventory of Storm Filter Vaults & Cartridges, 2025-2035**

Recommendations

- Increasing the LOS for this category is not recommended at this time. The City's goal is to conduct annual inspections, with all catch basins, manholes and inlets once every five years and this measure is met.
- Additional resources, however, will be needed over time to support routine inspection and maintenance of the growing stormwater system.
- Maintaining the high LOS will be supported by process efficiencies when the field application to separately track inspection and maintenance activities is introduced.
- The City should continue its proactive inspection approach for new infrastructure connecting to the stormwater system from new developments.

C. Inspections of Storm Pipes

Storm sewer pipes, like other underground stormwater infrastructure, should be inspected regularly. Maintaining an inspection frequency for the entire piped system helps identify issues with structural integrity, sediment buildup, and damage or blockages. The level of service for this category can be measured by inspecting a portion of the City's storm pipe network by CCTV each year. Inspection, maintenance, and cleaning of the MS4 is mandated by the City's MS4 Permit Schedule A.3.f. (Pollution Prevention and Good Housekeeping for Municipal Operations).

Current LOS: Low

The current level of service for inspection of storm sewer pipes is low. The stormwater utility does not own the necessary equipment to conduct routine CCTV inspections of pipes and must borrow from other divisions in the Water Services Department. While the City does not inspect existing pipes on a regular basis, it is proactive in its inspections of new pipes from private development connecting to the City's system to ensure quality infrastructure. It is a measurable goal of BMP OM-2 in the City's ISWMP to evaluate opportunities to initiate a prescribed stormwater pipeline inspection program to evaluate system condition and maintenance needs. This action is not yet implemented.

Inventory Increase

As new developments come online, the City's inventory of pipes will increase. Between 2015 and 2022 (the most recent data), the City increased its supply of storm pipe by 3% per year or by approximately 10,390 linear feet (see Figure 5). This increase in new infrastructure inspections has diverted resources from inspections of the current system.

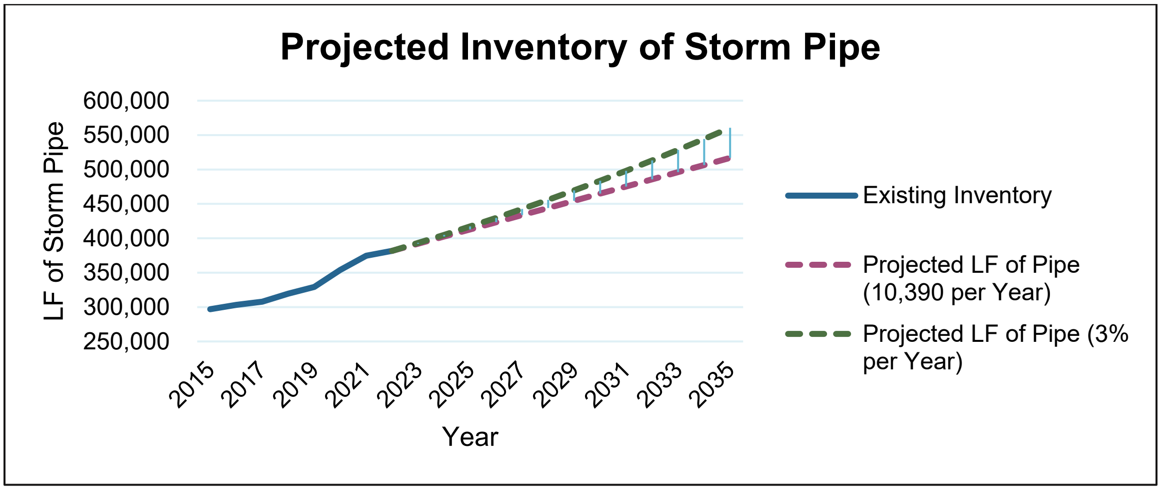


Figure 5. Projected inventory of Storm Pipe, 2022-2035

Recommendations

This category was identified as a priority category by utility staff in which to increase its level of service. Limited pipe inspections occur during routine inspection of other underground infrastructure, but pipes are not routinely inspected. If the stormwater utility needs to use CCTV equipment for inspections, it must borrow the required tools and truck from another department.

- It is recommended that the City establish a system-wide pipe inspection goal. Inspecting 10-20% of the existing storm pipe system per year may represent a high LOS. A rate within that range would ensure the storm pipe system is inspected once every five to ten years.
- It is recommended that the City introduce a standardized pipe assessment and condition rating protocol for stormwater pipes. Implementing a standardized protocol will require startup costs related to selecting a protocol, developing tracking tools, developing a prioritization method based on condition findings, and training staff. Pipes identified in poor or declining condition should be flagged for appropriate follow-up, which could include increased monitoring, increased maintenance frequency, major maintenance, repair and replacement, or decommissioning.
- The utility should consider purchasing equipment if the borrowed equipment is not available often enough to support an increase in inspection frequency and to support final acceptance inspections of inventory received from new development.
- The City should also evaluate current development processes for final inspections and acceptance of storm system assets. This should include appropriate roles and cost assignment for final TV'ing prior to city acceptance.

D. Inspections of Aboveground Water Quality Facilities

This category is measured by the frequency of inspections for above-ground infrastructure that removes pollutants from stormwater. The City has an inventory of water quality swales with four media types: native vegetation, grass, rock and soil, and infiltration basin/pond. Inspections of these facilities document structural integrity, general condition, sediment buildup, and vegetation condition. Inspection, maintenance, and cleaning of the MS4 is mandated by the City's MS4 Permit Schedule A.3.f. (Pollution Prevention and Good Housekeeping for Municipal Operations).

Current LOS: High

Current LOS for inspections of aboveground water quality facilities is high. Facilities are regularly inspected at least once per year for sediment accumulation, plant health, and structural integrity by the in the Water Services Department. In 2024, the City inspected 279 facilities. Vegetated facilities may require additional inspections during the growing season. The stormwater group provides inspections once per year and there may be overlap between regulatory and operational inspections.

Inventory Increase

Inspections of water quality facilities are expected to increase as the City receives additional inventory from development, self-constructs or improves streets and completes projects which utilize aboveground assets to improve stormwater quality before it enters the Deschutes River or groundwater. Between 2002 and 2022 (the most recent data available), the City's swale assets grew by approximately 400%. If the average rate of growth from 2015 to 2022 is maintained (13 swales per year or 6% growth per year), the City may increase its inventory by an additional 169 to 321 swales. (Figure 6).

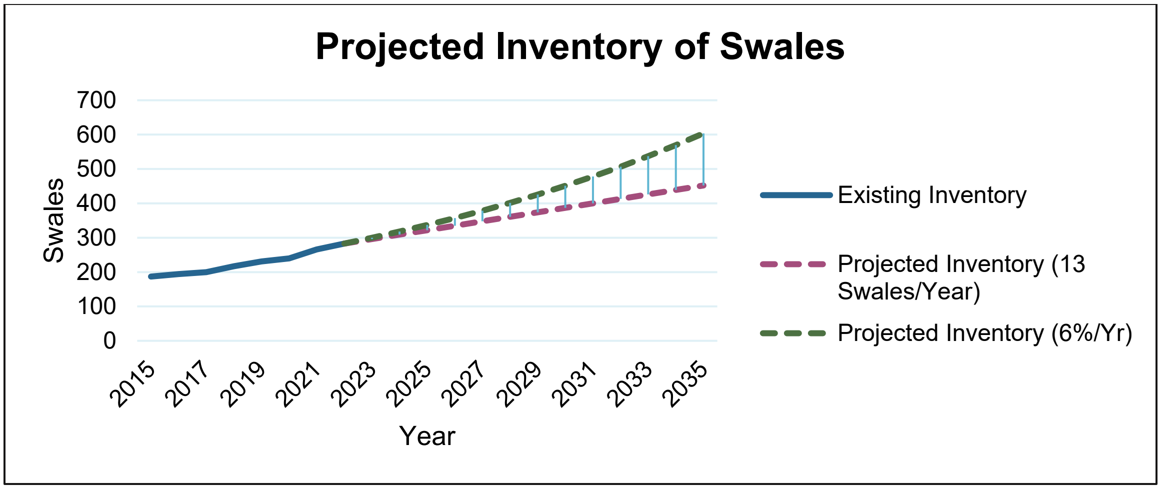


Figure 6. Projected Inventory of Swales, 2022-2035

Recommendations

- Increasing the LOS for inspecting aboveground water quality facilities is not recommended at this time. While overall frequency has been reduced, the City is able to inspect assets by zone according to a yearly schedule.
- Efficiencies in documentation and inspection protocol may reduce overall staff hours spent performing inspections. Clarifying the cycle for inspections, roles, responsibilities, and what to inspect is recommended.
- Without additional staff or operational efficiencies, LOS may decrease in the future because inventory is expected to continue growing.

E. Maintenance of Aboveground Water Quality Facilities

Maintenance of publicly owned or maintained water quality facilities may include removing debris and sediment and vegetation management, according to the BMPs for the facility. Maintenance, and cleaning of the MS4 is mandated by the City's MS4 Permit Schedule A.3.f. (Pollution Prevention and Good Housekeeping for Municipal Operations), which includes aboveground water quality facilities.

Current LOS: Low

Current LOS for maintenance of aboveground water quality facilities is low because maintenance responsibilities are partially outsourced via external contracts and interdepartmental coordination, base-level maintenance needs are not . The City relies on external contracts and inter-departmental coordination to maintain vegetated stormwater facilities. Currently, approximately 10% of the City's water quality swales are maintained by a contractor. Contractor maintenance of vegetated water quality facilities includes monthly trash and weed removal in addition to once per season pruning and deadheading. Mulching and planting are provided by the contractor on a case-by-case basis upon request by the Water Services Department. In addition to the contractor landscape maintenance, vegetated facilities are maintained three times per year by utility stormwater staff to ensure function of the system such as removing accumulated sediment at inlets to the facility. All other above ground facilities are maintained by the City's utility stormwater staff twice per year instead of three times due to staffing limitations and increased inventory.

A select number of vegetated water quality facilities not under the landscape contract have vegetation maintained by the Transportation and Mobility Department, which includes Reed Market Road. Irrigation is required for vegetated facilities and irrigation of all stormwater utility managed swales is performed by the Transportation and Mobility Department.

Inventory Increase

The inventory of swales has grown in the past 20 years. Between 2002 and 2022 (the most recent available data), the City's swale assets grew by approximately 400% (Figure 6). Vegetated water quality facilities are especially challenging for the City to upkeep without internal and external agreements.

Recommendations

- Increasing LOS for maintaining aboveground water quality facilities is recommended. In this category, increased LOS can be measured by performing in-house vegetation management, increasing the number of in-house maintenance visits per facility to match the contract rate, and improvements in operational efficiencies.
- Due to the current decentralized nature of maintenance tasks across departments, it is recommended that the City establish a checklist for base level of service for facility maintenance that incorporates responsibilities across departments. This checklist should cover a range of maintenance aspects, including vegetation management, sedimentation buildup, irrigation performance, and effects of roadway applications such as deicers and cinders.
- An increase of resources allocated for maintaining irrigation functionality and service is recommended to ensure required irrigation is performing as expected.

F. Groundwater Quality Protection Retrofit Projects

The Drillhole Water Quality Retrofit Program in the 2025 Stormwater Master Plan update focuses on installing sedimentation manholes or other pretreatment to remove sediment and pollutants before high priority drillholes. Drillholes are prioritized based on the highest likely risk to groundwater; the WPCF permit requires retrofit of existing injection systems that are within established horizontal setbacks of domestic wells or City owned municipal wells.

Current LOS: Low

Current LOS for water quality protection retrofits is low. The City has implemented a handful of drill hole retrofits with limited available funding. The outfall retrofit program is a new requirement in the City's Phase II Permit. The City has also completed eight drillhole retrofits, adding a sedimentation manhole to improve the quality of stormwater entering the drillholes.

Inventory Increase

A report by GSI identified 23 Priority 1 drillholes which pose a high risk to contaminating drinking well water. Eight of these have been completed. The remaining seven Priority 1 drillholes and the two Priority 2 drillholes are recommended for completion in the SMP update. After completing the 17 high-priority drillhole retrofits, the City may consider retrofitting more of the 91 additional drillholes (Priority 3 through Priority 5) that may pose risks to groundwater resources.

Recommendations

- Groundwater quality protection stormwater retrofits is relatively new program and its future level of service can be measured by number or retrofit projects completed each year, a strategy already identified in the City's ISWMP (BMP PL-2).
- A goal for moderate service is completing the 17 priority drillhole retrofit projects within a five year timeframe. The proposed Stormwater Budget for FY 2025-27 allocates $150,000 per year for retrofit projects and should be adjusted in future years to successfully implement the plan.
- Retrofits for the remaining 93 drillhole retrofits classified as Priority 3 through 5 should continue resources allow for the remaining retrofits and will further increase the LOS for this category.

G. Capital Projects Implementation

Implementing capital projects requires the ability to raise revenue and spend funds for capital programs on a regular schedule based on the capital improvement plan (CIP). Planning and completing projects is the primary metric to assess LOS. While capital project implementation on its face is not a required activity within the permits, the City's MS4 Permit requires that the City a implement a surface water quality retrofit program under Schedule A.3.f.x. (Stormwater Quality Retrofit Strategy).

Current LOS: Moderate

The current level of service for capital projects implementation is moderate. The Stormwater Utility CIP and capital funding is growing at a moderate pace yearly. Many projects from the 2014 Stormwater Master Plan have been completed and several large, high priority projects, while delayed from original implementation plans, are in the current 5-year CIP. This includes the Franklin and Greenwood Underpass projects as proposed in the Midtown Crossing Stormwater Report and, South Aubrey Butte Drainage Improvements. The Stormwater Fund issued long term debt for the first time in FY 2021.

The City recently completed a large outfall retrofit on Newport Ave which improves the quality of stormwater entering the Deschutes River.

Inventory Increase

As more stormwater infrastructure is added through completed capital projects, the inventory requiring maintenance and management continues to expand. This places additional pressure on operating budgets and resources, particularly in terms of inspections, maintenance, and eventual rehabilitation. Without a corresponding increase in operational capacity, the growing inventory can further strain capital implementation efforts in the absence of increased funding. The 2023-2028 Stormwater CIP from the FY 2023-25 Biennial Budget shows eight projects planned (Table 5). To date, 1RNPR Newport Corridor, 1GWAC Wilson Ave Corridor Improvements, and 1TNPS Neff & Purcell, and 1WABD Awbrey Butte Distribution Improvements, and subsets of 1RSAB South Awbrey Butte Drainage Improvements are complete.

Table 5. 2023-2028 Stormwater CIP

Project Name	2023-24	2024-25	2025-26	2026-27	2027-28	Total CIP
1GWAC Wilson Ave Corridor Improvements	200,000	-	-	-	-	200,000
1RCAP Stormwater Capital Repair and Replacement Program*	300,000	500,000	500,000	500,000	500,000	2,300,000
1RFGU Franklin & Greenwood Underpass	2,000,000	2,000,000	2,250,000	-	-	6,250,000
1RMP1 Stormwater Master Plan Update	450,000	50,000	-	-	-	500,000
1RNPR Newport Corridor Improvements	800,000	-	-	-	-	800,000
1RSAB South Awbrey Butte Drainage Improvements	-	-	2,000,000	5,500,000	2,500,000	10,000,000
1TNPS Neff & Purcell Intersection	25,000	-	-	-	-	25,000
1WABD Awbrey Butte Distribution Improvements	1,200,000	740,000	-	-	-	1,940,000
Total	**4,975,000**	**3,290,000**	**4,750,000**	**6,000,000**	**3,000,000**	**22,015,000**

**1RCAP Repair & Replacement (Major Maintenance) discussed separately in next section.*

The 2025 Stormwater Master Plan proposes eleven capital improvement projects to be implemented in the 20-year planning horizon. The outfall retrofit program focuses on providing water quality facilities in six priority basins

Six outfalls have been identified as likely candidates for outfall retrofits. Six outfall retrofit capital improvement projects have been recommended in the 2025 SMP update.

Recommendations

- The LOS for capital project implementation is trending downward in part due to allocation of CIP dollars on lower-priority capital improvements. This trend may lead to longer project timelines for priority projects and higher standalone costs.
- Strategic improvements in interdepartmental coordination and project planning coupled with the capital improvement program projects prioritized in the upcoming SMP update may increase the LOS for capital projects implementation.
- Planned improvements in the 2025 SMP update include drainage and water quality projects. Implementing these projects will increase this category's LOS, especially when surface water quality projects are implemented, as these meet regulatory requirements.

H. Major Maintenance Program Implementation

The Major Maintenance Program (prior to 2025, Stormwater Capital Repair and Replacement Program) uses the Stormwater Fund to repair or replace degraded stormwater infrastructure through synergy opportunities or standalone projects and to implement smaller drainage improvement projects[1]. This category's effectiveness can be measured by the number of projects per FY that use the funds and the funding allocated. With additional tracking, the City could begin to use more precise metrics such as linear feet of pipe repaired/replaced and count of structures repaired/replaced each year. The existing program is voluntary and is not bound by regulatory requirements.

Current LOS: Low

The LOS for this category is currently assessed as low due to limited available funding and rate of completion for repairs and other major maintenance activities. Through the process of developing the Stormwater Master Plan, a need was identified to increase major maintenance activity, which is reflected in recent budgeting. Initially included as budget line item in FY 2024 for $300,000, the program intends to support up to $500,000 in synergy projects, with the remainder to be allocated to one to two projects per year identified in the Major Maintenance Program in the 2025 SMP update (Figure 7).

In FY 2024, Stormwater Repair & Replacement funds were given to the ODOT North Corridor project to address problem areas beyond the scope of their work, but within the project limits. In FY 2025, funds were used for the Olney Pedestrian & Bike project to address a drainage issue at the limits of their project. Additionally in FY 2025, funds were used for the Silver Sage Septic to Sewer project to address some infiltration issues along their sewer alignment.

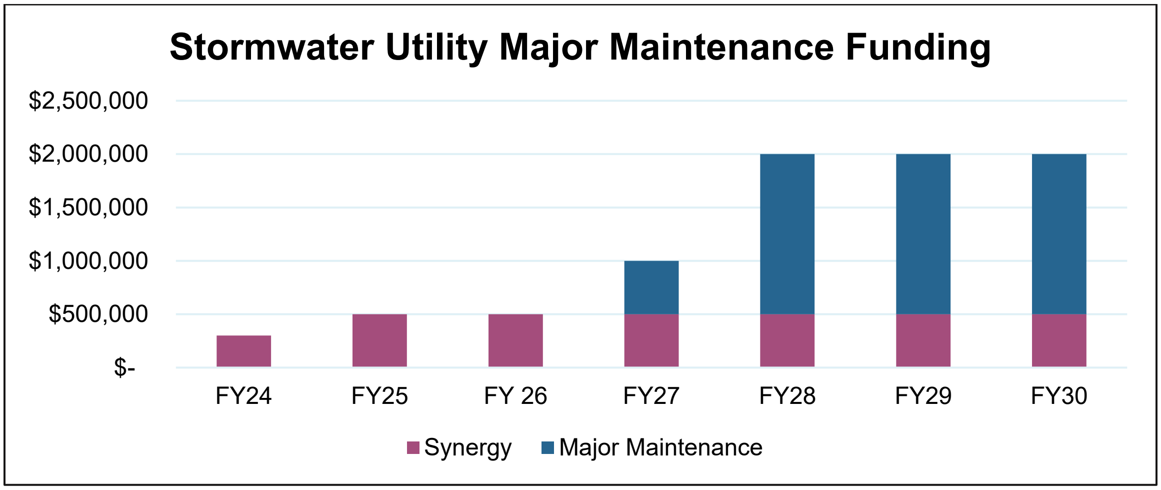


Figure 7. Stormwater Capital Repair and Replacement Funding (Proposed)

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[1] The 2023-2025 Adopted Biennial Budget lists the following line items in the Capital Repair and Replacement Program project plan: Stormwater Drainage Improvement Projects, Stormwater Synergy Opportunity Projects, Drillhole Pretreatment Retrofit Program, and Drillhole Rehabilitation Maintenance Program. This paper grouped the Drillhole Pretreatment actions into the Water Quality Protection Retrofit Project category and is not considering the funds allocated or projects planned for that program in the Repair and Replacement Program category.

Inventory Increase

As the existing stormwater infrastructure ages, it may need to be replaced. The rate at which infrastructure will need to be replaced is not accounted for at this time and is therefore not an appropriate metric to measure the level of service for this category. If the City implements a pipe inspection program and rating protocol, it may be expected to reveal a backlog of needed repair/replacement of stormwater pipe segments.

Recommendations

- The level of service for this category may increase organically over time considering the projected budget increase through FY 2030. While funding may be more available, efforts are needed to apply funds to synergy projects throughout the City.
- Prioritizing the projects in the Major Maintenance program identified in the upcoming update to the SMP and ensuring synergy opportunities are capitalized upon as they arise will improve LOS.

I. Street Sweeping

Street sweeping reduces the amounts of sediment and pollutants that enter the Deschutes River and stormwater infrastructure. The Water Services Department currently funds 40% of the Transportation & Mobility Department’s street sweeping program. This is an existing program and is part of the City’s 2023 ISWMP BMPs (OM-3 Street Sweeping).

LOS for street sweeping is defined in the Street Sweeping for Stormwater Plan (2024). Basins that drain into the MS4 are to be swept at least once per quarter, and all other roads in the city are to be swept at least twice per year. To ensure effectiveness of the street sweeping program for stormwater and that 40% of the budget is spent on stormwater activities, tracking is to be reported to the stormwater utility.

Current LOS: Moderate

Current LOS was identified as moderate by City staff, with the caveat that LOS may be trending downward due to increased inventory of street miles throughout the City. Process improvements are needed in the management and sharing of data between Stormwater and Transportation & Mobility Departments. There are efforts underway to use GIS to optimize street sweeping routes and collect data on locations and miles swept to increase efficiencies within the program.

Due to the absence of sweeping data specific to the MS4 and stormwater program, there are no metrics to show change of service over time.

Inventory Increase

As the inventory of streets and sidewalks continues to expand in the City, street sweeping costs from the Stormwater Fund will also grow.

Recommendations

- Increasing the level of service for street sweeping is not recommended at this time.
- Improvements are needed in the management tools and sharing of data between Water Services and Transportation & Mobility Departments to ensure resources are allocated appropriately.

J. Development Regulations for Private Stormwater Infrastructure & Inspections

Private stormwater facilities are required to be inspected post-construction. The City's Phase II Permit (Schedule A.3.e.v.) requires that private facilities have long-term operation and maintenance, which is implemented by the City though maintenance agreements, which will be verified by and enforced by City staff. Initial inspection of private stormwater facilities is an ongoing program. Long-term verification and enforcement of private facility maintenance is a new program which must be implemented by November 1, 2025. Plans for implementation are outlined in BMP PC-4 of the City's 2023 ISWMP.

Current LOS: Moderate

Current LOS for development regulations for private stormwater facilities is moderate. Parts of this program are new and have not yet been implemented at the time of writing. Future LOS of this category may be impacted by the number of Stormwater Management Agreements (SWMAs) the City processes.

Inventory Increase

As the city grows, the quantity of private stormwater facilities is expected to increase. A projection for future SWMAs uses only average quantity per year because it is relatively consistent. The average percent of growth is not relevant because the data begins in 2013. If the current rate is sustained, the City may have upwards of 650 SWMAs on file by 2035 (Figure 8).

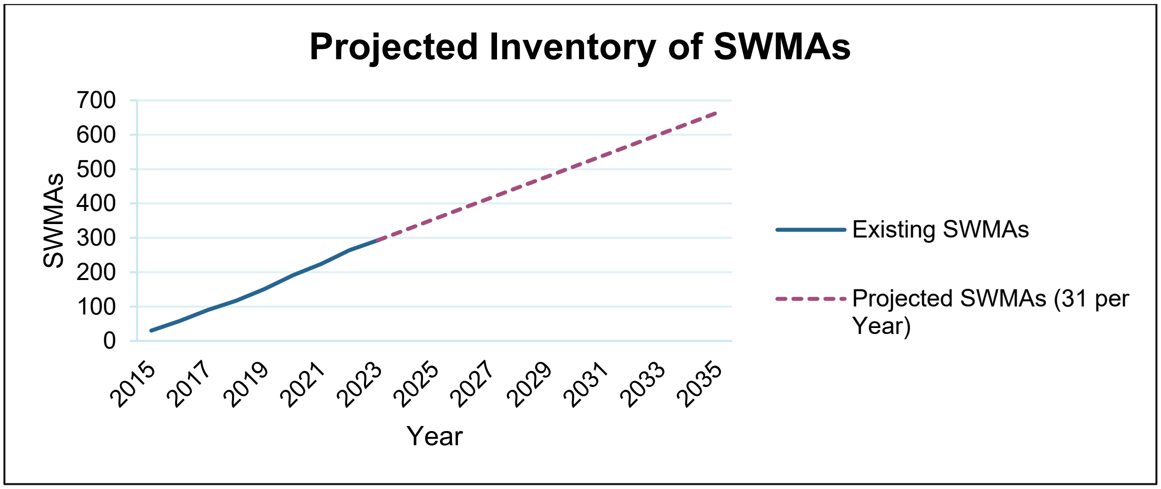

Figure 8. Projected inventory of stormwater management agreements, 2023-2035

Recommendations

- Increasing LOS is not recommended at this time because a new program is scheduled to be implemented.
- The upcoming program implementation should be monitored and assessed for effectiveness. After the implementation of this program, the number of SWMAs is expected to increase as the City must now verify and enforce long-term maintenance and operations of private stormwater facilities.

K. Other MS4 Permit Compliance

Bend's Phase II Permit requires that the City maintain compliance activities in Public Education and Outreach, Public Involvement and Participation, Illicit Discharge Detection and Elimination (IDDE), Construction Site Runoff Control, Post-Construction Site Runoff Control for New Development and Redevelopment, and Pollution Prevention and Good Housekeeping for Municipal Operations. The current Permit was issued in 2021 and will expire in 2026.

Current LOS: Moderate

The current level of service for MS4 Permit compliance for control measures not already discussed above is moderate. The City maintains good standing for compliance activities, and records required metrics and relevant milestones in its Annual Report submitted to DEQ.

Inventory and Regulatory Increase

Increased size of the stormwater system may impact other MS4 compliance activities. It is expected that the next Phase II Permit, which should become effective in 2026, will increase the City's requirements for some activities or metrics.

Recommendations

- It is not recommended that the City increase its level of service for other MS4 Permit compliance at this time.
- The City may need to reevaluate resources allocated during the next Permit cycle, depending on what new requirements are included and how much progress the City has already made in achieving the minimum requirements.

Recommendations & Next Steps

This analysis is a first step toward establishing LOS benchmarks for Bend's stormwater utility. The City's stormwater infrastructure inventory is projected to grow and regulatory requirements are also expected to increase. The utility's financial and staffing capacity under these conditions directly impacts levels of service.

To effectively plan for increasing levels of service, several next steps are recommended:

- Adopt the 2025 Stormwater Master Plan update
- Establish LOS goals and related resource needs and cost of service
- Engage internal stakeholders in budget planning
- Conduct a stormwater utility rate analysis

Adopt the 2025 Stormwater Master Plan Update

The SMP update will guide future capital investments and policy decisions. By adopting the plan, the stormwater utility will have a roadmap for a Major Maintenance Program, Drillhole Retrofit Program, and prioritized CIP projects. The SMP update should be considered in setting LOS goals.

Establish LOS Goals

This analysis compiled information and data about current levels of service, and the City hopes to develop and refine LOS benchmarks for its service categories. Recommended Strategies and Goals are included in Table 4.

Four categories are recommended for increased levels of service. Inspection of storm pipes, maintenance of aboveground water quality facilities, water quality protection retrofits, and major maintenance capital projects are categorized as low, which reflects increased inventory and workload demand, and lack of resources.

Maintaining high LOS is recommended for three categories: drainage complaint response, inspection & maintenance of underground facilities, and inspection of aboveground water quality facilities. These categories are proactive in activities and are employing strategies to increase efficiency.

Ongoing monitoring of resource use and implementation is recommended for four categories due to existing uncertainties. Upcoming anticipated changes to regulatory requirements, available funds, and process efficiencies may increase or decrease the future levels of service.

Engage Internal Stakeholders in Budget Planning

Conversations with internal stakeholders are needed to assess current and future budgetary needs. These discussions should involve a cross-section of City personnel: field staff who are familiar with day-to-day operational challenges and workload demands; program managers and department leaders who can provide insight into interdepartmental coordination and long-term planning; and representatives from departments that regularly intersect with stormwater services, such as Transportation & Mobility, Community & Economic Development, and Water Services.

The goal of these discussions is to align resource allocation with service expectations and identify areas where additional investment is needed to meet current and future LOS goals.

Conduct a Stormwater Utility Rate Analysis

After defining LOS goals and identifying the resources needed to achieve the target LOS, a stormwater rate analysis is needed. The rate analysis will evaluate current funding levels and determine the rate adjustments needed to support LOS improvements and capital project priorities. Aligning the rate structure with target levels of service will provide greater capacity for the utility to achieve its service goals.

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Bend Stormwater Master Plan

Climate Change Review

August 14, 2024

Anna Murphy and Daniele Spirandelli

Agenda

- Climate change and Bend’s stormwater challenges
- Current design standards and historical rainfall
- Climate models and climate projections
- Case studies
- Additional recommendations
- Funding
- Next steps

Projected Climate Changes in Bend

Increases (~6%) in overall annual precipitation by 2100

Less precipitation: April – October
More precipitation: December – March
More rain and less snow in winter

Increase in frequency and intensity of storms

Especially during winter months
Increased intensity of atmospheric rivers

Decline in snowpack

Decrease in overall mountain snowpack
Earlier snowmelt means decreased streamflow in summer

Increased severity and duration of drought

Increased annual number of dry days (from 186 in 1990s to 192 by 2050)

Source: Oregon Watershed Enhancement Board. (September 2023). *Region 4 Observed & Projected Climate Changes.* https://www.oregon.gov/oweb/Documents/climate-R4-variables.pdf

Climate Change Challenges to Bend’s Stormwater System

Inappropriately sized design storms for existing conditions

Climate change causing increased intensity and frequency of storm events

Drier summer impacts on water quality

Sedimentation from winter road sanding

Winter precipitation and ice storms clogging drain inlets and causing flooding

Increasing rapid urban development exacerbating impacts

Climate Change Challenges to Bend's Stormwater System

Inappropriately sized design storms for existing conditions

Climate change causing increased intensity and frequency of storm events

Drier summer impacts on water quality

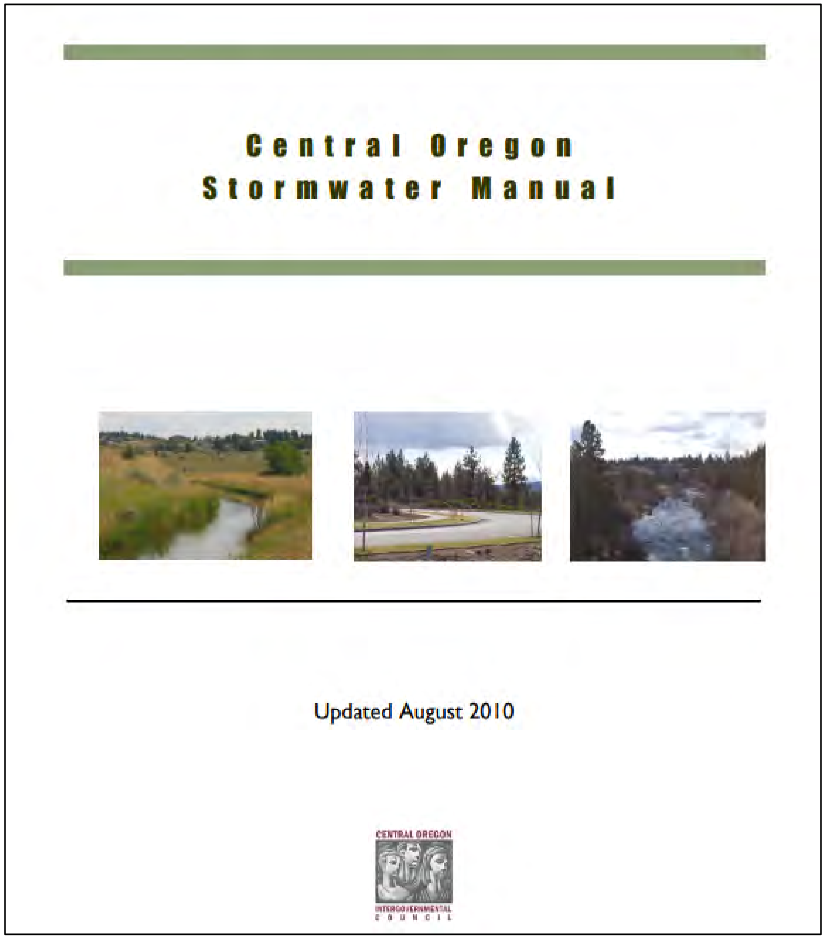
Sedimentation from winter road sanding

Winter precipitation and ice storms clogging drain inlets and causing flooding

Increasing rapid urban development exacerbating impacts

Design Guidelines and Rainfall Data

- Current design storms
  - Water Quality: 6-month 24-hour storm
  - Flow Control: 25-year 24-hour storm with safe overflow to convey 100-year storm
- NOAA Atlas 2
  - Last updated in 1973
  - Atlas 14 is not available for Oregon, Idaho, Montana, Washington, Wyoming



Central Oregon
Stormwater Manual

Updated August 2010

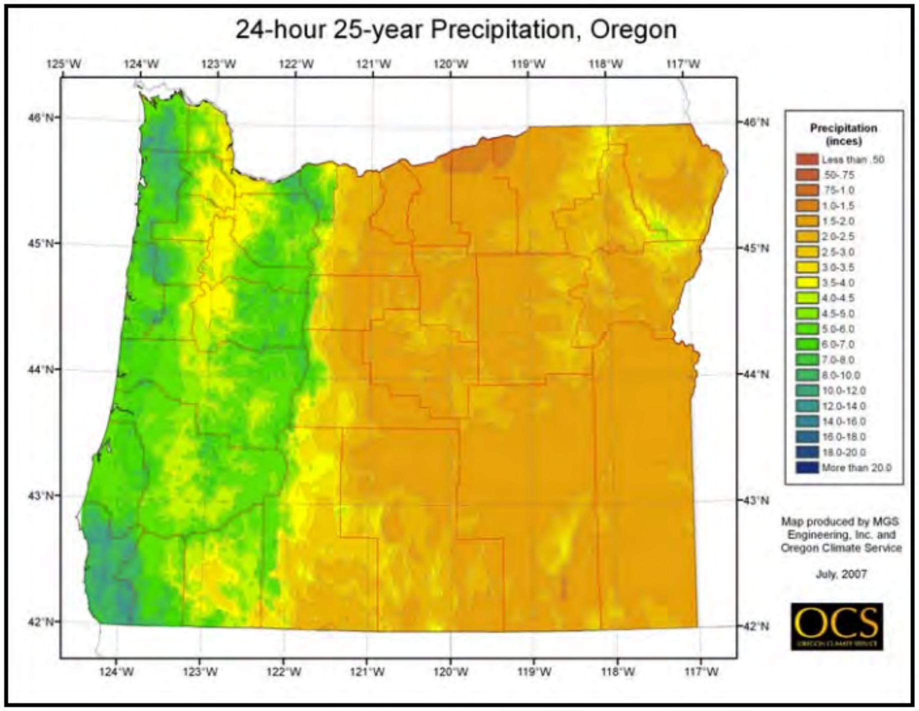
CENTRAL OREGON INTERGOVERNMENTAL COUNCIL

Sources: Central Oregon Intergovernmental Council. (2010). *Central Oregon Stormwater Manual.* https://www.coic.org/stormwater/

Sommer, Lauren. (2022, Feb 9). An unexpected item is blocking cities' climate change prep: obsolete rainfall records. *NPR/OPB.* NPR-Obsolete Rainfall Records

How Other PNW Municipalities Address Outdated Data

- Salem, OR
  - Uses Oregon Department of Transportation (ODOT) updated Atlas 2 24-hour storm maps from 2008
  - Based on historical rainfall
  - Data now almost 20 years old
- Eugene, OR
  - Specific historical storms for flood control storms
  - Statistical analysis of local rainfall data for water quality storm
- Seattle, WA
  - Developed design storms to replace Atlas 2 based on specific historical storms recorded by City of Seattle network of gauges



Source: ODOT. (2008).ODOT Regional Precipitation-Frequency Analysis and Spatial Mapping of 24-Hour Precipitation for Oregon Final Report SPR 656
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Salem Public Works. (2014). Stormwater Design Handbook for Developers and Large Projects. City of Salem Stormwater Design Handbook for Developers and Large Projects
City of Seattle. (2021). Stormwater Manual. https://www.seattle.gov/documents/Departments/SDCI/Codes/StormwaterCode/2021SWFullManualFinalClean.pdf

Historical Rainfall vs Projected Rainfall with Climate Change

This Photo by Unknown Author is licensed under CC BY-NC

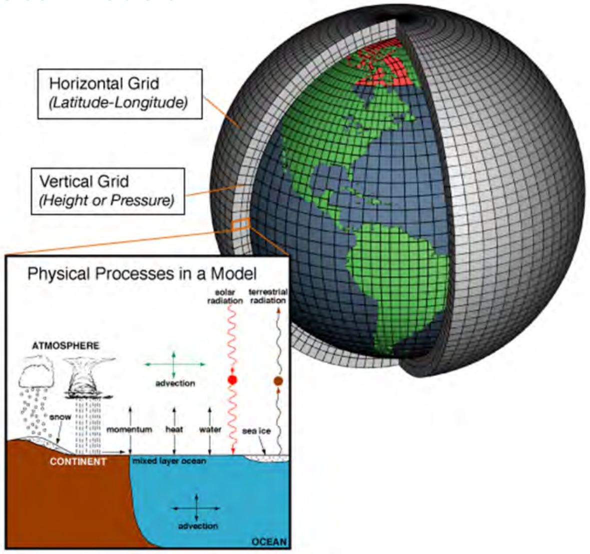
- Stormwater design standards assume historical rainfall intensity, frequency and duration
- Recent studies indicate storms are expected to become more severe
- Need to incorporate climate projections into design storms

Source: Hathaway et. al. (2023). A synthesis of climate change impacts on stormwater management systems: designing for resiliency and future challenges.
DOI: 10.1061/JSWBAY.SWENG-533.

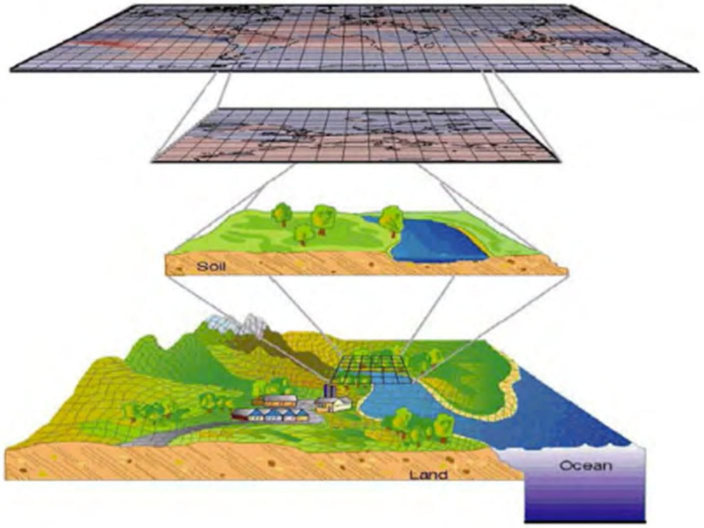
Global Climate Models

- Global models simulate future climate given set of scenarios
  - Scenarios of greenhouse gases, aerosols, assumptions of land use change
  - Most recent CMIP6 models (2024) associated with IPCC 6th Assessment Report
  - Models get downscaled for local & regional impact assessments

Global Models



Regional Models

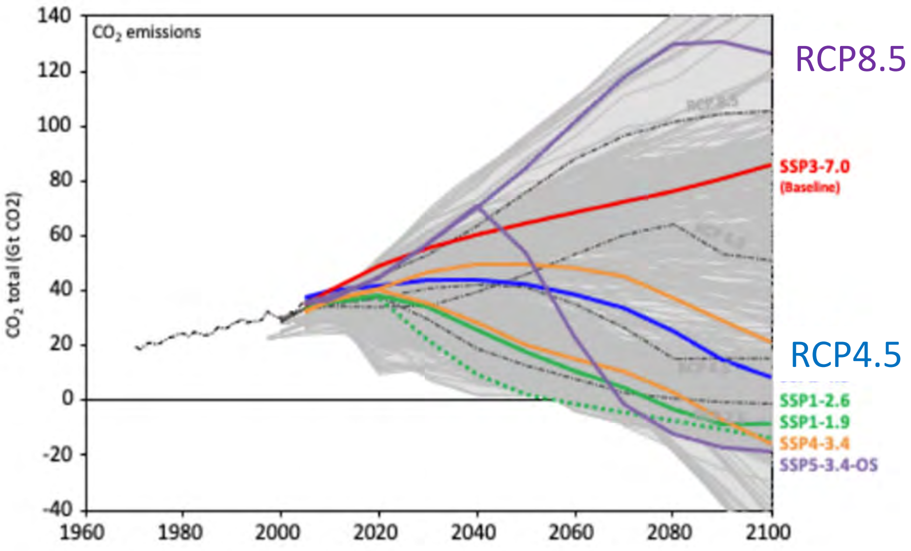


Khan and Pilz (2018)

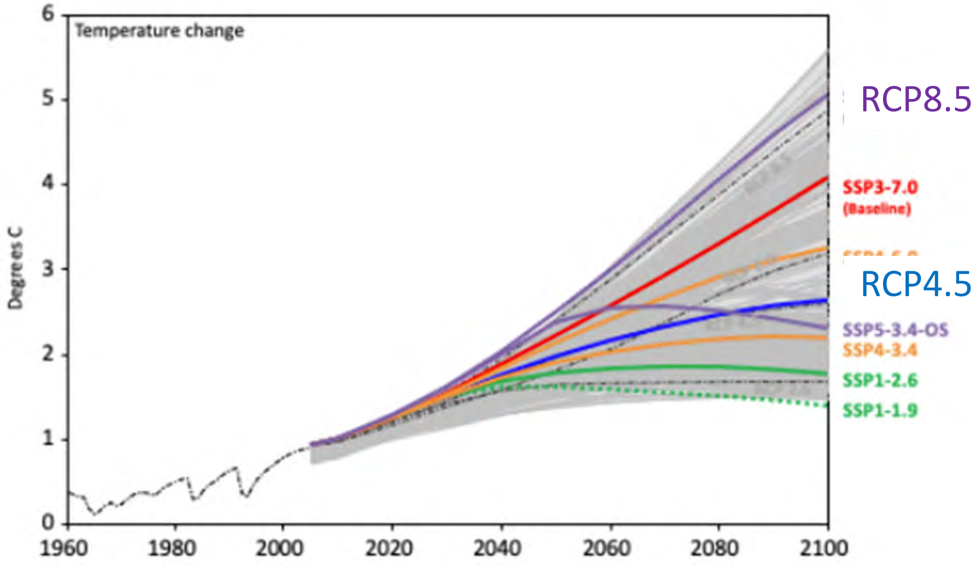
Source: NOAA Climate.gov. (2024). Climate Models. https://www.climate.gov/maps-data/climate-data-primer/predicting-climate/climate-models#:~:text=Climate%20models%2C%20also%20known%20as,the%20ocean%2C%20atmosphere%2C%20land.

Greenhouse Gas Emissions Scenarios (i.e. RCP4.5, RCP8.5)

Possible future warming scenarios defined in terms of total warming by 2100



Adapted from Fleishman (2023)



Downscaled Climate Data

- Downscaling translates large-scale climate model data to a regional scale
- Two strategies:

Statistical downscaling

- Statistical methods determine relationships between large-scale data and local conditions
- Computationally inexpensive
- More commonly used for stormwater design standards

Dynamic downscaling

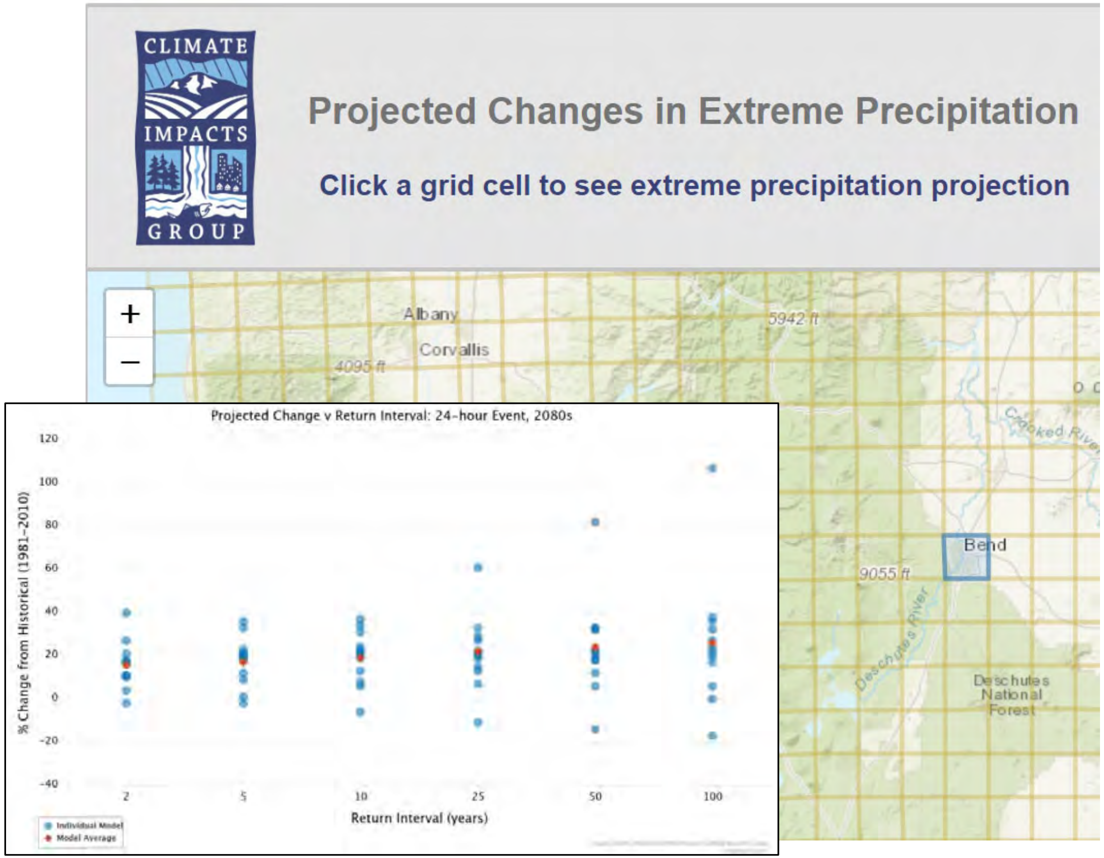
- Translates large-scale climate model data into higher resolution regional data
- Physical processes modeled at fine scale, includes effects of topography and land cover
- Computationally expensive

Source: Salathé Jr., Eric P., et. al. (2014). Estimates of Twenty-First Century Flood Risk in the Pacific Northwest Based on Regional Climate Model Simulations. J. Hydrometeor, 15, 1881–1899. http://dx.doi.org/10.1175/JHM-D-13-0137.1

Morgan, H. et. al. (2021). Climate change in Portland, Gresham, and Clackamas County. Climate Impacts Group, University of Washington.

University of Washington, Projected Changes in Extreme Precipitation

- Analysis covers Oregon, Washington, Idaho and portions of Montana, Wyoming, Utah, Nevada, and southwestern Canada
- 10 different climate models plus all-model average
- CMIP5 Dynamic downscaling
- 12 km^2 resolution, Model years: 1980-2099
- Business-as-usual greenhouse gas emissions scenario (i.e. RCP8.5)
- This data used climate model output to calculate the projected change (2030s-2080s) in duration and return interval of storms



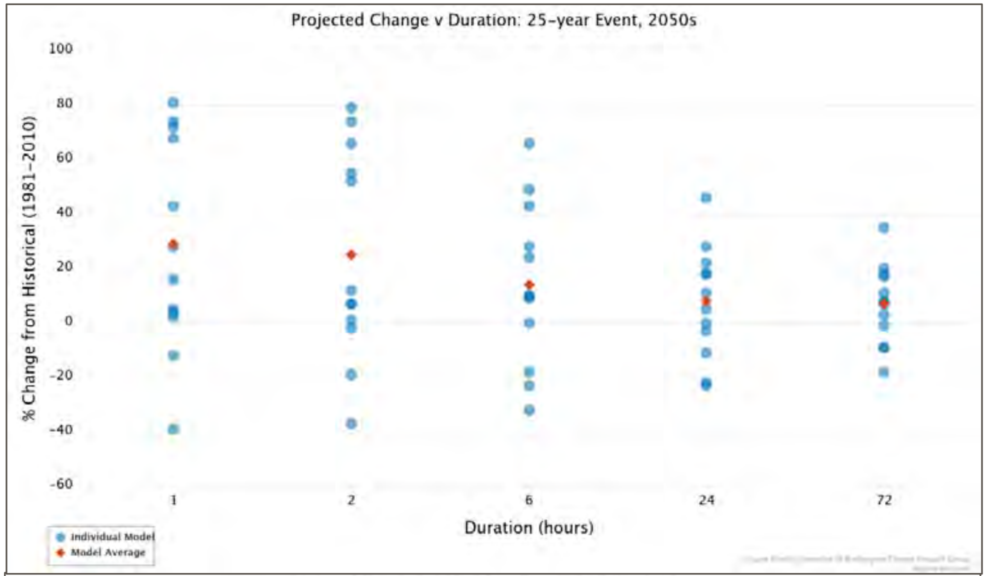
Projected Changes in Extreme Precipitation

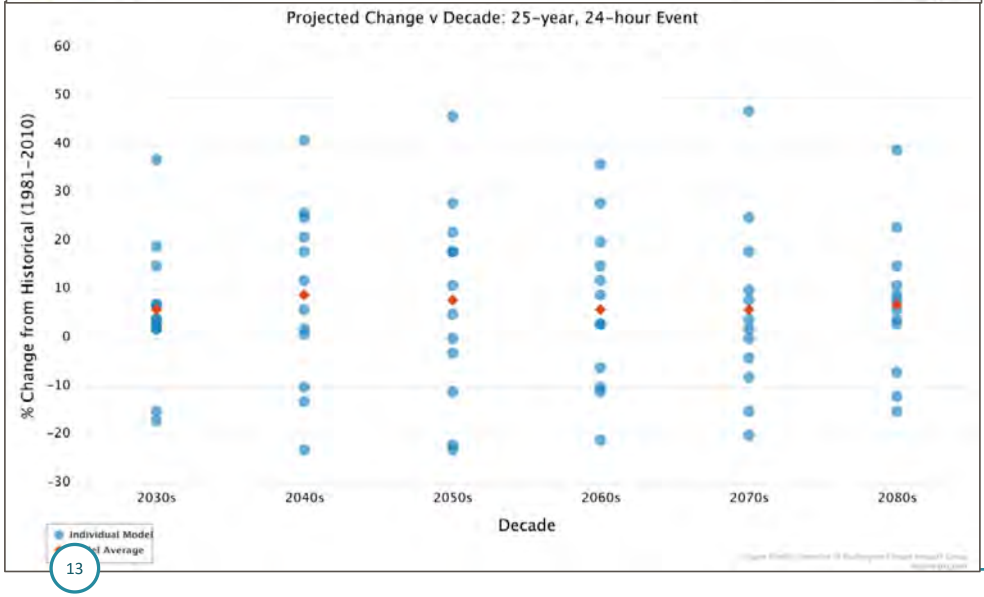
Click a grid cell to see extreme precipitation projection

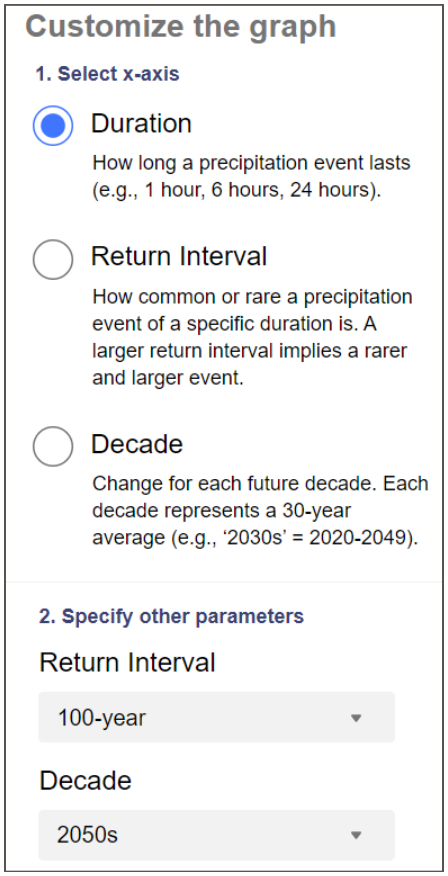
Source: Morgan, H., Mauger, G., Won, J., Gould, D. 2021 *Projected Changes in Extreme Precipitation Web Tool.* University of Washington Climate Impacts Group. https://doi.org/10.6069/79CV-4233

Projected Precipitation Data

https://data.cig.uw.edu/picea/stormwater/pub/viz/


Projected Change v Duration: 25-year Event, 2050s


Projected Change v Decade: 25-year, 24-hour Event


Customize the graph

1. Select x-axis

● Duration

How long a precipitation event lasts (e.g., 1 hour, 6 hours, 24 hours).

○ Return Interval

How common or rare a precipitation event of a specific duration is. A larger return interval implies a rarer and larger event.

○ Decade

Change for each future decade. Each decade represents a 30-year average (e.g., '2030s' = 2020-2049).

2. Specify other parameters

Return Interval

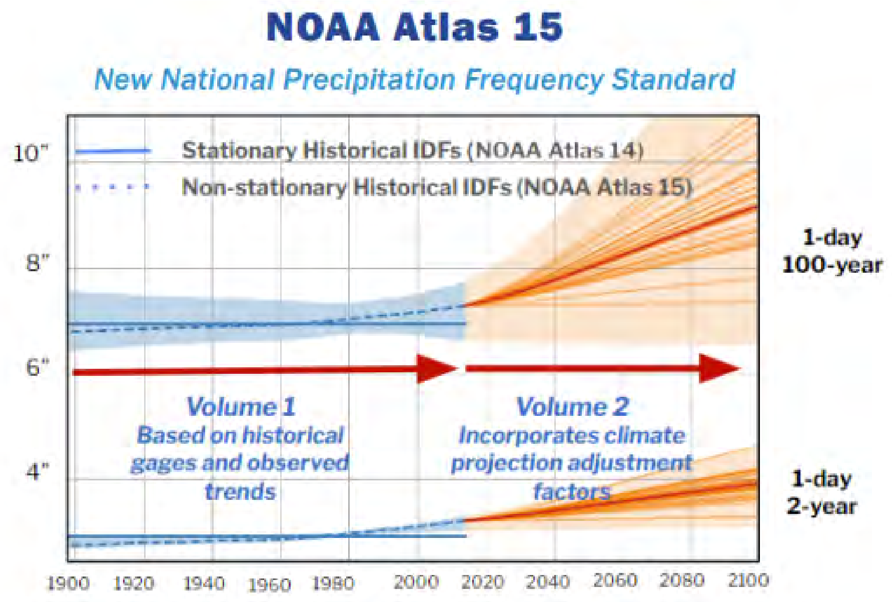
100-year ▾

Decade

2050s ▾

Source: Morgan, et al. 2021

Climate Change Projections and Stormwater Design



Historical and future intensity-duration-frequency estimates (IDFs)

- FLOODS Act – NOAA Atlas 15
  - Volume 1: updated historical and present-day data, covering the entire United States
  - Volume 2: will generate adjustment factors for Volume 1 based on climate model projections
- Many cities and regions are incorporating climate change into stormwater design standards in the meantime

Source: NOAA Office of Water Prediction. (2022). NOAA Atlas 15: Update to the National Precipitation Frequency Standard. https://www.weather.gov/media/owp/hdsc_documents/NOAA_Atlas_15_Flyer.pdf

Case Studies

Incorporating climate projections into stormwater design standards

City of Virginia Beach DPW

Interim steps and prioritization of key interventions

Portland, OR

Regional approach to standardizing stormwater design

Chesapeake Stormwater Network

Case Study: City of Virginia Beach DPW

Scenario:

- Study assessed changes in heavy rainfall frequency and intensity using historical observations and future projections after series of 3 large storms in 2016 led to 33 inches of rain over 6 weeks, and heavy flooding.
- Atlas 14 precipitation values were found to be 7-10% below observed precipitation data from local rain gauges.
- Projections of the 10-year storm event showed an increase in precipitation of 24-27% from 2000 to 2060 for RCP 8.5 scenario.

Outcome:

- City recommended 20% increase in extreme precipitation based on combination of historical data and projections to 2060 for RCP8.5 assuming a 40-year life for infrastructure
- Revised design guidelines increase Atlas 14 design storm rainfall depths by 20% and require the use of dynamic (SWMM) modeling for design and analysis of pre vs post development conditions

Source: Water Utility Climate Alliance. (2022). Scaling and Application of Climate Projections to Stormwater and Wastewater Resilience Planning. https://www.wucaonline.org/assets/pdf/stormwater-wastewater-report-2022.pdf

Case Study: Portland, OR Bureau of Environmental Services

Scenario:

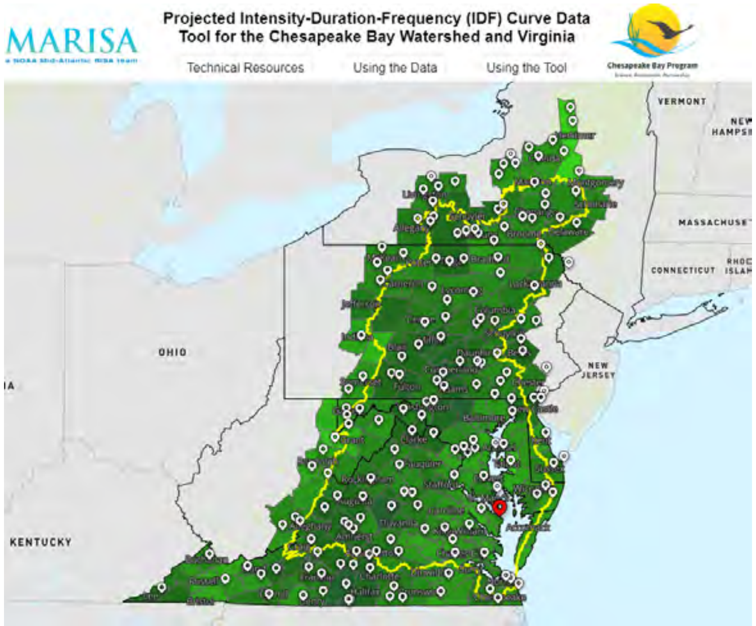
- Wanted to test stormwater system's resilience to climate change. Initial goal was to update historical data and create design storms using downscaled climate data, but did not have sub-daily rainfall for short intense storms.
- Instead, used a combined approach of sensitivity analysis (quantitative) and scenario planning (qualitative).
- Modeled the system and stressed the modeled system by increasing volume and intensity in increments of 10%. Found that system was more susceptible to higher intensity than higher volume.

Outcome:

- Stress testing helped them identify relative levels of risk throughout the system to combine with economic impact estimates to prioritize certain projects and certain parts of the system that will experience risk first.
- The Bureau of Environmental Services plans to apply this approach to basins across the city and will place additional priority on communities with greater social vulnerability and critical infrastructure.

Source: U.S. Climate Resilience Toolkit. (2024). Throw Away Your Crystal Ball: A Stress Testing Approach to Infrastructure Planning Under Climate Change Uncertainty. https://toolkit.climate.gov/case-studies/throw-away-your-crystal-ball-stress-testing-approach-infrastructure-planning-under

Case Study: Chesapeake Stormwater Network



Scenario:

- Regional project that aims to standardize stormwater design standards and practices throughout the Chesapeake Bay watershed.
- Recognized that Atlas 14 IDF curves were outdated for current conditions and there was inconsistency in stormwater policies across the region
- Reviewed the state of stormwater practice across the mid Atlantic region with a survey, review of design standards, climate projections and vulnerability of BMPs

Outcome:

- Developed a Mid-Atlantic IDF curve online tool in collaboration with NOAA. The tool provides IDF curves and change factors for projected future climate scenarios at a county scale.
- The Chesapeake Stormwater Network plans to launch four new tools that build on the IDF curve tool and provide improved data that is consistent across the region.

Sources: MARISA, Chesapeake Bay Program. (2024). Projected Intensity-Duration-Frequency (IDF) Curve Data Tool for the Chesapeake Bay Watershed and Virginia. https://midatlantic-idf.rcc-acis.org/

Water Utility Climate Alliance. (2022). Scaling and Application of Climate Projections to Stormwater and Wastewater Resilience Planning. https://www.wucaonline.org/assets/pdf/stormwater-wastewater-report-2022.pdf

Key Takeaways and Recommendations

- Develop a strong baseline of historical observed rainfall data:
  - Increase data collection with more gauges and a larger monitoring network.
- Integrate projected climate change precipitation using downscaled data
- New design guidelines based on most updated data and climate projections requires time, expertise, and resources.
- An interim approach and prioritization of key projects based on city objectives can help where resources are limited.
- Combine multiple approaches, both quantitative and qualitative.
- Working regionally and partnering across jurisdictions with universities and Federal agencies can help to pool resources and coordinate research.
- The science and data is continually evolving and improving. Now is the time to begin!

Additional Recommendations

Low impact development/green infrastructure

Preventative operations and maintenance

Retrofit existing stormwater BMPs and infrastructure to enhance their capacity

Change flow control BMP requirements based on other factors when a complete update based on climate projections is not yet possible

Community engagement and education

Source: Hathaway et. al. (2023). A synthesis of climate change impacts on stormwater management systems: designing for resiliency and future challenges. DOI: 10.1061/JSWBAY.SWENG-533.

Washington Department of Ecology. (2024). Stormwater Management Manual for Western Washington. 2024SWMMWW (wa.gov)

Aqualis. (2024). Stormwater Winter Preparedness Checklist. Stormwater Winter Preparedness Checklist - AQUALIS (aqualisco.com)

Funding Sources for Climate Change Impact Assessment

Federal

- FEMA Building Resilient Infrastructure for Communities (BRIC) Grants - BRIC Grant
- USDOT Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation Program (PROTECT) Grants - PROTECT Grant
- EPA Community Change Grants

State

- DLCD Community Green Infrastructure Grant Program - CGI Grant

Philanthropic

- The Funders Network Urban Water Funders - Urban Water Funders
- National Fish and Wildlife Foundation America the Beautiful Challenge - America the Beautiful Challenge

Next Steps

August 14
(this meeting)

Present preliminary results and get feedback from city staff

August 28

Deadline to receive feedback from city staff and incorporate into our findings

October 2

Meeting with UPAG to give a high-level summary of our results

Questions?

HALEY ALDRICH

Appendix E:

Project Prioritization Materials

City of Bend Stormwater Master Plan
Capital Project Rating Criteria - Final Version

January 28, 2025

						Score Values			
Criterion	**Weight**	**High Score**	**Max Total**	**Description**	**Scoring Concept**	**0**	**1**	**3**	**5**
1. Conveyance & Flooding									
Frequency of Flooding Event	2.00	5	10.00	Does the project reduce flooding and if yes, for flooding at what frequency?	Projects that address more frequent floods receive more points.	No flooding caused by storm system	Large thunderstorms, Infrequent, Unknown	Large rainstorms, Thunderstorms, Frozen conditions only	Annual, ongoing, or All rains
Flooding Severity/Risk Avoidance	2.00	5	10.00	What types of properties or assets will be protected from flooding under this project? What risks to the traveling public will be avoided under this project?	Projects that address flooding that damages private property or has serious traffic impacts receive more points.	No flooding caused by storm system	Future flooding is predicted only (not observed), flooding on minor streets, no expected property damage, or previous flooding may have been solved and is being monitored	Severity score = Moderate. Includes moderate traffic impacts, flooding on private property (without indication of permanent damage), or pedestrian impacts	Severity score = High. Includes damage to structure (interior), damage to structure (exterior), property damage (exterior), or serious traffic impacts
		Max Points	**20.00**						
2. Water Quality Improvements									
River & Groundwater Protection	3.00	5	15.00	Did the outfall rate highly in a needs analysis to identify outfalls that are most in need and best suited to water quality retrofit?	Projects that address already-prioritized drillholes and outfalls receive more points.	No, and no water quality improvement component is proposed	n/a	No, but the project would include a water quality component	Yes
Permit Compliance	1.00	5	5.00	Does the project assist in meeting WPCF or MS4 Permit requirements?	Projects that assist in meeting WPCF or MS4 Permit requirements receive more points.	No	n/a	n/a	Yes
		Max Points	**20.00**						
3. Multiple Benefits									
Increases Equitable Distribution of Public Stormwater Assets	1.00	5	5.00	Does the project provide drainage and stormwater management where public storm system is lacking OR does the project serve a location with a traditionally underserved population identified by City of Bend?	Projects that are located where City storm system is not present and that will serve populations living below the federal poverty level (by Census Block Group) or have a relatively high minority populations receive more points.	The project is in an area with public stormwater infrastructure and does not meet any of the scoring criteria for traditionally underserved populations identified at right	The project is in an area with no public stormwater infrastructure OR the project is in a Census Block Group where EITHER more than 20% of the population lives below the federal poverty level (FPL) OR is more than 15.6% minority	The project is in an area with no public stormwater infrastructure OR the project is in a Census Block Group where EITHER more than 35% of the population lives 200% below the federal poverty level (FPL) OR is more than 30% minority	The project is in an area with no public stormwater infrastructure AND the project is in a Census Block Group where EITHER more than 35% of the population lives 200% below the federal poverty level (FPL) OR is more than 30% minority
Supports Housing or Economic Development	1.00	5	5.00	Does the project support urban renewal or production of middle or affordable housing?	Projects receive more points when they are located at the intersection of more City focus areas: - Urban Renewal District - Economic Improvement District - Enterprise Zone - Opportunity Area - Potential Climate Friendly Area	None	The project will create a regional stormwater facility within one of the types of City focus areas.	The project will create a regional stormwater facility within two types of City focus areas.	The project will create a regional stormwater facility within at least three types of City focus areas.
Maintenance Safety/Access	0.50	5	2.50	Does the project improve the ease of maintenance and/or safety of staff during maintenance?	If access is increased, safety considerations are improved, or callouts for drainage concerns are reduced, project scores 5.	No change	n/a	n/a	Yes
Green Infrastructure / Ecosystem Services	0.50	5	2.50	Does the project provide additional ecosystem services through Green Infrastructure, such as vegetation and aesthetics.	Projects that are likley to include an above-ground component that is vegetated, including swales, ponds, LID planters, stormwater trees, tree canopy, and riverbank restoration receive maximum points.	No change / gray or underground solution	n/a	n/a	Green Infrastructure solution likely
System Longevity	0.50	5	2.50	Does the project rehabilitate an existing asset or improve the function or longevity of an existing asset?	Projects receive either maximum points or no points.	No	n/a	n/a	Yes
Community Partnerships	0.50	5	2.50	Will the project be developed in partnership with an organization such as Bend Park and Recreation District or Upper Deschutes Watershed Council?	Projects receive either maximum points or no points.	No	n/a	n/a	Yes
		Max Points	**20.00**						
4. Recognized Priority Projects									
Staff Priority	2.00	5	10.00	Is the project an agreed priority for City staff?	Points are awarded based on City Utilities Operations staff priorities (1-3). One point is available for Engineering and Compliance staff priorities.	No	Utilities Operations Priority 3 or Utilities Environmental Resources or Engineering priority	Utilities Operations Priority 2	Utilities Operations Priority 1
		Max Points	**10.00**						
5. Feasibility & Cost									
Complexity / Site Constraints	1.00	5	5.00	Does a physical condition such as proximity to a water well, landslide, or unfractured bedrock or need to acquire significant property mean that a solution is likely higher cost than a similar project in a less complex location?	Projects receive more points when they have less complex site conditions.	Requires significant land acquisition, or any federal or state permitting, or unusual system design, or expensive construction methods	Requires a permanent easement and local permitting only; site conditions are not well understood	Requires a permanent easement and local permitting only; site conditions are well understood and moderate impediments are present	Requires neither acquisition nor permanent easement, and site conditions are well understood with few complexities
Low Cost	1.00	5	5.00	Is the project a low-cost solution?	Projects with low initial capital costs and low ongoing maintenance costs receive maximum points. Points reduce with higher capital cost and higher ongoing maintenance cost.	It will cost more than $250,000 and is not expected to have low ongoing maintenance cost	It will cost more than $250,000 and is expected to have low ongoing maintenance cost	n/a	It will cost less than $250,000 and is expected to have low ongoing maintenance cost
		Max Points	**10.00**						

City of Bend Stormwater Master Plan
Capital Improvement Project Scoring and Ranking - Final Results
January 2025

Rating Criteria Version: 1/28/25			**Conveyance & Flooding Improvements**				**Water Quality Improvements**			
			Frequency of Flooding		**Flooding Severity/Risk Avoidance**		**River & Groundwater Protection**		**Permit Compliance**	
PP-ID	**Project Name**	**Primary Type**	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
35	**Riverfront Street Stormwater Improvements**	***Retrofit***	3, Large rainstorms, Thunderstorms, Frozen conditions only	**6.0**	3, Severity score = Moderate. Includes moderate traffic impacts, flooding on private property (without indication of permanent damage), or pedestrian impacts	**6.0**	5, Yes	**15.0**	5, Yes	**5.0**
42	**Downtown Pedestrian Safety Drainage Improvements Program**	**Drainage**	5, Annual, ongoing, or All rains	**10.0**	3, Severity score = Moderate. Includes moderate traffic impacts, flooding on private property (without indication of permanent damage), or pedestrian impacts	**6.0**	0, No, and no water quality improvement component is proposed	**0.0**	0, N/A	**0.0**
44	**Drake Park Stormwater Quality Improvements**	***Retrofit***	0, No flooding caused by storm system	**0.0**	0, No flooding caused by storm system	**0.0**	5, Yes	**15.0**	5, Yes	**5.0**
14	**Congress Street Drainage Improvements**	**Drainage**	1, Large thunderstorms, Infrequent, Unknown	**2.0**	5, Severity score = High. Includes damage to structure (interior), damage to structure (exterior), property damage (exterior), or serious traffic impacts	**10.0**	0, No, and no water quality improvement component is proposed	**0.0**	0, No	**0.0**
46	**Vicksburg Avenue Drainage Improvements**	**Drainage**	5, Annual, ongoing, or All rains	**10.0**	5, Severity score = High. Includes damage to structure (interior), damage to structure (exterior), property damage (exterior), or serious traffic impacts	**10.0**	0, No, and no water quality improvement component is proposed	**0.0**	0, No	**0.0**
47	**Galveston Avenue Stormwater Quality Improvements**	***Retrofit***	0, No flooding caused by storm system	**0.0**	0, No flooding caused by storm system	**0.0**	5, Yes	**15.0**	5, Yes	**5.0**
48	**Fresno Avenue Stormwater Improvements**	***Retrofit***	0, None	**0.0**	0, None	**0.0**	5, Yes	**15.0**	5, Yes	**5.0**
12	**Columbia Park Outfall Retrofit** - project later removed from list after discovery that it is infeasible	***Retrofit***	0, No flooding caused by storm system	**0.0**	0, None	**0.0**	5, Yes	**15.0**	5, Yes	**5.0**
45	**12th Street Stormwater Quality Improvements**	***Retrofit***	0, None	**0.0**	0, No flooding caused by storm system	**0.0**	5, Yes	**15.0**	5, Yes	**5.0**
1	**Dove Lane Drainage Improvements**	**Drainage**	3, Large rainstorms, Thunderstorms, Frozen conditions only	**6.0**	5, Severity score = High. Includes damage to structure (interior), damage to structure (exterior), property damage (exterior), or serious traffic impacts	**10.0**	0, No, and no water quality improvement component is proposed	**0.0**	0, No	**0.0**
43	**Saginaw Avenue Stormwater Quality Improvements**	***Retrofit***	0, No flooding caused by storm system	**0.0**	0, No flooding caused by storm system	**0.0**	5, Yes	**15.0**	5, Yes	**5.0**
16	**Campbell Road Drainage Improvements**	**Drainage**	1, Large thunderstorms, Infrequent, Unknown	**2.0**	3, Severity score = Moderate. Includes moderate traffic impacts, flooding on private property (without indication of permanent damage), or pedestrian impacts	**6.0**	0, No, and no water quality improvement component is proposed	**0.0**	0, No	**0.0**

City of Bend Stormwater Master Plan
Capital Improvement Project Scoring and Ranking - Final Results
January 2025

	Multiple Benefits											
	Increases Equitable Distribution of Public Stormwater Assets		Supports Housing or Economic Development		Maintenance Safety/Access		Green Infrastructure / Ecosystem Services		System Longevity		Community Partnerships	
PP-ID	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
35	0, The project is in an area with public stormwater infrastructure and does not meet any of the scoring criteria for traditionally underserved populations identified at right	0.0	0, No	0.0	5, Yes	2.5	0, No change / gray or underground solution	0.0	5, Yes	2.5	0, No	0.0
42	3, The project is in an area with no public stormwater infrastructure OR the project is in a Census Block Group where EITHER more than 35% of the population lives 200% below the federal poverty level (FPL) OR is more than 30% minority	3.0	3, The project will create a regional stormwater facility within two types of City focus areas listed here: - Urban Renewal District - Economic Improvement District - Enterprise Zone - Opportunity Area	3.0	5, Yes	2.5	5, Green Infrastructure solution likely	2.5	5, Yes	2.5	0, No	0.0
44	0, The project is in an area with public stormwater infrastructure and does not meet any of the scoring criteria for traditionally underserved populations identified at right	0.0	0, No	0.0	5, Yes	2.5	5, Green Infrastructure solution likely	2.5	5, Yes	2.5	5, Yes	2.5
14	1, The project is in an area with no public stormwater infrastructure OR the project is in a Census Block Group where EITHER more than 20% of the population lives below the federal poverty level (FPL) OR is more than 15.6% minority	1.0	0, No	0.0	5, Yes	2.5	0, No change / gray or underground solution	0.0	5, Yes	2.5	0, No	0.0
46	1, The project is in an area with no public stormwater infrastructure OR the project is in a Census Block Group where EITHER more than 20% of the population lives below the federal poverty level (FPL) OR is more than 15.6% minority	1.0	0, No	0.0	5, Yes	2.5	5, Green Infrastructure solution likely	2.5	0, No	0.0	0, No	0.0
47	1, The project is in an area with no public stormwater infrastructure OR the project is in a Census Block Group where EITHER more than 20% of the population lives below the federal poverty level (FPL) OR is more than 15.6% minority	1.0	0, No	0.0	0, No change	0.0	5, Green Infrastructure solution likely	2.5	5, Yes	2.5	0, No	0.0
48	0, The project is in an area with public stormwater infrastructure and does not meet any of the scoring criteria for traditionally underserved populations identified at right	0.0	0, No	0.0	0, No change	0.0	0, No change / gray or underground solution	0.0	5, Yes	2.5	0, No	0.0
12	0, The project is in an area with public stormwater infrastructure and does not meet any of the scoring criteria for traditionally underserved populations identified at right	0.0	0, No	0.0	0, No change	0.0	5, Green Infrastructure solution likely	2.5	5, Yes	2.5	5, Yes	2.5
45	0, The project is in an area with public stormwater infrastructure and does not meet any of the scoring criteria for traditionally underserved populations identified at right	0.0	0, No	0.0	0, No change	0.0	5, Green Infrastructure solution likely	2.5	0, No	0.0	0, No	0.0
1	1, The project is in an area with no public stormwater infrastructure OR the project is in a Census Block Group where EITHER more than 20% of the population lives below the federal poverty level (FPL) OR is more than 15.6% minority	1.0	0, No	0.0	5, Yes	2.5	0, No change / gray or underground solution	0.0	0, No	0.0	0, No	0.0
43	0, The project is in an area with public stormwater infrastructure and does not meet any of the scoring criteria for traditionally underserved populations identified at right	0.0	0, No	0.0	0, No change	0.0	5, Green Infrastructure solution likely	2.5	5, Yes	2.5	0, No	0.0
16	1, The project is in an area with no public stormwater infrastructure OR the project is in a Census Block Group where EITHER more than 20% of the population lives below the federal poverty level (FPL) OR is more than 15.6% minority	1.0	0, No	0.0	5, Yes	2.5	5, Green Infrastructure solution likely	2.5	0, No	0.0	0, No	0.0

City of Bend Stormwater Master Plan
Capital Improvement Project Scoring and Ranking - Final Results
January 2025

	Recognized Priority Projects		**Feasability & Cost**				**Total**	**Rank**
	Staff Priority		**Complexity / Site Constraints**		**Low Cost**		**Total Score**	**Rank, With Duplicates**
PP-ID	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Total Score (Current)	Overall Rank.EQ (Current)
35	5, Utilities Operations Priority 1	**10.0**	3, Requires a permanent easement and local permitting only; site conditions are well understood and moderate impediments are present	**3.0**	1, It will cost more than $250,000 and is expected to have low ongoing maintenance cost	**1.0**	***51.0***	1
42	5, Utilities Operations Priority 1	**10.0**	5, Requires neither acquisition nor permanent easement, and site conditions are well understood with few complexities	**5.0**	1, It will cost more than $250,000 and is expected to have low ongoing maintenance cost	**1.0**	***45.5***	2
44	1, Utilities Operations Priority 3 or Utilities Environmental Resources or Engineering priority	**2.0**	3, Requires a permanent easement and local permitting only; site conditions are well understood and moderate impediments are present	**3.0**	1, It will cost more than $250,000 and is expected to have low ongoing maintenance cost	**1.0**	***36.0***	3
14	5, Utilities Operations Priority 1	**10.0**	5, Requires neither acquisition nor permanent easement, and site conditions are well understood with few complexities	**5.0**	1, It will cost more than $250,000 and is expected to have low ongoing maintenance cost	**1.0**	***34.0***	4
46	1, Utilities Operations Priority 3 or Utilities Environmental Resources or Engineering priority	**2.0**	5, Requires neither acquisition nor permanent easement, and site conditions are well understood with few complexities	**5.0**	1, It will cost more than $250,000 and is expected to have low ongoing maintenance cost	**1.0**	***34.0***	4
47	1, Utilities Operations Priority 3 or Utilities Environmental Resources or Engineering priority	**2.0**	5, Requires neither acquisition nor permanent easement, and site conditions are well understood with few complexities	**5.0**	0, It will cost more than $250,000 and is not expected to have low ongoing maintenance cost	**0.0**	***33.0***	6
48	1, Utilities Operations Priority 3 or Utilities Environmental Resources or Engineering priority	**2.0**	3, Requires a permanent easement and local permitting only; site conditions are well understood and moderate impediments are present	**3.0**	5, It will cost less than $250,000 and is expected to have low ongoing maintenance cost	**5.0**	***32.5***	7
12	0, No	**0.0**	1, Requires a permanent easement and local permitting only; site conditions are not well understood	**1.0**	1, It will cost more than $250,000 and is expected to have low ongoing maintenance cost	**1.0**	***29.5***	8
45	0, No	**0.0**	5, Requires neither acquisition nor permanent easement, and site conditions are well understood with few complexities	**5.0**	1, It will cost more than $250,000 and is expected to have low ongoing maintenance cost	**1.0**	***28.5***	9
1	3, Utilities Operations Priority 2	**6.0**	1, Requires a permanent easement and local permitting only; site conditions are not well understood	**1.0**	1, It will cost more than $250,000 and is expected to have low ongoing maintenance cost	**1.0**	***27.5***	10
43	0, No	**0.0**	0, Requires significant land acquisition, or any federal or state permitting, or unusual system design, or expensive construction methods	**0.0**	1, It will cost more than $250,000 and is expected to have low ongoing maintenance cost	**1.0**	***26.0***	11
16	3, Utilities Operations Priority 2	**6.0**	3, Requires a permanent easement and local permitting only; site conditions are well understood and moderate impediments are present	**3.0**	0, It will cost more than $250,000 and is not expected to have low ongoing maintenance cost	**0.0**	***23.0***	12

Appendix F:

Public Involvement Materials

CITY OF BEND

Utilities Public Advisory Group

March 6, 2024 • 11 am–12:30 pm

Hybrid Meeting • MS Teams or Bend Utilities Department Deschutes Conference Room

Lori Faha, P.E., Environmental Resources Manager
Austin Somhegyi, Stormwater Master Plan Project Manager
Dan Denning, Water Conservation Program Manager
Elisabeth O'Keefe, Stormwater Program Manager
Aubrie Koenig, Facilitator

Purpose & Agenda

Share an overview of the Stormwater Master Plan process and collect initial input on key issues. Share water conservation program highlights and get input on reporting.

1. Introduction
2. Stormwater Master Plan
   - Overview and timeline
   - Areas for UPAG input
3. Water Conservation Program
   - Annual reporting
   - Key metrics
4. Erosion Control Program
   - Permit compliance
   - Future standards updates
5. UPAG Discussion
6. Summary and Closing

February meeting reflections

MARCH 6, 2024

THINK OUT LOUD

How Central Oregon is coming together to meet challenges related to scarce water resources, worsening drought

Recorded at the RiverHouse, published March 5, 2024

CITY OF BEND

Stormwater Master Plan

Overview, Timeline, Areas for UPAG Input

City Project Manager: Austin Somhegyi

Consultant Project Manager: Trista Kobluskie, OTAK

Stormwater Master Plan purpose and overview

- Update conveyance and drainage projects from 2014 Stormwater Master Plan
- Identify and assess new conveyance/drainage issues
- Create a long-term plan for reducing risk to groundwater from drill holes and drywells (UICs)
- Create a plan for improving the quality of runoff discharged to the Deschutes River through the City's outfalls
- Develop a capital program incorporating conveyance/drainage projects, UIC retrofits, and outfall retrofits

Stormwater Master Plan purpose and overview

- Review the state of the practice among stormwater utilities for climate change resilience
- Explore options for facilitating denser development, such as:
  - Allowing stormwater runoff from private properties to be managed in the rights-of-way
  - Considering regional stormwater management facilities – placement and necessary policies to support and fund

Stormwater Master Plan development and areas for UPAG input

- Visioning – what is most important to you and the community?
- Visioning – what is the story of stormwater in Bend?
- Solution Priorities – how will we prioritize stormwater capital improvements?
- Policy Solutions – what are the opportunities and impediments to regional facilities?
- Policy Solutions – what are the opportunities and impediments to managing runoff from private properties in the rights-of-way?
- Policy Solutions – how much emphasis on climate change in the next SMP?

Project Timeline

At-a-glance

PLANNING

Define the project scope, objectives, and deliverables.

Communications planning.

Manage the project over time.

2024

Jan – Closeout

DISCOVERY

Intake data and reports.

Assess existing conditions & identify issues to be solved.

Study outfall retrofits.

Study drywells and drill holes.

Study climate change.

2024

Feb - Sept

VISIONING

Assess and document values surrounding stormwater and goals for plan among various groups, including staff, stakeholders, and community.

Use values and goals to prioritize issues, capital projects, and inform policy recommendations.

2024

Feb - Dec

SOLUTIONS

Select capital improvement projects (CIPs).

Develop CIP fact sheets.

Develop policy white papers.

2024 - 2025

Jun – Mar

IMPLEMENT

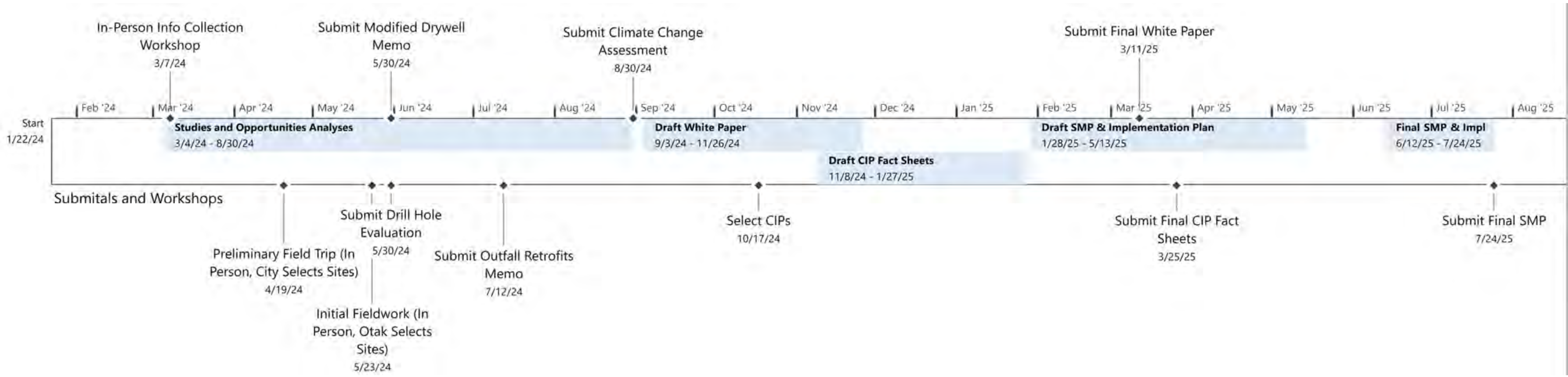
Write and deliver Stormwater MP.

Develop content for implementation tracking web page.

2025

Feb - Jul

Key Milestones



Start 1/22/24

Feb '24 | Mar '24 | Apr '24 | May '24 | Jun '24 | Jul '24 | Aug '24 | Sep '24 | Oct '24 | Nov '24 | Dec '24 | Jan '25 | Feb '25 | Mar '25 | Apr '25 | May '25 | Jun '25 | Jul '25 | Aug '25

In-Person Info Collection Workshop
3/7/24

Submit Modified Drywell Memo
5/30/24

Submit Climate Change Assessment
8/30/24

Submit Final White Paper
3/11/25

Studies and Opportunities Analyses
3/4/24 - 8/30/24

Draft White Paper
9/3/24 - 11/26/24

Draft CIP Fact Sheets
11/8/24 - 1/27/25

Draft SMP & Implementation Plan
1/28/25 - 5/13/25

Final SMP & Impl
6/12/25 - 7/24/25

Submitals and Workshops

Preliminary Field Trip (In Person, City Selects Sites)
4/19/24

Initial Fieldwork (In Person, Otak Selects Sites)
5/23/24

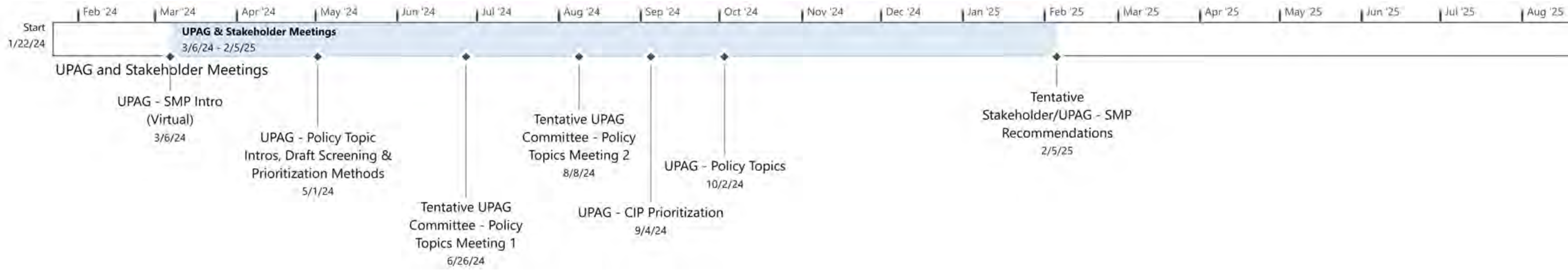
Submit Drill Hole Evaluation
5/30/24

Submit Outfall Retrofits Memo
7/12/24

Select CIPs
10/17/24

Submit Final CIP Fact Sheets
3/25/25

Submit Final SMP
7/24/25



Start 1/22/24

Feb '24 | Mar '24 | Apr '24 | May '24 | Jun '24 | Jul '24 | Aug '24 | Sep '24 | Oct '24 | Nov '24 | Dec '24 | Jan '25 | Feb '25 | Mar '25 | Apr '25 | May '25 | Jun '25 | Jul '25 | Aug '25

UPAG & Stakeholder Meetings
3/6/24 - 2/5/25

UPAG and Stakeholder Meetings

UPAG - SMP Intro (Virtual)
3/6/24

UPAG - Policy Topic Intros, Draft Screening & Prioritization Methods
5/1/24

Tentative UPAG Committee - Policy Topics Meeting 1
6/26/24

Tentative UPAG Committee - Policy Topics Meeting 2
8/8/24

UPAG - CIP Prioritization
9/4/24

UPAG - Policy Topics
10/2/24

Tentative Stakeholder/UPAG - SMP Recommendations
2/5/25

UPAG discussion

- Where is the most talked about stormwater problem in Bend?
- What is the most important outcome of a utility master plan?
- Are you available twice in July and August for a UPAG “summer subcommittee”? (Stormwater Master Plan and Erosion Control)

Thank you!

CITY OF BEND

Accommodation Information for People with Disabilities

To obtain this information in an alternate format such as Braille, large print, electronic formats, etc. please contact Lori Faha at lfaha@bendoregon.gov or (541) 317-3025; Relay Users Dial 7-1-1.

CITY OF BEND

STORMWATER MASTER PLANNING:
VALUES AND PRIORITIES

Utilities Public Advisory Group
May 1, 2024

Meeting Goals

1. Stormwater Master Planning overview recap
2. Progress report
3. Visioning and prioritization input

SMP Overview Recap

- Update conveyance and drainage projects from 2014 Stormwater Master Plan
- Identify and assess new conveyance/drainage issues
- Create a long-term plan for reducing risk to groundwater from drill holes and drywells (UICs)
- Create a plan for improving the quality of runoff discharged to the Deschutes River through the City’s outfalls
- Develop a capital program incorporating conveyance/drainage projects, UIC retrofits, and outfall retrofits

Project Timeline

At-a-glance

PLANNING	DISCOVERY	VISIONING	SOLUTIONS	IMPLEMENT
Define the project scope, objectives, and deliverables. Communications planning. Manage the project over time.	Intake data and reports. Assess existing conditions & identify issues to be solved. Study outfall retrofits. Study drywells and drill holes. Study climate change.	Assess and document values surrounding stormwater and goals for plan among various groups, including staff, stakeholders, and community. Use values and goals to prioritize issues, capital projects, and inform policy recommendations.	Select capital improvement projects (CIPs). Develop CIP fact sheets. Develop policy white papers.	Write and deliver Stormwater MP. Develop content for implementation tracking web page.
2024	2024	2024	2024 - 2025	2025
Jan – Closeout	Feb - Sept	Feb - Dec	Jun – Mar	Feb - Jul

UPAG Input Focus Areas

Vision

- What is most important to you and the community?
- What is the story of stormwater needs and solutions in Bend?

Priorities

- How will we prioritize stormwater capital improvements?

Policy Solutions

- What are the opportunities and impediments to regional facilities?
- What are the opportunities and impediments to managing runoff from private properties in the rights-of-way?
- How much emphasis on climate change in the next SMP?

Key Considerations from March

- Refining stormwater solution set for higher density development and smaller lot sizes
- Education resources for residential onsite stormwater management requirements
- Align master plan and codes related to residential runoff in the right-of-way
- Maintenance resources for privately owned (sometimes failing) stormwater facilities
- Continued focus on groundwater protection

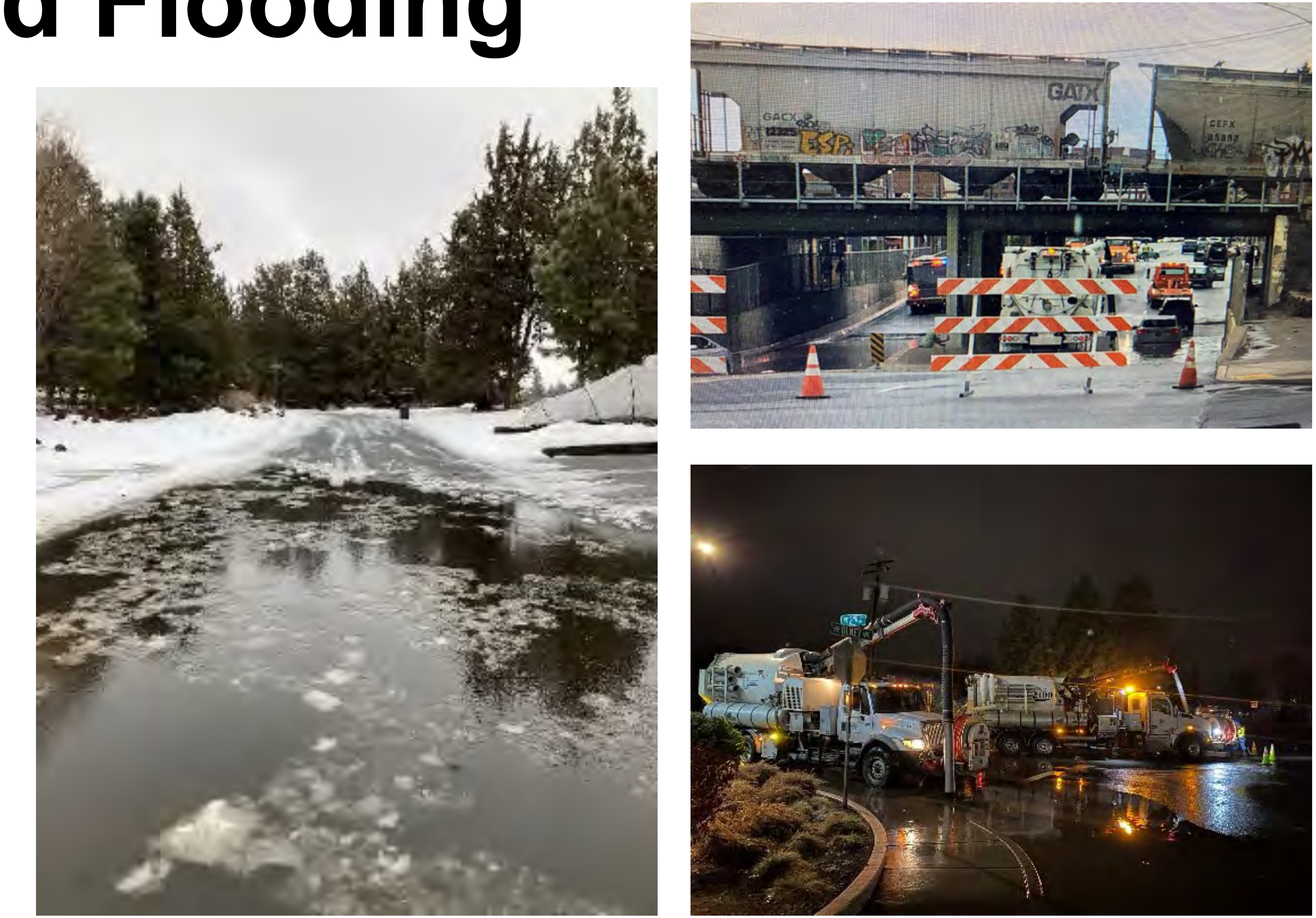
Problem Prioritization Topics

- Ponding and Flooding
- Erosion and Sediment
- Groundwater Quality
- Surface Water Quality

Ponding and Flooding

Main Issues

- Roadway safety
- Property damage
- Inconvenience
- Cost to respond



CITY OF BEND

Erosion and Sediment

Main Issues

- Property damage
- Clogging storm system
- Contributes to degradation of groundwater
- Contributes to degradation of surface water
- Contributes to ponding / flooding
- Cost of maintenance

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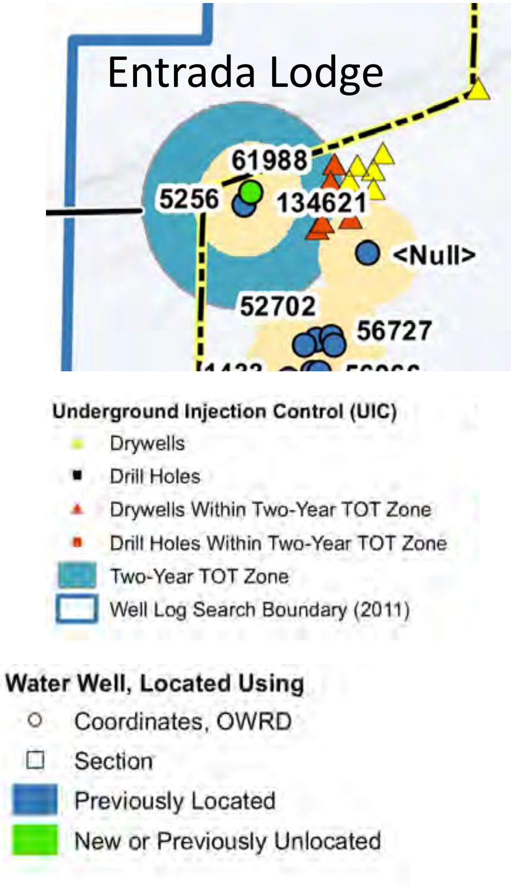
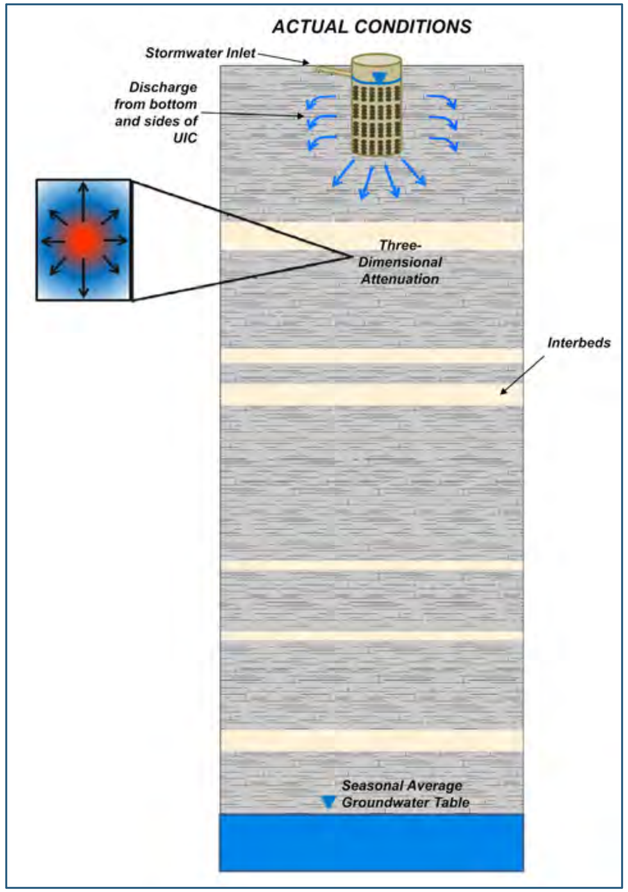
Groundwater Quality

Main Issues

- Safety of drinking water supply
- Compliance with WPCF Permit



Excerpt of Map – UICs within Setback to Wells



Conceptual Model for UIC Discharge in Bend

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Surface Water Quality

Main Issues

- Suitability of river for aquatic wildlife habitat
- Suitability of river for recreation and enjoyment
- Compliance with NPDES Permit
- Possibility of future regulation via TMDL

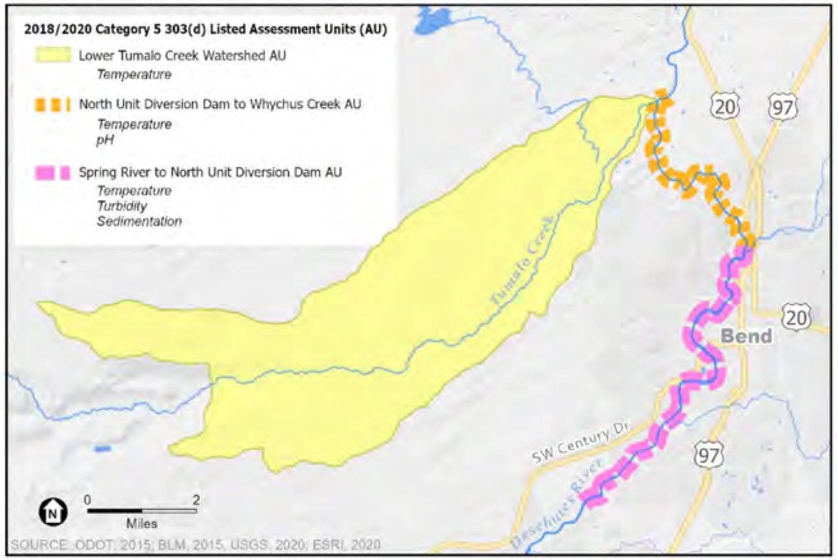

Figure 8. 2018/2020 Category 5 303(d) Listed Assessment Units (AU) for the Tumalo Creek

Figure 4. Example of the Deschutes River as it enters the City of Bend

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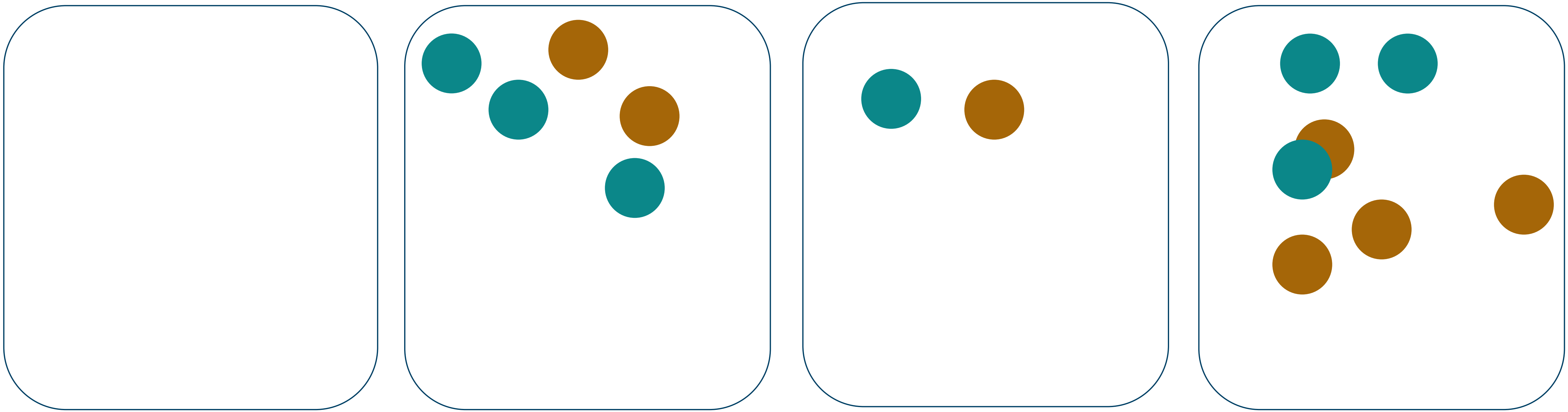
What is more important?

Use the bubbles to indicate your priorities. Green=1st priority. Orange=2nd priority.



Reducing ponding or flooding across the city

Protecting groundwater

Managing erosion and sediment

Protecting the Deschutes River

Solution Categories

1. Maintain/Repair Existing System

- Increase maintenance frequency
- Fix broken or degraded pipes
- Construct small structure to improve removal of pollutants before entry to drainage system
- Construct small structure to improve capacity of existing drainage system
- Replace failing UIC
- Reconfigure poorly performing swale

2. Install New Facilities

- Construct drainage system in neighborhood where none / little exists
- Build regional stormwater swales to manage runoff in focused redevelopment areas (e.g. Central District)

● ● ● ● ● ● ● ●

Which of the following is most important to you?

Please use a bubble to indicate your selection.

Maintenance, repair and replacement of existing facilities	New facilities to improve conveyance, groundwater and surface water quality
● ● ●	● ● ●

What is your top priority outcome from this SMP?

Use a box to briefly describe your thoughts.

Mitigating Erosion and Sediment as it applies to all 4 action items, Ponding, water quality, etc. Also consistency across the plan.

Preserving water quality and resource

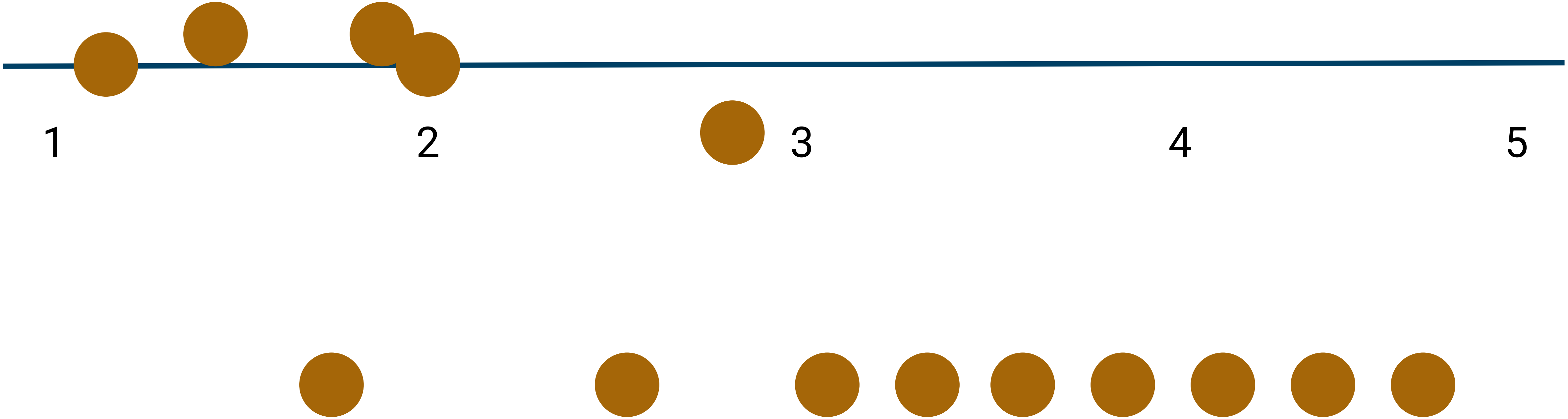
Stormwater management options that recognize we are moving toward urban dense development

Preserving water quality (surface and groundwater)
Stormwater reuse
Ecological approach to mitigating the effects of climate change.

I will +1 to everything the person to my left has written

STORMWATER FUNDING

How well informed do you feel about how we pay for stormwater management?
(With 1 being not at all and 5 being extremely well)



Stormwater Master Plan
Review and Input – Selected Topics

Modified Drywell Siting Criteria

Drillhole Decommissioning & Retrofit Prioritization Results

Capital Project Prioritization Criteria Discussion

CITY OF BEND

Stormwater Master Plan purpose and overview

- Update conveyance and drainage projects from 2014 Stormwater Master Plan
- Identify and assess new conveyance/drainage issues
- **Create a long-term plan for reducing risk to groundwater from drill holes and drywells (UICs)**
- Create a plan for improving the quality of runoff discharged to the Deschutes River through the City's outfalls
- **Develop a capital program incorporating conveyance/drainage projects, UIC retrofits, and outfall retrofits**

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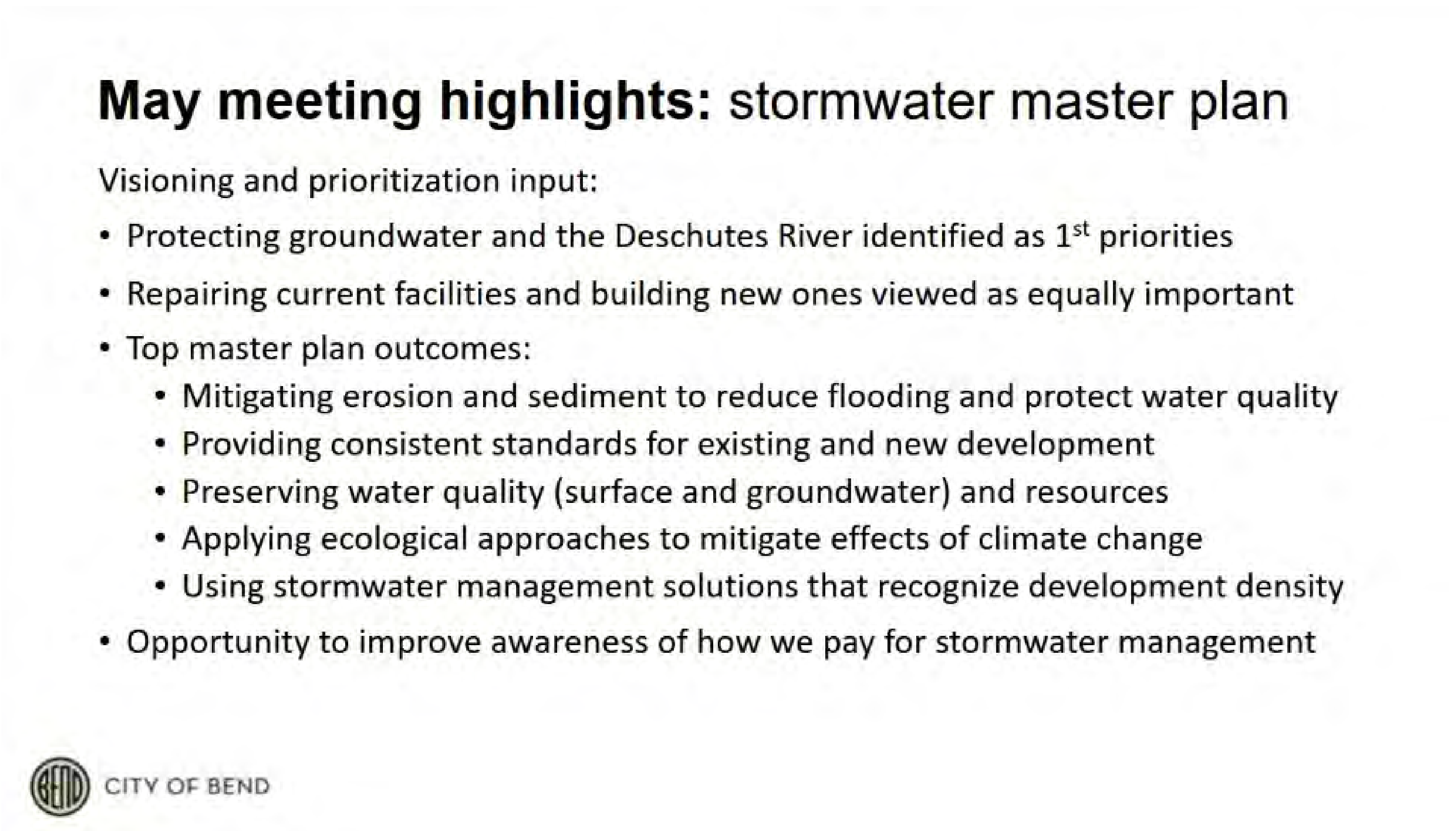
Stormwater Master Plan development and areas for UPAG input

- **Visioning – what is most important to you and the community?**
- Visioning – what is the story of stormwater in Bend?
- **Solution Priorities – how will we prioritize stormwater capital improvements?**
- Policy Solutions – what are the opportunities and impediments to regional facilities?
- Policy Solutions – what are the opportunities and impediments to managing runoff from private properties in the rights-of-way?
- Policy Solutions – how much emphasis on climate change in the next SMP?



May meeting highlights: stormwater master plan

Visioning and prioritization input:

- Protecting groundwater and the Deschutes River identified as 1st priorities
- Repairing current facilities and building new ones viewed as equally important
- Top master plan outcomes:
  - Mitigating erosion and sediment to reduce flooding and protect water quality
  - Providing consistent standards for existing and new development
  - Preserving water quality (surface and groundwater) and resources
  - Applying ecological approaches to mitigate effects of climate change
  - Using stormwater management solutions that recognize development density
- Opportunity to improve awareness of how we pay for stormwater management

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UPAG focus questions

- Do the Modified Drywell Siting Criteria provide enough flexibility to add Modified Drywells to the stormwater toolbox in a variety of development scenarios?
- The process for ranking drillholes for decommissioning or replacement has identified 17 high priority locations. How quickly do you think the City should attempt to work through these locations? 5 years, 10 years, 15 years, 20 years?
- We are seeking a robust discussion of draft capital project rating criteria with UPAG. We will ask for your feedback on:
  - Relative total score available in each category
  - Relative maximum score of each criterion within a category
  - General concurrence with the scoring approach

Modified Drywell Siting Criteria

Refer to attached technical memorandum, Sections 1 & 2

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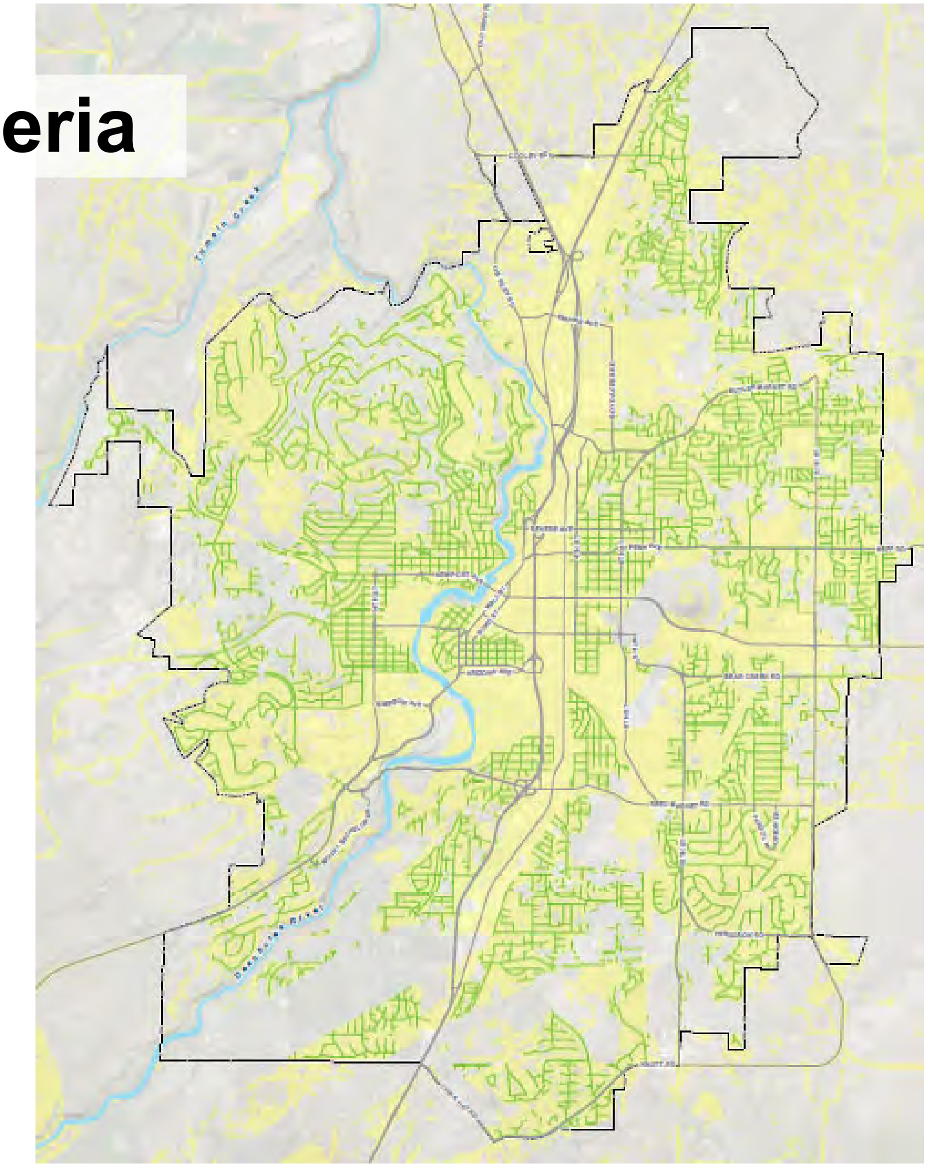
Modified Drywell Siting Criteria

- Modified drywell definition
- Advantages
- Disadvantages / risks
- Risk mitigation
- Recommended siting criteria
  - Default approval areas
  - Approval with additional mitigation and review



CITY OF BEND

Discussion and Feedback

- Do the Modified Drywell Siting Criteria provide enough flexibility to add Modified Drywells to the stormwater toolbox in a variety of development scenarios?

Drillhole Prioritization

Refer to attached technical memorandum, Sections 1 & 3

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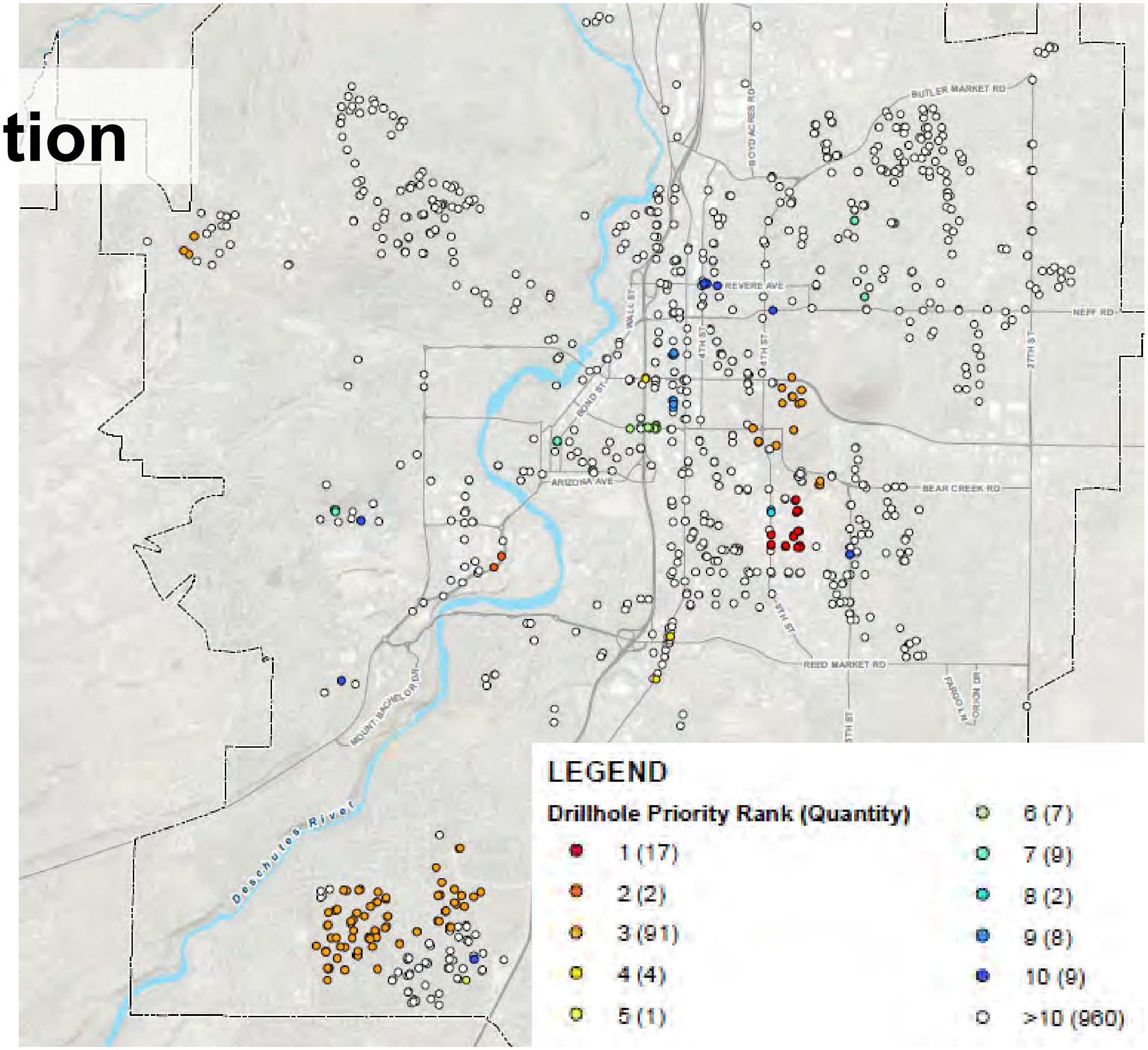
Drillhole Prioritization

- Drillhole definition
- Current status of drillholes in City
- Intent of prioritization
- Prioritization factors
- Results



Discussion and Feedback

- How quickly do you think the City should attempt to work through the 17 high priority locations?
  - 5 years, 10 years, 15 years, 20 years?

Capital Project Prioritization Criteria

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Relative Category Scores

Category	Maximum Score	Discussion
Conveyance and Flooding	10	
Water Quality Improvements	20	More points available due to UPAG emphasis on water quality during the May meeting
Multiple Benefits	15	
Recognized Priority Projects	15	
Feasibility and Cost	10	
Total Points Available	**70**	

Discussion and Feedback

- Do you agree with the relative total score available in each category?
  - This provides a macro level of prioritization and answers the question: which of the categories is most important?
- Do you agree with the relative maximum score of each criterion within a category?
  - This allows us to compare the importance of the criteria against each other within a category.
  - It provides a more nuanced level of prioritization and answers the question: within each category, which factors are most and least important?
- Any general comments or questions?

Stormwater Master Plan

Review and Input – Selected Topics

Capital Project Prioritization Criteria Discussion

Outfall Retrofit Needs Assessment

CITY OF BEND

Stormwater Master Plan purpose and overview

- Update conveyance and drainage projects from 2014 Stormwater Master Plan
- Identify and assess new conveyance/drainage issues
- Create a long-term plan for reducing risk to groundwater from drill holes and drywells (UICs)
- **Create a plan for improving the quality of runoff discharged to the Deschutes River through the City's outfalls**
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Stormwater Master Plan development and areas for UPAG input

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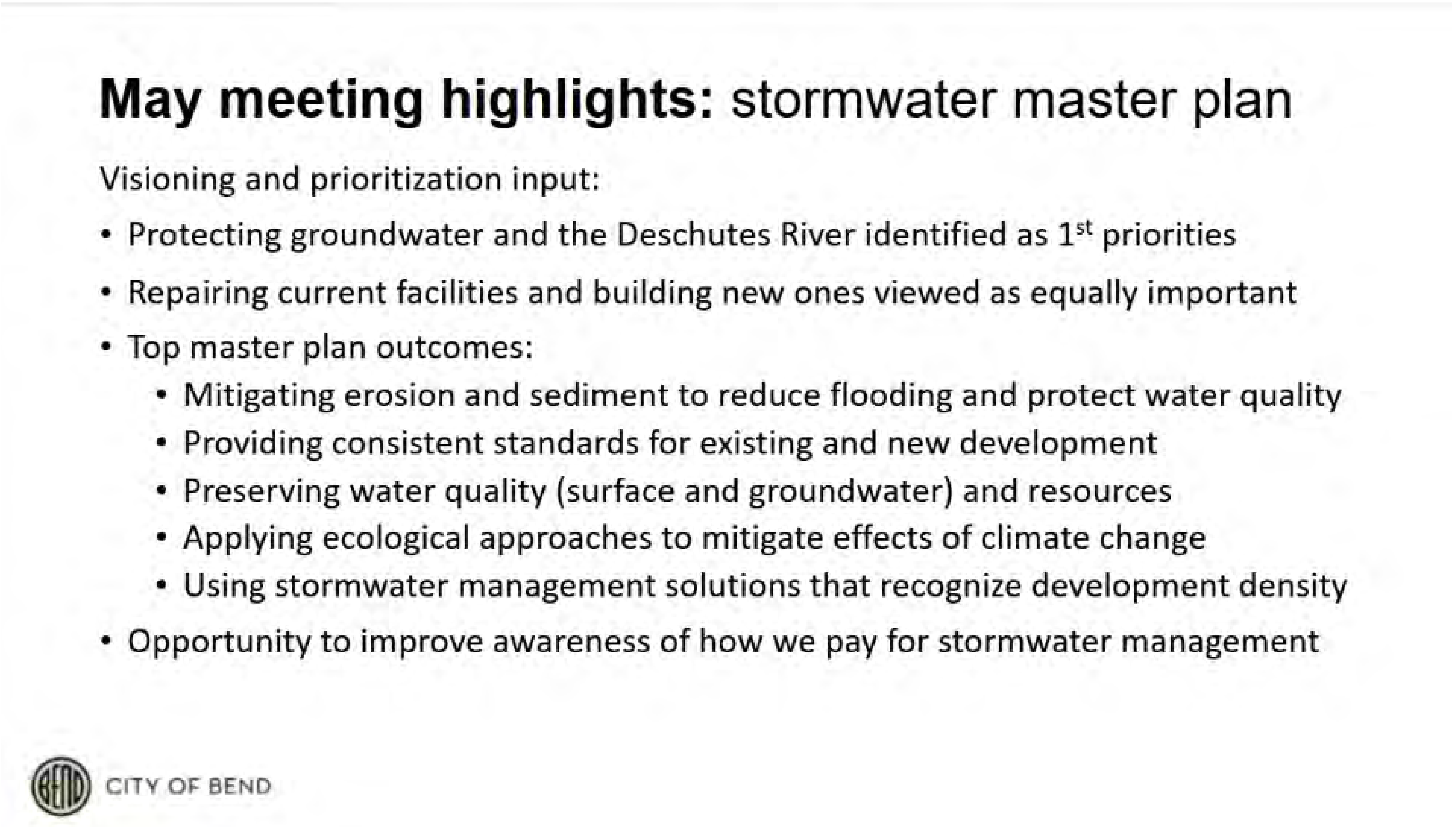

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  - Preserving water quality (surface and groundwater) and resources
  - Applying ecological approaches to mitigate effects of climate change
  - Using stormwater management solutions that recognize development density
- Opportunity to improve awareness of how we pay for stormwater management

CITY OF BEND

UPAG focus questions

- We are seeking a robust discussion of draft capital project rating criteria with UPAG. We will ask for your feedback on:
  - Relative total score available in each category
  - Relative maximum score of each criterion within a category
  - General concurrence with the scoring approach
- Does the prioritization approach for outfall retrofits make sense?

Capital Project Prioritization Criteria

CITY OF BEND

Relative Category Scores

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Feasibility and Cost	10	
Total Points Available	**70**	

Discussion and Feedback

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    - It provides a more nuanced level of prioritization and answers the question: within each category, which factors are most and least important?
- Any general comments or questions?

Outfall Retrofit Needs Assessment

Refer to attached technical memorandum

Outfall Retrofit Needs Assessment

- What is an Outfall Retrofit?
- Where are the outfalls?
- Goals
- Needs Assessment Criteria
  - Untreated Area
  - Pollutant Load
  - Sediment Load
  - Related Known Issues
- Prioritized Outfalls

Newport Outfalls Retrofits

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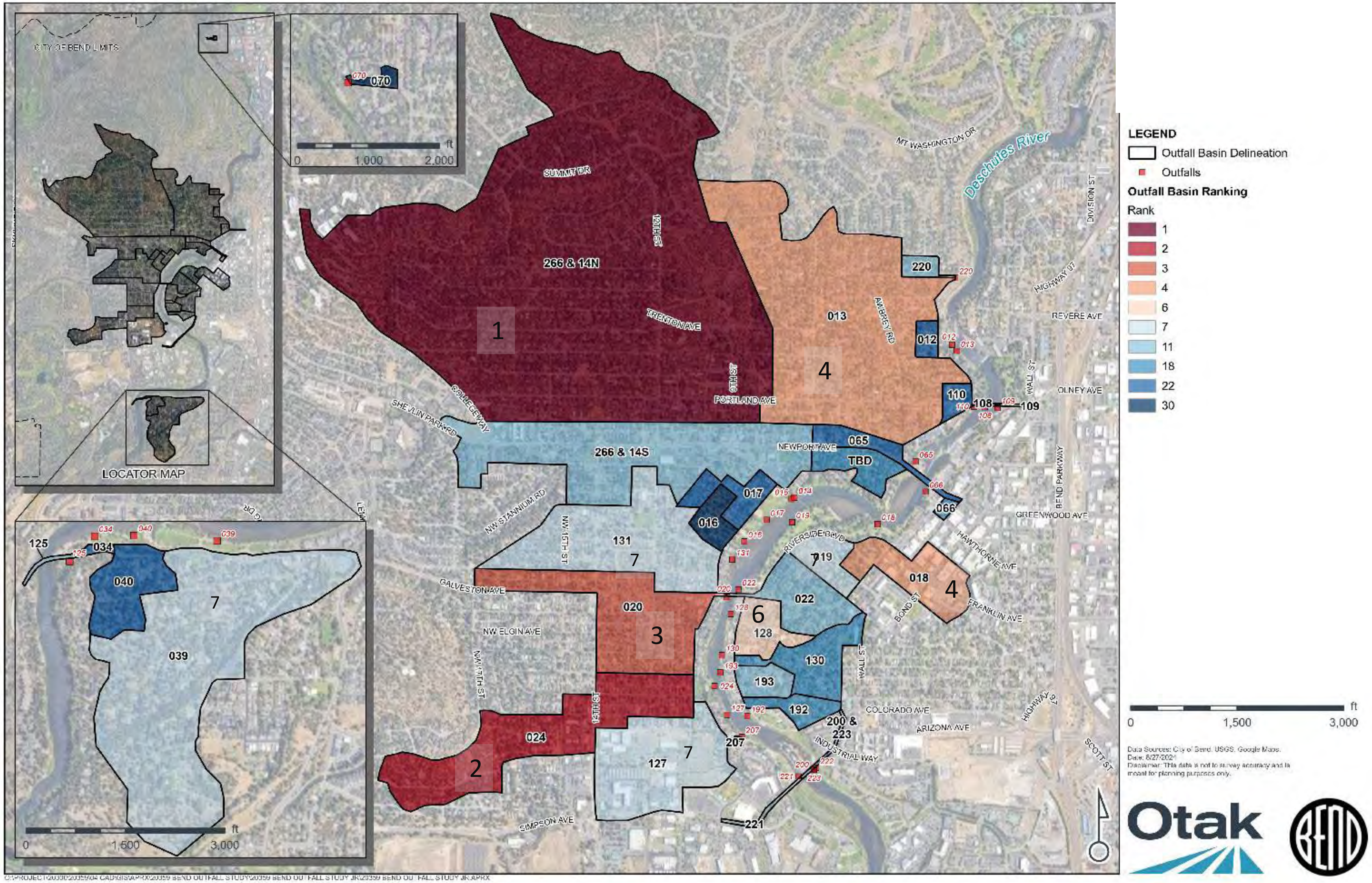
Prioritized Outfalls



Data Sources: City of Bend, USGS, Google Maps.
Date: 8/27/2024
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

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Discussion and Feedback

- Does the prioritization approach for outfall retrofits make sense?

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Utilities Public Advisory Group

October 2, 2024 • 11 am–12:30 pm

Hybrid Meeting • MS Teams or Bend Utilities Department Deschutes Conference Room

Lori Faha, P.E., Environmental Resources Manager
Elisabeth O'Keefe, Stormwater Program Manager
Austin Somhegyi, PE, Stormwater Master Plan Project Manager
Trista Kobluskie, Stormwater Master Plan Consultant Lead
Anna Murphy & Daniele Spirandelli, Stormwater Master Plan Consultant Team
Aubrie Koenig, Facilitator

Purpose & Agenda

Discuss and collect input on potential climate-related recommendations in Stormwater Master Plan and share master plan progress updates and stormwater program regulatory updates.

1. Introduction
2. Stormwater Master Plan & Climate Change
3. Stormwater Master Plan Updates
    - CIP Prioritization Criteria
    - Drillhole and Outfall Prioritization
4. Stormwater Regulatory Updates
    - Updated UIC Standards
    - Erosion Control Requirements
5. UPAG Discussion
6. Summary and Closing

September meeting reflections: Stormwater Master Plan capital project prioritization criteria feedback

- **Conveyance and flooding:** suggest increased weighting for flooding to capture known public safety hazards (e.g., ice following downtown winter flooding)
- **Water quality improvements:** support current weightings with higher emphasis on subcategory for protection of groundwater as a drinking water source
- **Multiple benefits:**
  - Consider modifying/adding line item(s) to reflect ecological services, improved recreation/access to green spaces, community greening and aesthetics, and/or related subcategories not currently captured
  - Potentially weight all subcategories equally or consider one weighting for people benefit and one for infrastructure benefit subcategories
- **Recognized priority projects:** support having category that reflects staff's operational knowledge of known issues in the field
- **Feasibility and cost:** support for current weighting and subcategories

Stormwater Master Plan

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Stormwater Master Plan purpose and overview

- Update conveyance and drainage projects from 2014 Stormwater Master Plan
- Identify and assess new conveyance/drainage issues
- Create a long-term plan for reducing risk to groundwater from drill holes and drywells (UICs)
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- Develop a capital program incorporating conveyance/ drainage projects, UIC retrofits, and outfall retrofits

Stormwater Master Plan development and areas for UPAG input

- Visioning – what is most important to you and the community?
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- Policy Solutions – how much emphasis on climate change in the next SMP?

Stormwater Master Plan & Climate Change

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Bend Stormwater Master Plan

Climate Change Review

Anna Murphy and Daniele Spirandelli

Projected Climate Changes in Bend

Increases (~6%) in overall annual precipitation by 2100	Less precipitation: April – October More precipitation: December – March More rain and less snow in winter
Increase in frequency and intensity of storms	Especially during winter months Increased intensity of atmospheric rivers
Decline in snowpack	Decrease in overall mountain snowpack Earlier snowmelt means decreased streamflow in summer
Increased severity and duration of drought	Increased annual number of dry days (from 186 in 1990s to 192 by 2050)

Source: Oregon Watershed Enhancement Board. (September 2023). *Region 4 Observed & Projected Climate Changes.*
https://www.oregon.gov/oweb/Documents/climate-R4-variables.pdf

Climate Change Challenges to Bend’s Stormwater System

Inappropriately sized design storms for existing conditions

Climate change causing increased intensity and frequency of storm events

Drier summer impacts on water quality

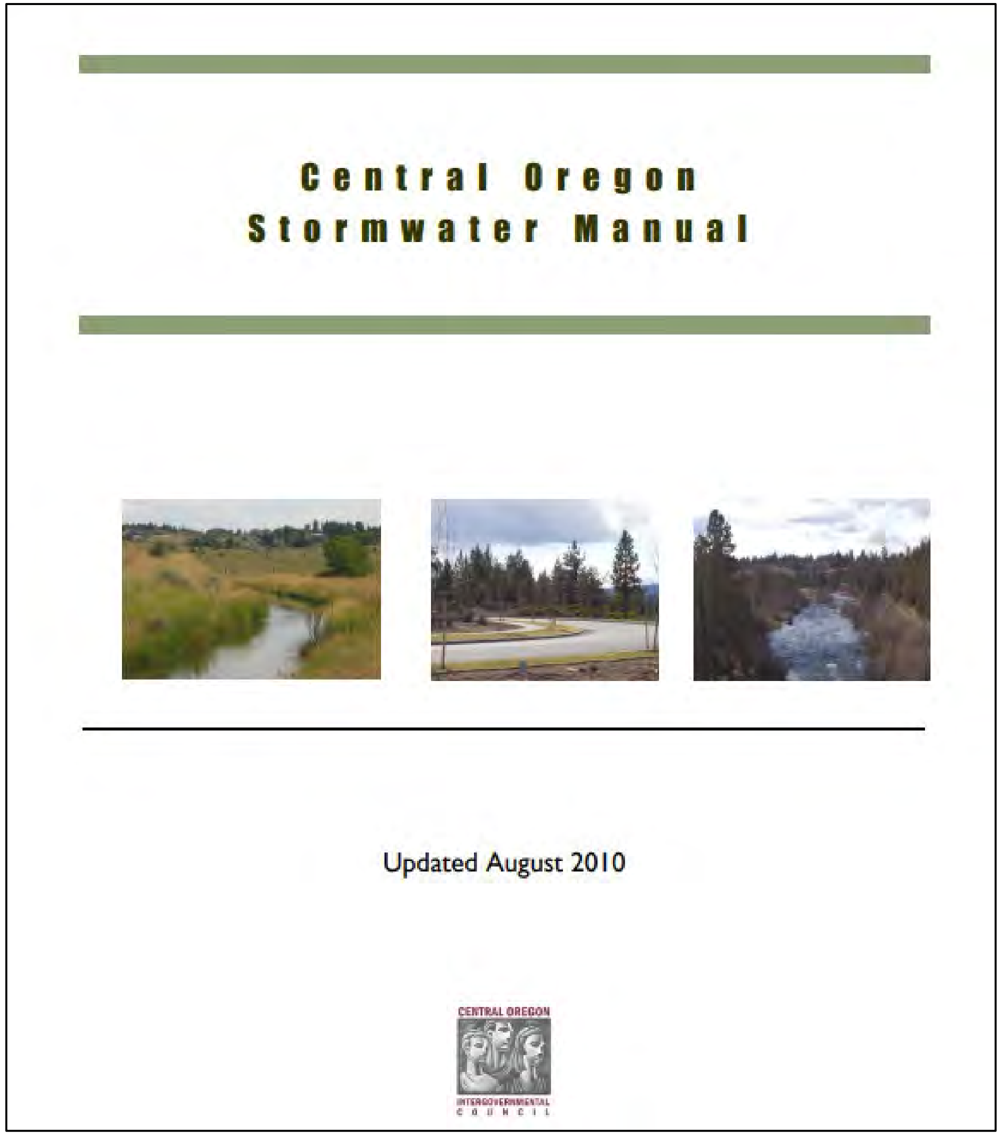
Sedimentation from winter road sanding

Winter precipitation and ice storms clogging drain inlets and causing flooding

Increasing rapid urban development exacerbating impacts

Design Guidelines and Rainfall Data

- Current design storms
  - Water Quality: 6-month 24-hour storm
  - Flow Control: 25-year 24-hour storm with safe overflow to convey 100-year storm
- NOAA Atlas 2
  - Last updated in 1973
  - Atlas 14 is not available for Oregon, Idaho, Montana, Washington, Wyoming
- Stormwater design standards assume historical rainfall intensity, frequency and duration
- Recent studies indicate storms are expected to become more severe
- Need to incorporate climate projections into design storms



Central Oregon Stormwater Manual

Updated August 2010

CENTRAL OREGON INTERGOVERNMENTAL COUNCIL

Sources: Central Oregon Intergovernmental Council. (2010). *Central Oregon Stormwater Manual.* https://www.coic.org/stormwater/

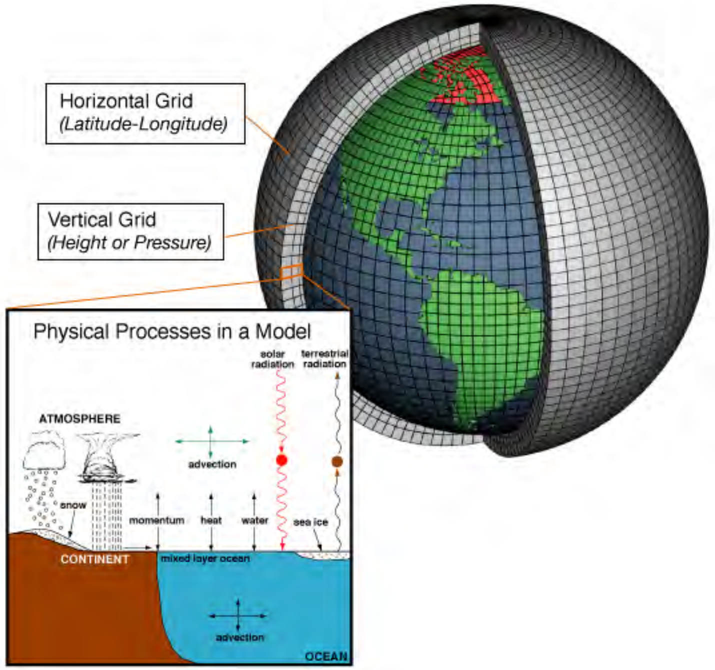
Sommer, Lauren. (2022, Feb 9). An unexpected item is blocking cities' climate change prep: obsolete rainfall records. *NPR/OPB.* NPR-Obsolete Rainfall Records

Source: Hathaway et. al. (2023). A synthesis of climate change impacts on stormwater management systems: designing for resiliency and future challenges. DOI: 10.1061/JSWBAY.SWENG-533.

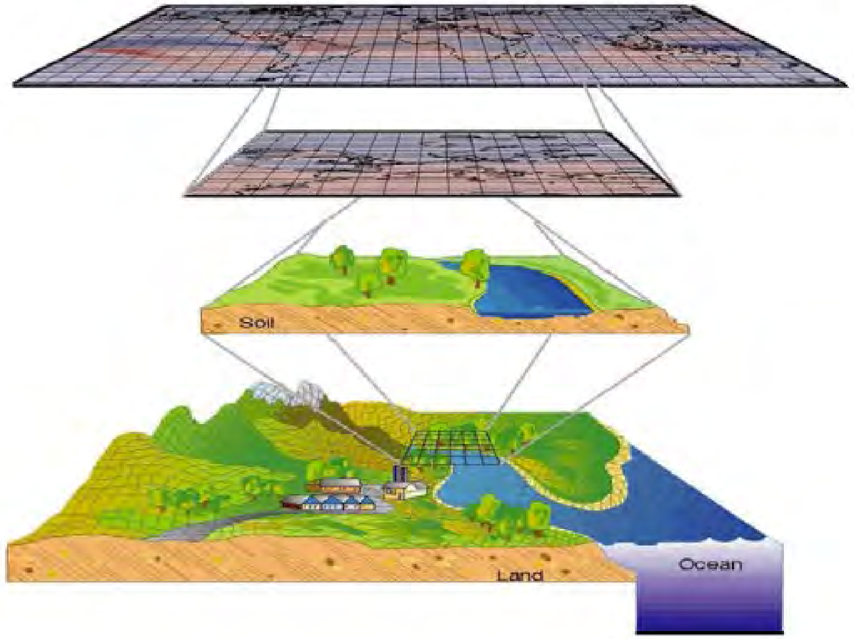
Global Climate Models

- Global models simulate future climate given set of scenarios
  - Scenarios of greenhouse gases, aerosols, assumptions of land use change
  - Most recent CMIP6 models (2024) associated with IPCC 6th Assessment Report
  - Models get downscaled for local & regional impact assessments

Global Models



Regional Models

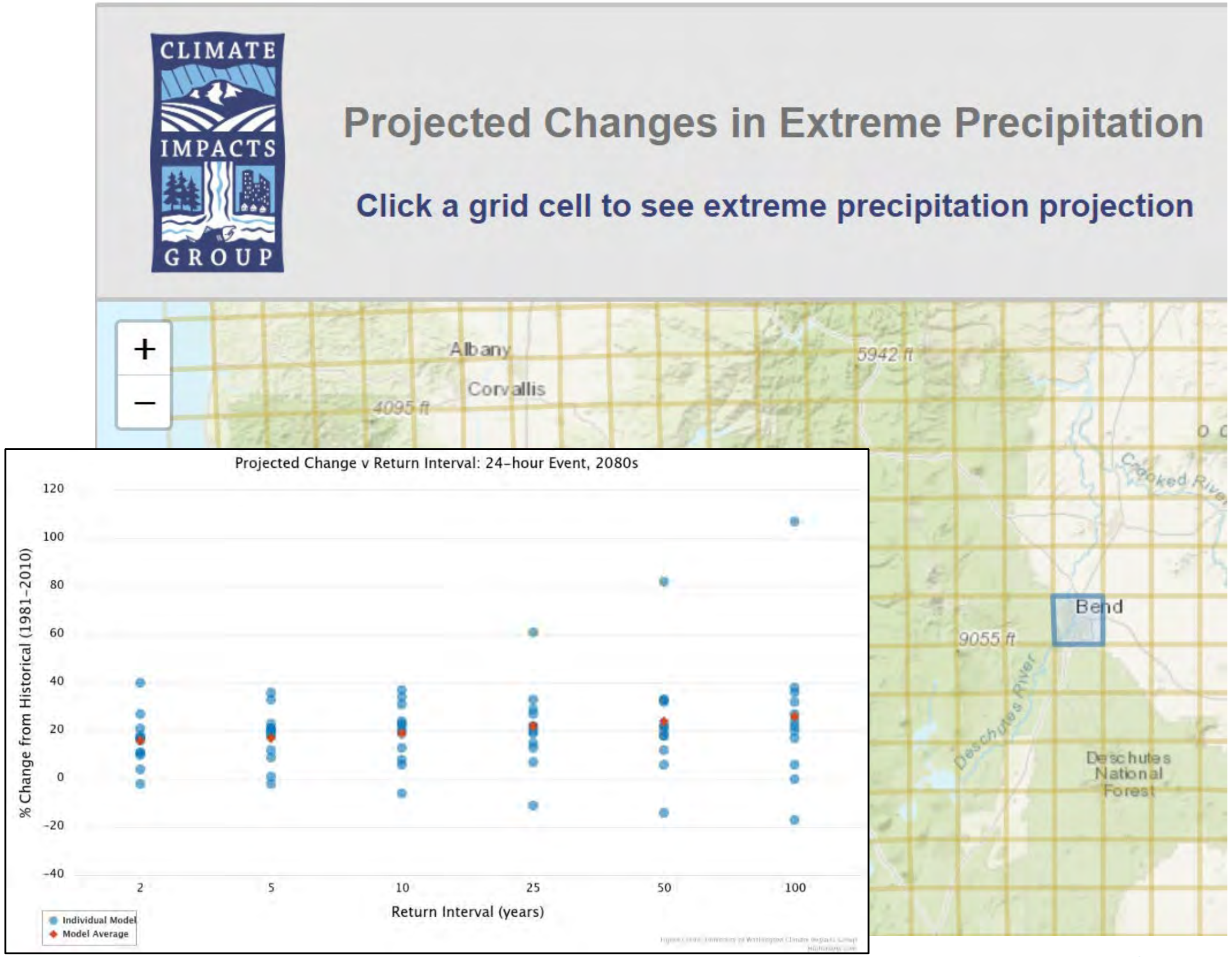


Khan and Pilz (2018)

Source: NOAA Climate.gov. (2024). Climate Models. https://www.climate.gov/maps-data/climate-data-primer/predicting-climate/climate-models#:~:text=Climate%20models%2C%20also%20known%20as,the%20ocean%2C%20atmosphere%2C%20land.

University of Washington, Projected Changes in Extreme Precipitation

- Analysis covers Oregon, Washington, Idaho and portions of Montana, Wyoming, Utah, Nevada, and southwestern Canada
- 10 different climate models plus all-model average
- CMIP5 Dynamic downscaling
- 12 km^2 resolution, Model years: 1980-2099
- Business-as-usual greenhouse gas emissions scenario (i.e. RCP8.5)
- This data used climate model output to calculate the projected change (2030s-2080s) in duration and return interval of storms



Projected Changes in Extreme Precipitation

Click a grid cell to see extreme precipitation projection

Source: Morgan, H., Mauger, G., Won, J., Gould, D. 2021 *Projected Changes in Extreme Precipitation Web Tool.* University of Washington Climate Impacts Group. https:/doi.org/10.6069/79CV-4233

Case Study: City of Virginia Beach DPW

Scenario:

- Study assessed changes in heavy rainfall frequency and intensity using historical observations and future projections following 3 large storms in 2016 led to 33 inches of rain over 6 weeks, and heavy flooding.
- Atlas 14 precipitation values were found to be 7-10% below observed precipitation data from local rain gauges.
- Projections of the 10-year storm event showed an increase in precipitation of 24-27% from 2000 to 2060 for RCP 8.5 scenario.

Outcome:

- City recommended 20% increase in extreme precipitation based on combination of historical data and projections to 2060 for RCP8.5 assuming a 40-year life for infrastructure
- Revised design guidelines increase Atlas 14 design storm rainfall depths by 20% and require the use of dynamic (SWMM) modeling for design and analysis of pre vs post development conditions

Source: Water Utility Climate Alliance. (2022). Scaling and Application of Climate Projections to Stormwater and Wastewater Resilience Planning. https://www.wucaonline.org/assets/pdf/stormwater-wastewater-report-2022.pdf

Key Takeaways and Recommendations

- Build accurate historical rainfall data:
  - Increase data collection with more gauges
  - Build a robust monitoring network.
- Integrate climate change precipitation with downscaled data
- Update design standards; requires time, expertise, and resources.
- An interim approach and prioritization of key projects based on city objectives can help where resources are limited.
- Combine multiple approaches, both quantitative and qualitative.
- Work regionally, across jurisdictions, with universities and Federal agencies to pool resources and coordinate research.
- The science and data is continually evolving and improving. Now is the time to begin!

HALEY ALDRICH

Next Steps and Areas of Further Research

- Evaluate rain gauge network and historical precipitation data for right-sizing stormwater and predicting localized flooding
- Study comparable cities in the PNW that have updated storm data
- Study creative ways to increase storage
  - i.e. easements for storage on private properties
- Study how to incorporate climate change data into regional stormwater design standards

Funding Sources for Climate Change Impact Assessment

Federal

- FEMA - Building Resilient Infrastructure for Communities (BRIC) Grants
- USDOT - Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation Program (PROTECT) Grants
- EPA - Community Change Grants
- EPA - Water Infrastructure Finance and Innovation Act (WIFIA) Loans
- US Bureau if Reclamation - WaterSMART Applied Science Grants

State

- DLCD - Community Green Infrastructure Grant Program

Philanthropic

- The Funders Network - Urban Water Funders
- National Fish and Wildlife Foundation - America the Beautiful Challenge

UPAG discussion

- Do you think there is a need for climate-related policy or program recommendations in the Stormwater Master Plan?

Stormwater Master Plan Updates

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Relative Category Scores

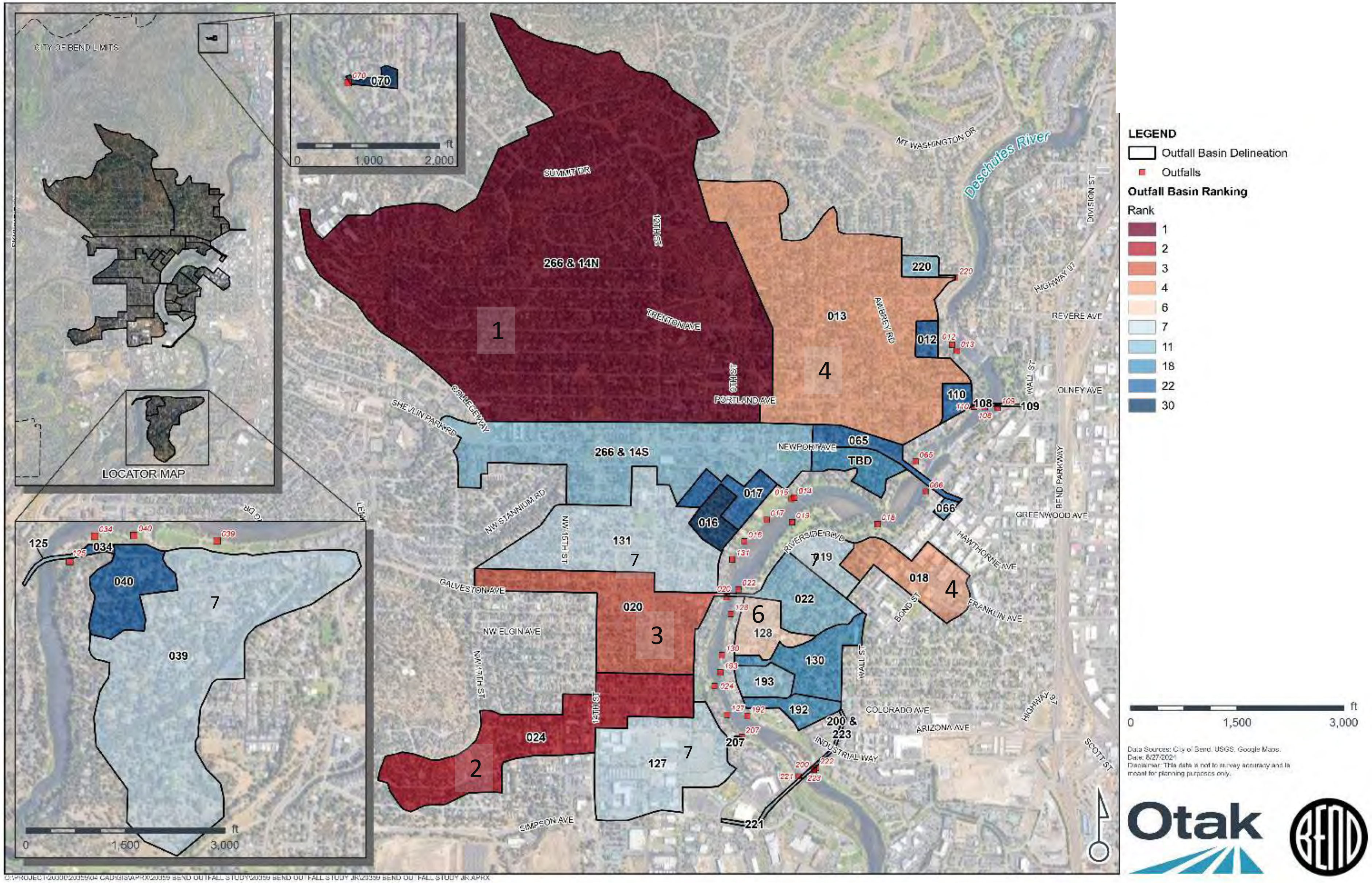
Category	Max Score	Discussion
Conveyance and Flooding	20	• Increased from 10 to 20 points
Water Quality Improvements	20	
Multiple Benefits	20	• Projects unlikely to receive all 20 points • Includes a new "Green Infrastructure / Ecosystem Services" criterion which gives points to projects that may have an above-ground vegetated facility • Exact scoring criteria and terminology for "Increases Equitable Distribution of Public Assets" criterion will be discussed with Long Range Planning before solidifying language
Recognized Priority Projects	10	• Reduced from 15 to 10 points • UPAG priority criterion removed because we will seek UPAG input on final project ordering later in the planning process
Feasibility and Cost	10	
Total Points Available	**80**	

Outfall Retrofit Needs Assessment

- What is an Outfall Retrofit?
- Outfalls have been prioritized for further investigation to find opportunities to add water quality treatment facilities.
- Outfalls that serve a larger area, handle runoff from more polluting land uses, may be susceptible to sedimentation, and have known capacity or structural issues in their drainage systems have been prioritized.
- Does the approach make sense?

Newport Outfalls Retrofits

Prioritized Outfalls



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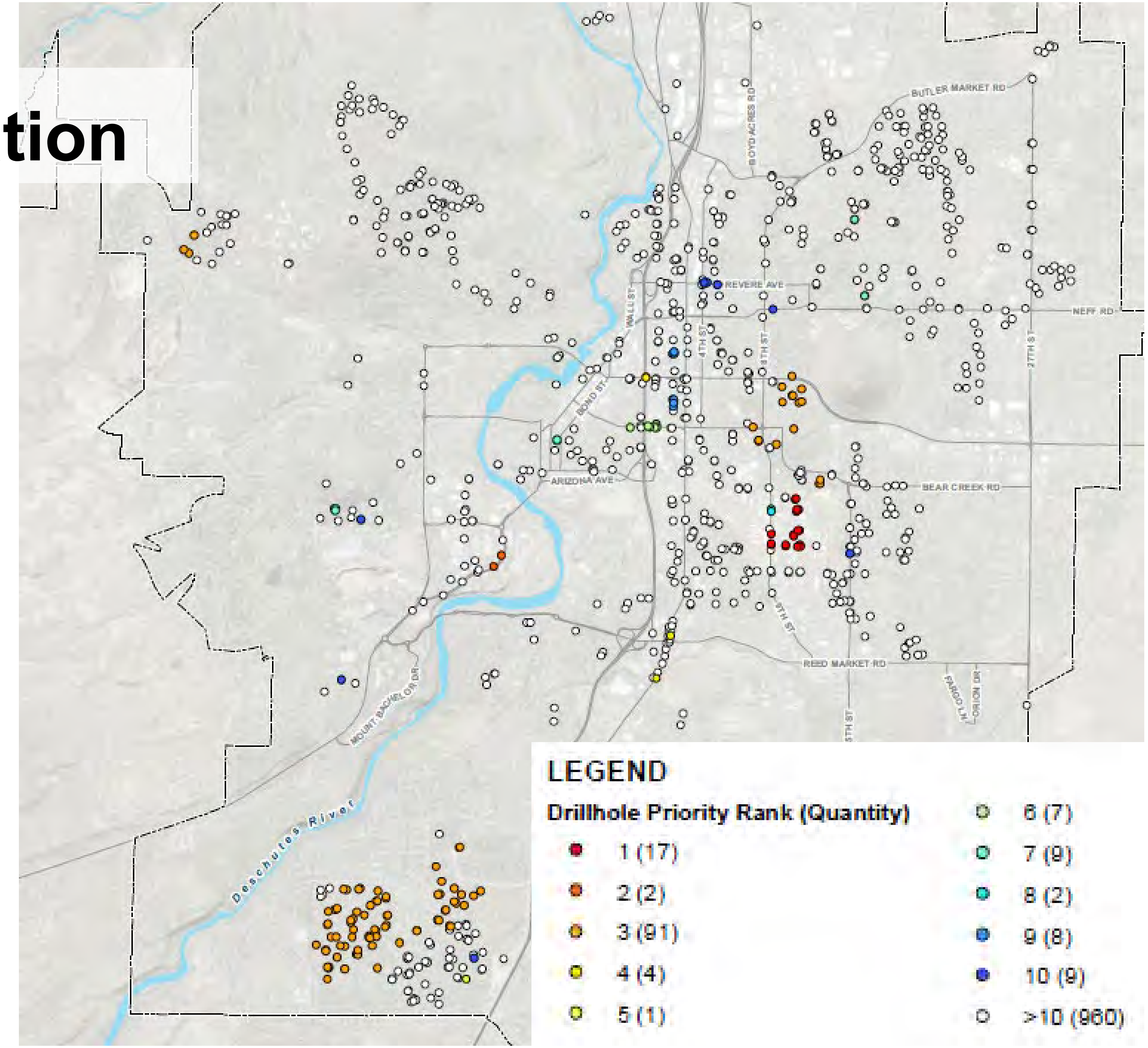
Drillhole Prioritization

- What is a drillhole?
- Drillholes have been prioritized for retrofit or decommissioning if they pose a risk to groundwater, already are failing or structurally compromised, and/or are located where spills or high pollution is likely.
- There are 17 high-priority drillholes. How quickly should the City address them? 5 years? 10 years? 20 years?



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UPAG focus questions

- Do you have any questions about the updated CIP prioritization criteria?
- How quickly should the City address the 17 high priority drillholes? 5 years? 10 years? 20 years?
- Does the outfall prioritization approach make sense to you?

Stormwater Program Regulatory Update

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Underground Injection Control (UIC) Specifications Update

City discussing modified deep drywells in certain locations using tech memo and UPAG subcommittee input	May involve a formal exception process with technical justification and additional spill control in certain locations
Update for all UIC standards (traditional drywells and modified):	Calendar year 2025

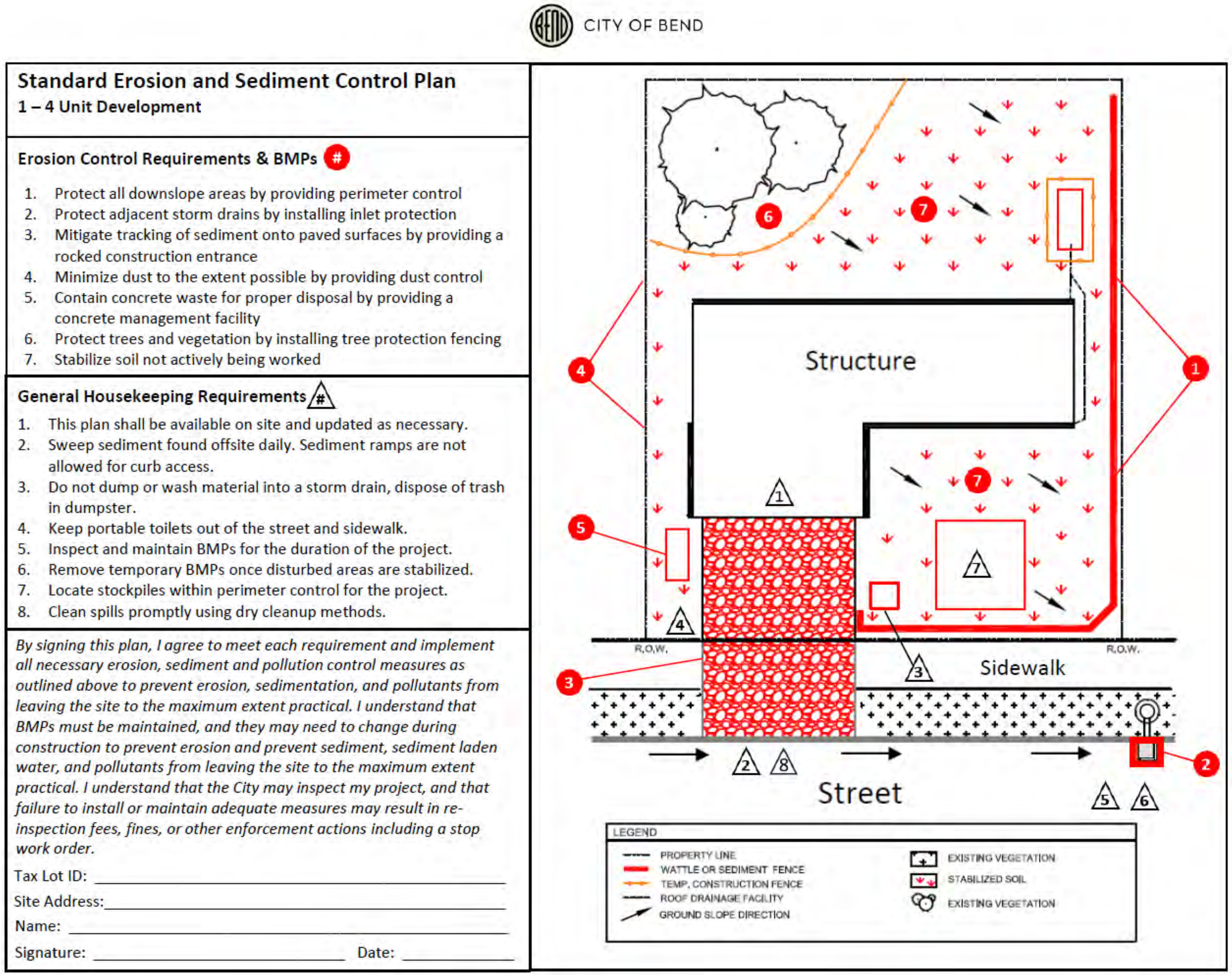
Small Construction Site Erosion Control

DEQ stormwater permit requirement for all projects with $\geq$ 5,000 sq ft of land disturbance

- Nov 1, 2024 implementation deadline
- City Code updated in August 2024
  - Applies to development not already under the existing grading permit process (single family and 1-4 unit housing)
- **CityView building permit process changes effective Nov 1, 2024**

Small Site Erosion Control Plan

- Template provided by the City
- Sign and submit with (1-4 unit) building permit application packets



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Standard Erosion and Sediment Control Plan

1 – 4 Unit Development

Erosion Control Requirements & BMPs

1. Protect all downslope areas by providing perimeter control
2. Protect adjacent storm drains by installing inlet protection
3. Mitigate tracking of sediment onto paved surfaces by providing a rocked construction entrance
4. Minimize dust to the extent possible by providing dust control
5. Contain concrete waste for proper disposal by providing a concrete management facility
6. Protect trees and vegetation by installing tree protection fencing
7. Stabilize soil not actively being worked

General Housekeeping Requirements

1. This plan shall be available on site and updated as necessary.
2. Sweep sediment found offsite daily. Sediment ramps are not allowed for curb access.
3. Do not dump or wash material into a storm drain, dispose of trash in dumpster.
4. Keep portable toilets out of the street and sidewalk.
5. Inspect and maintain BMPs for the duration of the project.
6. Remove temporary BMPs once disturbed areas are stabilized.
7. Locate stockpiles within perimeter control for the project.
8. Clean spills promptly using dry cleanup methods.

By signing this plan, I agree to meet each requirement and implement all necessary erosion, sediment and pollution control measures as outlined above to prevent erosion, sedimentation, and pollutants from leaving the site to the maximum extent practical. I understand that BMPs must be maintained, and they may need to change during construction to prevent erosion and prevent sediment, sediment laden water, and pollutants from leaving the site to the maximum extent practical. I understand that the City may inspect my project, and that failure to install or maintain adequate measures may result in re-inspection fees, fines, or other enforcement actions including a stop work order.

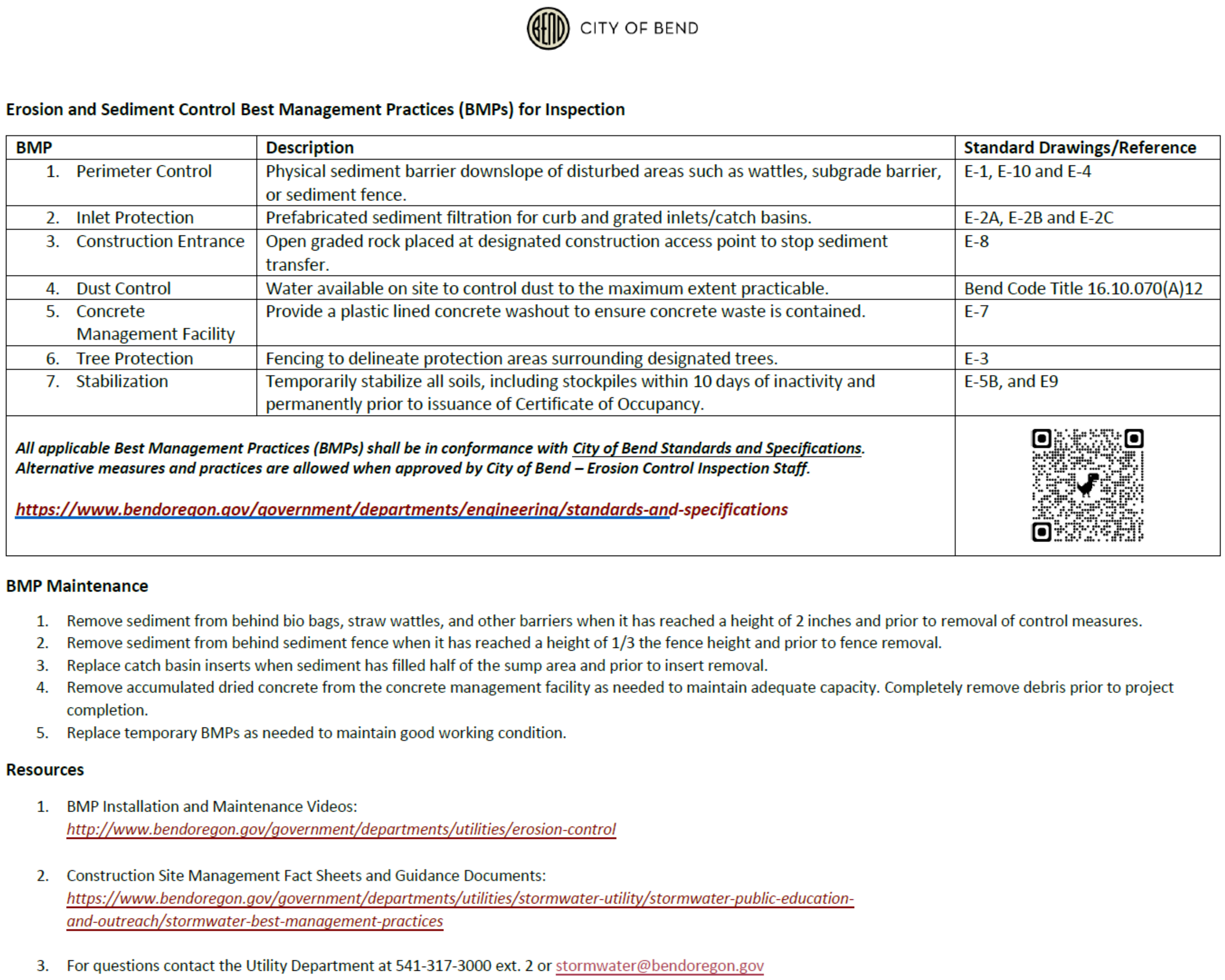
Tax Lot ID: ____________________

Site Address: ____________________

Name: ____________________

Signature: ____________________ Date: __________

Small Site Erosion Control Plan



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Erosion and Sediment Control Best Management Practices (BMPs) for Inspection

BMP	Description	Standard Drawings/Reference
1. Perimeter Control	Physical sediment barrier downslope of disturbed areas such as wattles, subgrade barrier, or sediment fence.	E-1, E-10 and E-4
2. Inlet Protection	Prefabricated sediment filtration for curb and grated inlets/catch basins.	E-2A, E-2B and E-2C
3. Construction Entrance	Open graded rock placed at designated construction access point to stop sediment transfer.	E-8
4. Dust Control	Water available on site to control dust to the maximum extent practicable.	Bend Code Title 16.10.070(A)12
5. Concrete Management Facility	Provide a plastic lined concrete washout to ensure concrete waste is contained.	E-7
6. Tree Protection	Fencing to delineate protection areas surrounding designated trees.	E-3
7. Stabilization	Temporarily stabilize all soils, including stockpiles within 10 days of inactivity and permanently prior to issuance of Certificate of Occupancy.	E-5B, and E9

All applicable Best Management Practices (BMPs) shall be in conformance with City of Bend Standards and Specifications.
Alternative measures and practices are allowed when approved by City of Bend – Erosion Control Inspection Staff.

https://www.bendoregon.gov/government/departments/engineering/standards-and-specifications

BMP Maintenance

1. Remove sediment from behind bio bags, straw wattles, and other barriers when it has reached a height of 2 inches and prior to removal of control measures.
2. Remove sediment from behind sediment fence when it has reached a height of 1/3 the fence height and prior to fence removal.
3. Replace catch basin inserts when sediment has filled half of the sump area and prior to insert removal.
4. Remove accumulated dried concrete from the concrete management facility as needed to maintain adequate capacity. Completely remove debris prior to project completion.
5. Replace temporary BMPs as needed to maintain good working condition.

Resources

1. BMP Installation and Maintenance Videos:
   http://www.bendoregon.gov/government/departments/utilities/erosion-control

2. Construction Site Management Fact Sheets and Guidance Documents:
   https://www.bendoregon.gov/government/departments/utilities/stormwater-utility/stormwater-public-education-and-outreach/stormwater-best-management-practices

3. For questions contact the Utility Department at 541-317-3000 ext. 2 or stormwater@bendoregon.gov

CityView Building Permits


9/11/24, 11:06 AM

Lot size triggers new requirement

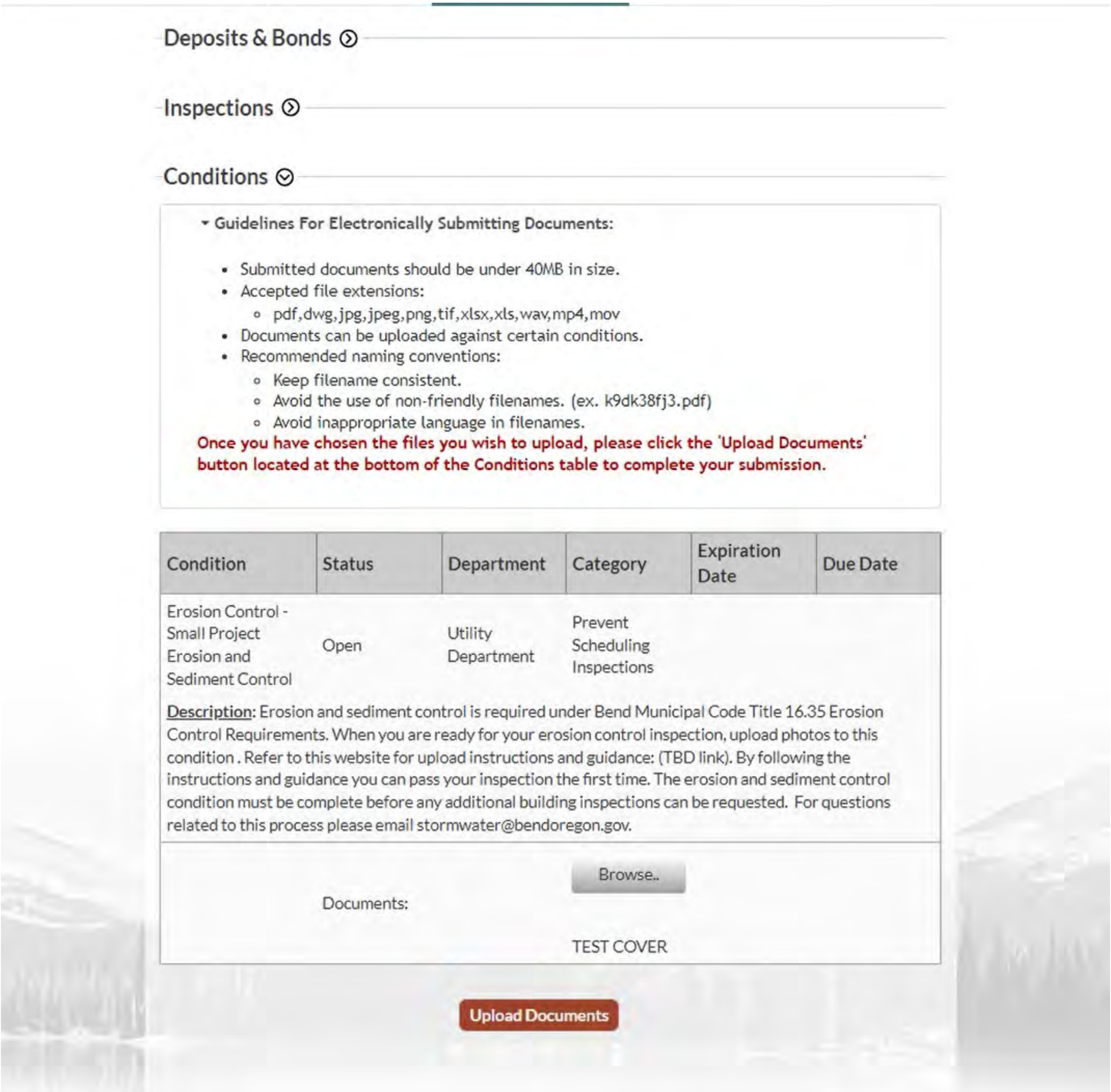
Condition under building permit to submit erosion control Best Management Practice (BMP) photos for City review (virtual inspection)

Condition must be approved before building inspections can be requested (footings/foundation).

1 onsite inspection later in the project

No new permit fees, additional inspection fees for escalated enforcement

CityView Building Permit Condition (draft)



▾ **Guidelines For Electronically Submitting Documents:**

- Submitted documents should be under 40MB in size.
- Accepted file extensions:
  - pdf,dwg,jpg,jpeg,png,tif,xlsx,xls,wav,mp4,mov
- Documents can be uploaded against certain conditions.
- Recommended naming conventions:
  - Keep filename consistent.
  - Avoid the use of non-friendly filenames. (ex. k9dk38fj3.pdf)
  - Avoid inappropriate language in filenames.

Once you have chosen the files you wish to upload, please click the 'Upload Documents' button located at the bottom of the Conditions table to complete your submission.

Condition	Status	Department	Category	Expiration Date	Due Date
Erosion Control - Small Project Erosion and Sediment Control	Open	Utility Department	Prevent Scheduling Inspections		

Description: Erosion and sediment control is required under Bend Municipal Code Title 16.35 Erosion Control Requirements. When you are ready for your erosion control inspection, upload photos to this condition . Refer to this website for upload instructions and guidance: (TBD link). By following the instructions and guidance you can pass your inspection the first time. The erosion and sediment control condition must be complete before any additional building inspections can be requested. For questions related to this process please email stormwater@bendoregon.gov.

Documents: TEST COVER

- After building permit application
- Portal to upload photos of installed BMPs

- Must be completed and reviewed by City staff prior to requesting any building inspections

Online Guidance and Resources (draft)

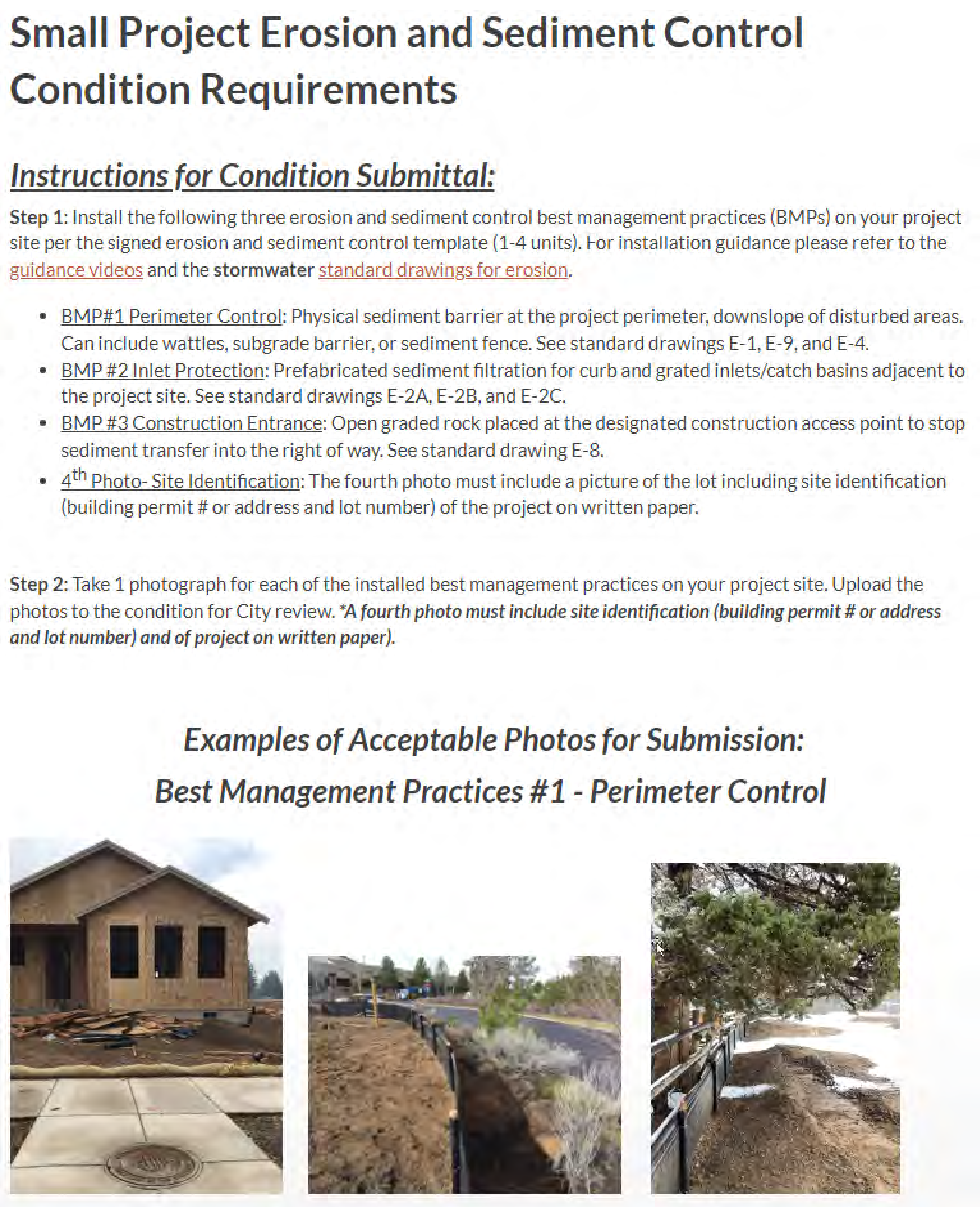
Requested photos

#1 Perimeter Control

#2 Inlet Protection

#3 Construction Entrance

#4 Site Identification



Small Project Erosion and Sediment Control Condition Requirements

Instructions for Condition Submittal:

Step 1: Install the following three erosion and sediment control best management practices (BMPs) on your project site per the signed erosion and sediment control template (1-4 units). For installation guidance please refer to the guidance videos and the **stormwater** standard drawings for erosion.

- BMP#1 Perimeter Control: Physical sediment barrier at the project perimeter, downslope of disturbed areas. Can include wattles, subgrade barrier, or sediment fence. See standard drawings E-1, E-9, and E-4.
- BMP #2 Inlet Protection: Prefabricated sediment filtration for curb and grated inlets/catch basins adjacent to the project site. See standard drawings E-2A, E-2B, and E-2C.
- BMP #3 Construction Entrance: Open graded rock placed at the designated construction access point to stop sediment transfer into the right of way. See standard drawing E-8.
- 4th Photo- Site Identification: The fourth photo must include a picture of the lot including site identification (building permit # or address and lot number) of the project on written paper.

Step 2: Take 1 photograph for each of the installed best management practices on your project site. Upload the photos to the condition for City review. **A fourth photo must include site identification (building permit # or address and lot number) and of project on written paper).*

Examples of Acceptable Photos for Submission:

Best Management Practices #1 - Perimeter Control

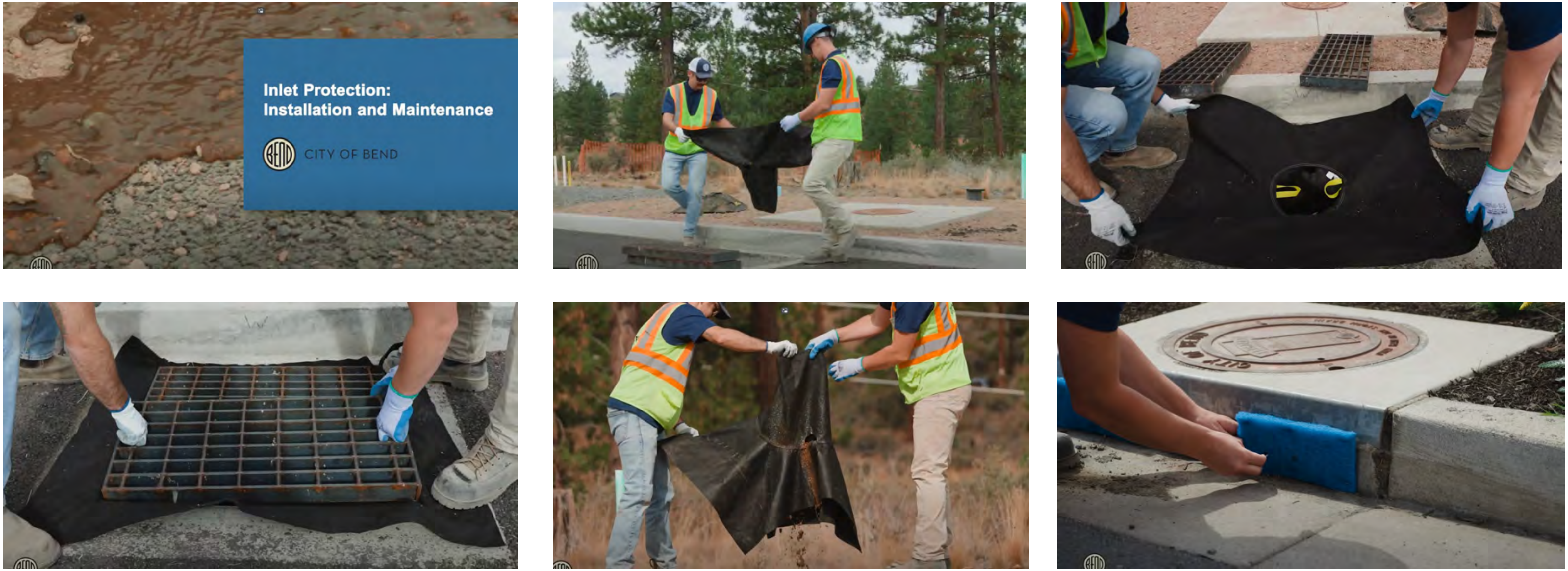
Example BMP Photos

Perimeter Control

Inlet Protection

Construction Entrance

BMP Guidance Videos



- 5 two-minute videos for specific BMP installation and maintenance
- 10 informational, short 30-second videos
- Will be available and linked on the City's stormwater public website

Example Short Video- What are BMPs?

COB_BMPs_Social.mp4

What are Best Management Practices (BMPs) on a Construction Site?

UPAG focus questions

- Is the draft guidance and resources for small developers understandable?
- Are there any guidance areas that may require more support?

Discussion & Feedback

Look ahead

November 6, 2024: Water Conservation Program
11am-12:30pm Hybrid Meeting (Boyd Acres or MS Teams)

Outcome: *Input on water conservation program planning for 2025.*

December 4, 2024: Stormwater Master Plan & UPAG Annual Review
11am-12:30pm Hybrid Meeting (Boyd Acres or MS Teams)

Thank you!

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Accommodation Information for People with Disabilities

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Water Advisory Group

January 8, 2025 • 11 am–12:30 pm

Hybrid Meeting • MS Teams or Bend Utilities Department Deschutes Conference Room

Lori Faha, PE, Environmental Resources Manager
Austin Somhegyi, PE, Stormwater Master Plan Project Manager
Trista Kobluskie, Stormwater Master Plan Consultant Lead
Aubrie Koenig, Facilitator

Purpose & Agenda

Discuss potential stormwater management strategies to address drainage and development density.

1. Welcome & Introductions
2. Stormwater Drainage & Density Policy Discussion
   - Stormwater considerations
   - Types of development and stormwater tools
3. Summary & Closing

Welcome to the WAG

- A new name for a new year – introducing the **City of Bend Water Advisory Group** (WAG)
- Same purpose and membership – community stakeholders invited by the City of Bend to **provide input to Water Services staff on programs and policies** for stormwater management, water conservation, and other City water system topics

- **Timing:** 1st Wednesday monthly 11am-12:30pm through spring 2025
- **Format:** Hybrid (MS Teams+Boyd Acres)
- **Materials:** bendoregon.gov/UPAG

December meeting reflections

Topics of greatest interest:

- FireWise/WaterWise program coordination
- Water conservation program & performance
- Stormwater standards updates (consistency/alignment, new best practices, stakeholder considerations)

Additional interest areas/questions:

- Stormwater/street tree right-of-way implementation (new urban forester as guest)
- Water/stormwater rates
- Drainage/density potential new codes and standards (core area case study)
- Code development (multi-disciplinary input)
- Code and standard updates:
  - City code language clarity on separation distance between water and storm systems
  - UIC updated standards details, including implementation in 2-yr time of travel areas
  - Code/standards/Central Oregon Stormwater Manual updates for trash enclosures

Stormwater Management Policies

Drainage and Density

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Drainage & Density

- Stormwater Master Plan Work Scope
  - “White Paper” summarizing issues, regulatory requirements, recommendations (next steps)
  - Focus topics:
    - Infill development
    - Use of regional facilities & context for master plan or district specific areas
- Today’s discussion:
    - Summary – background, context
    - Onsite/Offsite options discussion for various types of development

Stormwater and development

From March 2023 UPAG meeting

Current Typical Requirements

- Development must retain all stormwater onsite
- Street/ROW systems are designed to handle ROW runoff plus the front 20’ of adjacent lots
- UIC’s (drywells with pretreatment from sedimentation manholes) typical in most ROW areas and many private sites
- SF lots typically just use surface retention in the landscape
- A few master planned developments send some “private” runoff into private or public ROW systems

Upcoming Changes/Needs

- Apply standards to smaller sites (5000 sf impervious area threshold, no exemptions) ★
- Increased density, less available pervious areas (“drainage and density”)
- Apply standards to re-development (replacement of existing impervious) ★
- Create hierarchy for standards – first manage onsite, then if needed have options for offsite stormwater management ★
- Consider impacts of more frequent, short duration, high intensity storms

★ = DEQ permit reqmt

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Prior Work Will Inform Stormwater Updates

From March 2023 UPAG meeting

Past Work:

- The previous Bend Stormwater PAG discussed in detail the complexity of “drainage and density” issues in 2017-2022 *(per emailed attachment)*
- Technical work needs were identified and some progress made by the City on research, compiling gaps/needs for standards updates

Next Steps:

- Program/standards/codes updates to ensure permit compliance, and reporting steps and timing to DEQ in updated iSWMP
- Create reasonable and sustainable methods for accommodating drainage and density that:
  - Continues to prioritize onsite stormwater management
  - Provides simple tools and pathways for small and infill projects

DRAINAGE TO UNDERGROUND DRINKING WATER PROTECTION AREAS

Small Infill Lot
- Onsite & Streetside Controls

New Developments or Large Redevelopments
- Combination: Onsite, Streetside, and Regional
- Onsite and Regional

GEOLOGIC CHALLENGES

Small Infill Lot
- Combination: Onsite, Streetside, and Regional

New Developments or Large Redevelopments
- Combination: Onsite, Streetside, and Regional
- Onsite and Regional

DENSITY OPPORTUNITY AREAS

Small Infill Lot
- Onsite
- Regional
- Combination: Onsite, Streetside, and Regional

New Developments or Large Redevelopments
- Regional
- Combination: Onsite, Streetside, and Regional

DRAINAGE TO THE RIVER

Small Infill Lot
- Onsite & Streetside Controls
- Onsite

New Developments or Large Redevelopments
- Combination: Onsite, Streetside, and Regional
- Onsite and Regional

LESS SENSITIVE DRAINAGE AREAS

Small Infill Lot
- Onsite

New Developments or Large Redevelopments
- Onsite
- Combination: Onsite, Streetside, and Regional

Stormwater Public Advisory Group Recommendations - Fall 2018

SPAG Drainage & Density Ideas:

- Provide options for all types of development
- Green Infrastructure approaches

Glossary of Terms -

ONSITE CONTROLS seek to increase permeability, reduce impervious surface area and directly connected impervious areas to increase retention and detention through such practices as (a) reduced building and (b) parking footprints, (c) rain gardens, (d) disconnected downspouts, (e) permeable pavement or decks/benches, (f) green roofs, (g) cisterns, (h) underground injection controls.

NEIGHBORHOOD STREETSIDE CONTROLS are controls in the public right of way or private streetside designed either to retain or detain stormwater to reduce the amount or rate of runoff. These may include (a) green streets bioinfiltration, planter boxes, (b) filter strips, or underground injection controls.

REGIONAL (SUBDIVISION) CONTROLS are designed to take, detain/retain the stormwater from multiple lots through a retention or detention basin or swale.

Accommodation Information for People with Disabilities
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UPAG focus question

From March 2023 UPAG meeting

Given:

- There is a regulatory emphasis for on-site retention/low impact development.
- There is legislative/land-use emphasis on density.
- Ensuring long-term private maintenance of disbursed LID measures is difficult.

- Question: Under what scenarios should offsite drainage be an option for development projects?

Approaches to drainage and density

From March 2023 UPAG meeting

<u>A potential stormwater hierarchy:</u>

1. All onsite disposal
2. 25-yr storm onsite, 100-year overflow to ROW
3. Partial onsite (WQ storm?), remainder to "subdivision level" facility
4. All stormwater managed at "subdivision level"
5. Partial (or none) onsite, remainder to ROW or public regional facility

When to allow moving down the hierarchy?

Townhomes- Empire Blvd

Townhomes- Reed Market

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Luderman Crossing Development

Developer gave up two lots for regional drainage facilities.

- Reduced the number of drywells by half, installing private collection systems for roof runoff.
- Subdivision is designed to keep the 100-year storm event onsite.
- HOA maintains

From March 2023 UPAG meeting

Discussion & Feedback

WAG focus questions

- What are your concerns/challenges about drainage and development density?
- Where do you experience hurdles in the development process related to stormwater management?
- What new tools could be effective to help manage stormwater with smaller lot sizes and less available vegetated area?
- Should there be options for combining private and public stormwater, and who should pay and maintain them?

Naming Convention

*Need to establish naming convention to clearly identify different possible scenarios

Location of Facility	Who is Draining	Facility Owner	Development Type	Other?
Onsite	Single Lot	Private	Residential	
Subdivision	Multi Lot	Public	Commercial	
Onsite + Subdivision	Multi Lot + ROW	Other?	Industrial	
ROW	ROW		ROW	
Subdivision + ROW	Other?		Mixed Use	
Onsite + ROW			Other?	
Other?				

What other categories should we consider? Should any of these options be removed/added?

Strategy 1

*All Onsite Stormwater Management – Current Practice

Location of Facility	Who is Draining	Facility Owner	Development Type
Onsite	Single Lot	Private	Residential
Onsite	Single Lot	Private	Commercial
Onsite	Single Lot	Private	Industrial
Onsite	Single Lot	Private	ROW

- Examples?
- Concerns/challenges?
- Benefits?
- Thresholds?

Strategy 2

*Subdivision Level Stormwater Management

Location of Facility	Who is Draining	Facility Owner	Development Type
Onsite + Subdivision	Multi Lot	Private	
Subdivision	Multi Lot	Private	
Subdivision	Multi Lot	Public	
Subdivision	Multi Lot + ROW	Private	
Subdivision	Multi Lot + ROW	Public	

- Examples?
- Concerns/challenges?
- Benefits?
- Thresholds?
- Should this be restricted to certain development types?

Strategy 3

*ROW Stormwater Management

- Examples?
- Concerns/challenges?
- Benefits?
- Thresholds?
- Should this be restricted to certain development types?

Location of Facility	Who is Draining	Facility Owner	Development Type
ROW	Single Lot	Private	
ROW	Multi Lot	Private	
ROW	Multi Lot + ROW	Private	
ROW	Single Lot	Public	
ROW	Multi Lot	Public	
ROW	Multi Lot + ROW	Public	

April extended meeting or subcommittee?

Topic/Purpose:

- Share and collect feedback on draft drainage/density policy concept

Questions:

- Are you interested?
- Would you rather:
  - Extend April 2 meeting to 11a-1:30p
  - Add new 1-hr meeting in April for subcommittee
  - Just read document and provide individual input

Look ahead

February 5, 2025: Stormwater Master Plan Project Priorities
11am-12:30pm   Hybrid Meeting (Boyd Acres or MS Teams)

Outcome: *Input on project prioritization 'tie breakers.'*

March 5, 2025: Water Conservation Program Performance Measures
11am-12:30pm   Hybrid Meeting (Boyd Acres or MS Teams)

Thank you!

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WAG
Stormwater Master Plan
Project Priorities Follow-up Discussion

Updates to Rating Criteria

Capital Project Prioritization Results – Water Quality Retrofits and Drainage

Other Capital Programs

February 5, 2025

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Stormwater Master Plan purpose and overview

- Update conveyance and drainage projects from 2014 Stormwater Master Plan
- **Identify and assess new conveyance/drainage issues**
- **Create a long-term plan for reducing risk to groundwater from drill holes and drywells (UICs)**
- **Create a plan for improving the quality of runoff discharged to the Deschutes River through the City's outfalls**
- **Develop a capital program incorporating conveyance/drainage projects, UIC retrofits, and outfall retrofits**

Stormwater Master Plan development and areas for UPAG input

- **Visioning – what is most important to you and the community?**
- Visioning – what is the story of stormwater in Bend?
- **Solution Priorities – how will we prioritize stormwater capital improvements?**
- Policy Solutions – what are the opportunities and impediments to regional facilities?
- Policy Solutions – what are the opportunities and impediments to managing runoff from private properties in the rights-of-way?
- Policy Solutions – how much emphasis on climate change in the next SMP?

UPAG focus questions

- With the mix of drainage projects and outfall retrofits projects in the CIP list, do you feel WAG's equal emphasis on protecting the public from ponding/flooding and protecting water quality has been achieved?
- Is there anything crucial missing from the lists of projects or capital programs?

Updates to Rating Criteria

Relative Category Scores – Draft vs. Final

Category	Draft Maximum Score	Final Maximum Score	Change Summary
Conveyance and Flooding	10	20	Increased emphasis on flooding to protect public safety; included pedestrian issues
Water Quality Improvements	20	20	No change
Multiple Benefits	15	20	Increased weights for equitable distribution of public assets and support for housing and economic development
Recognized Priority Projects	15	10	Reduced weight
Feasibility and Cost	10	10	
Total Points Available	**70**	**80**	

Capital Project Prioritization Results

Bend SMP Web Application

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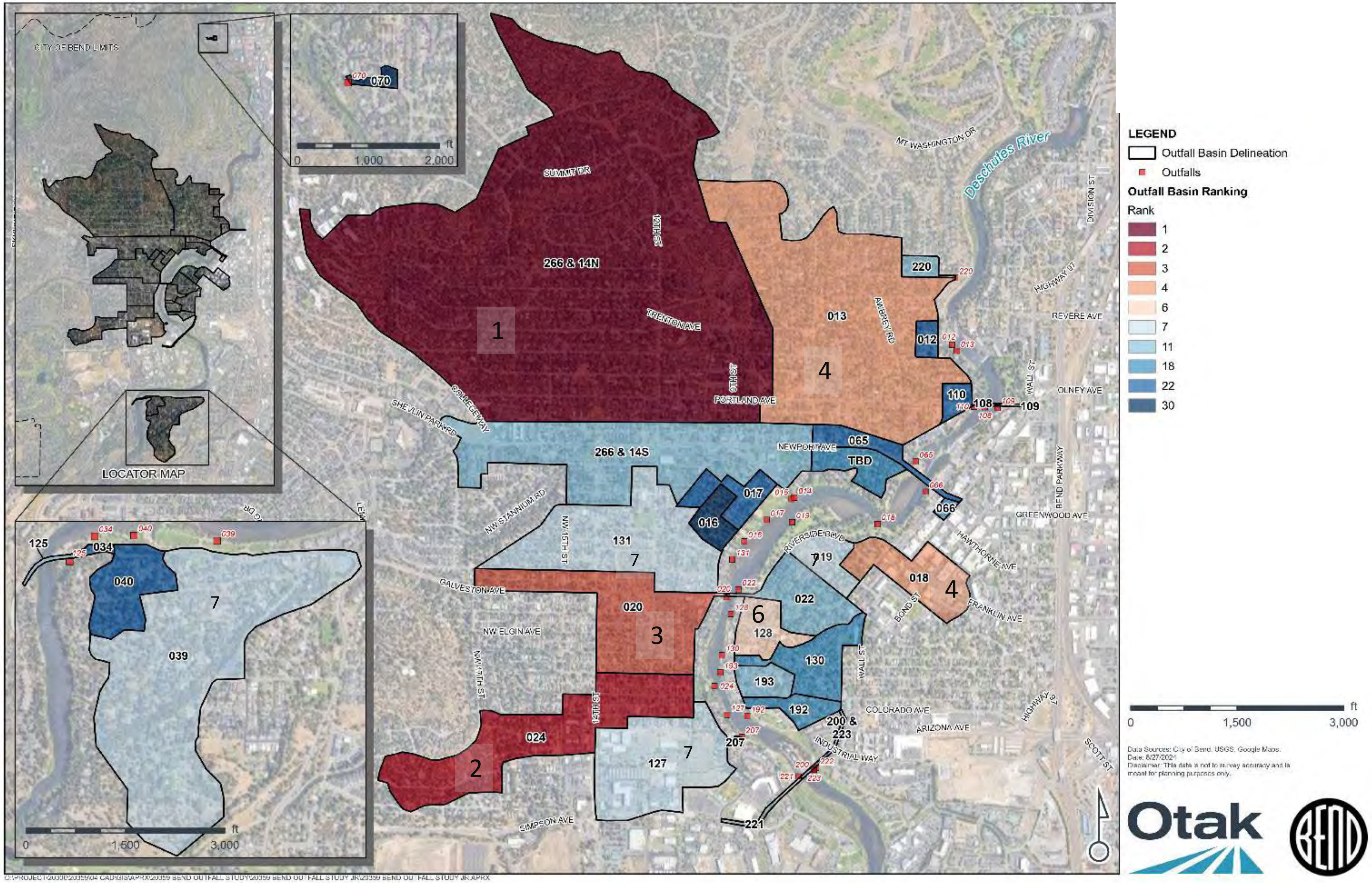
Outfall Retrofits – Priority Outfall Basins



Data Sources: City of Bend, USGS, Google Maps.
Date: 8/27/2024
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

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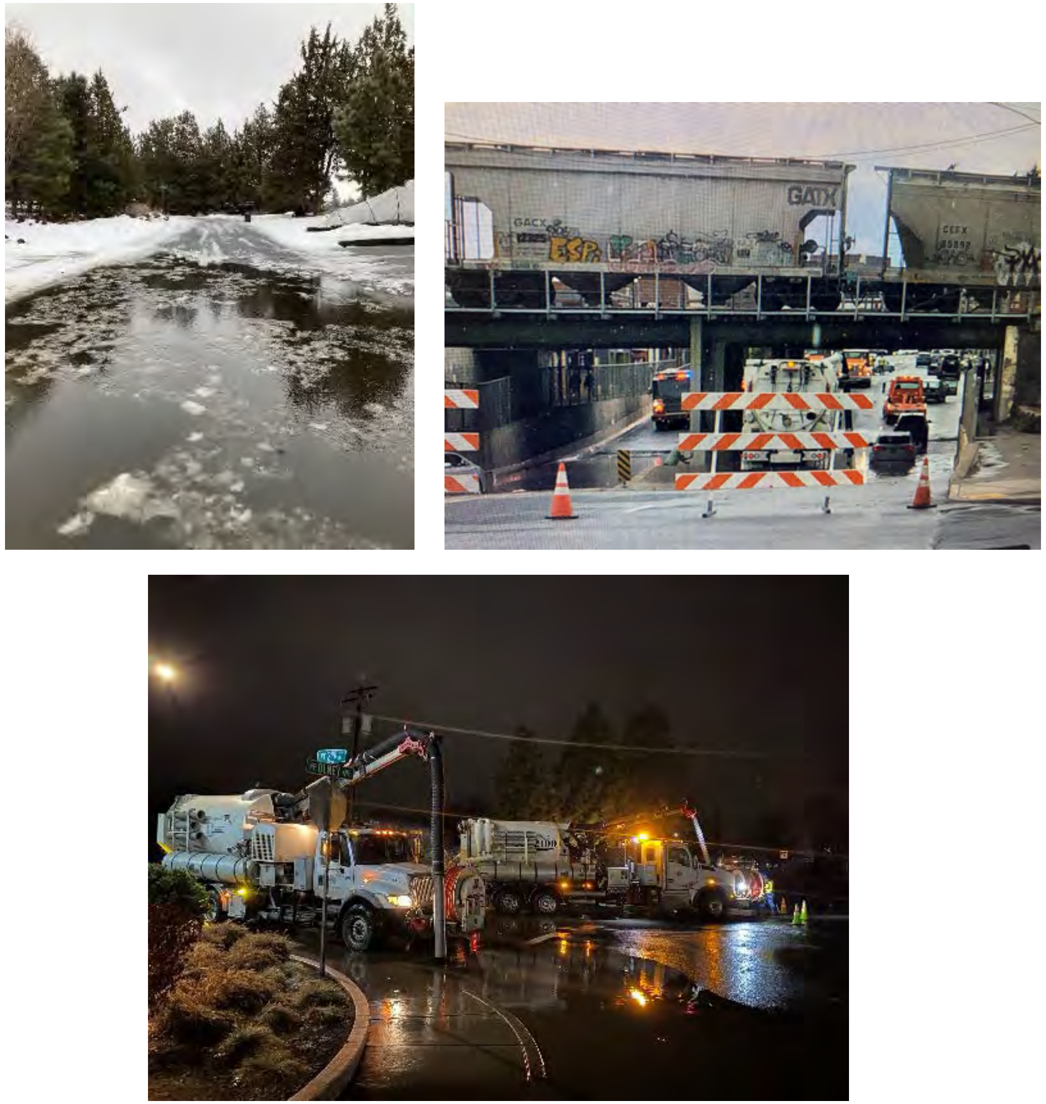
Outfall Retrofit Examples

Newport Outfalls Retrofits

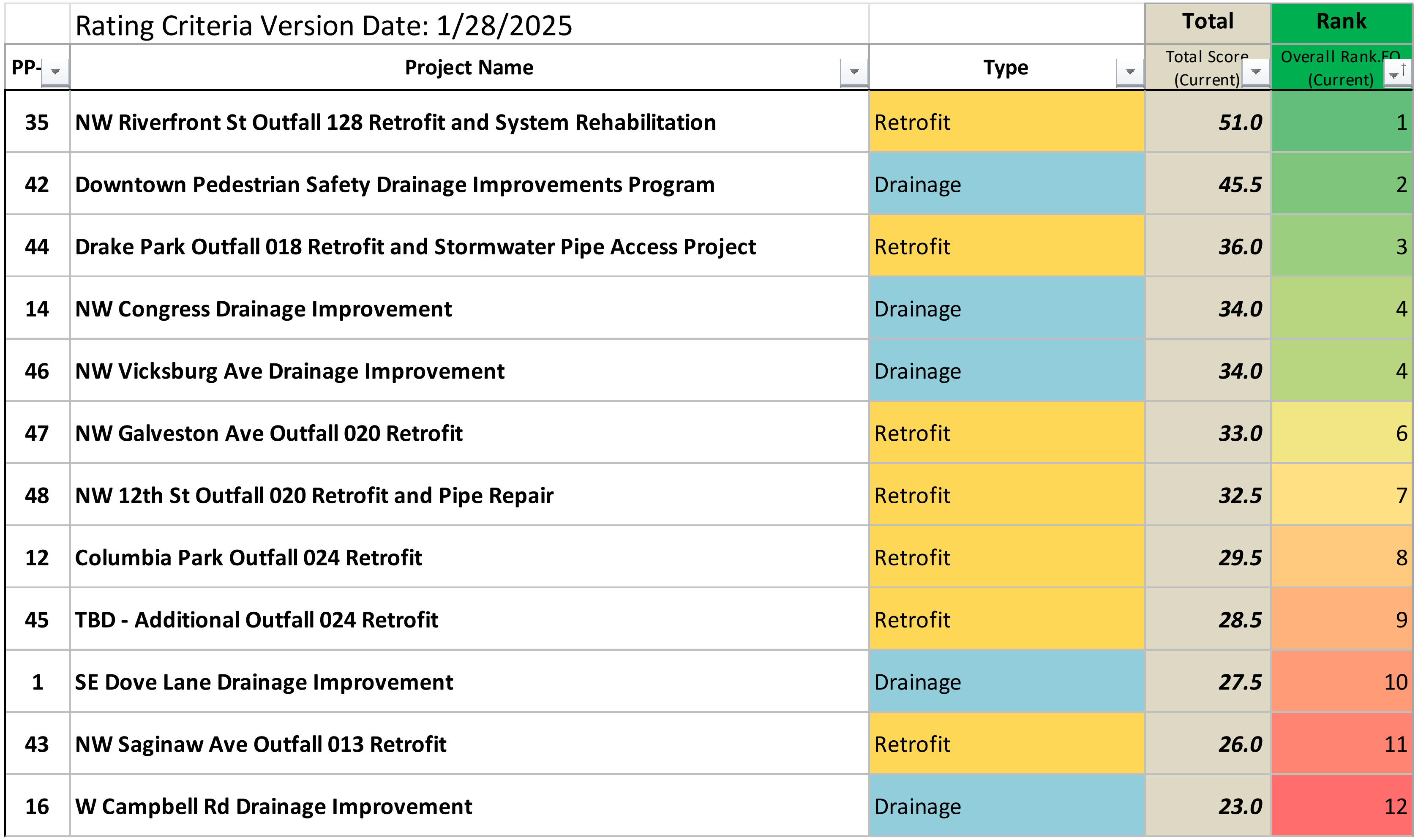
Drainage Projects - Ponding / Flooding Issues



Characterize Issue

- Roadway safety
- Property damage
- Inconvenience
- Cost to respond

Ranked Projects – Combined Drainage and Retrofit List



	Rating Criteria Version Date: 1/28/2025		Total	Rank
PP-	Project Name	Type	Total Score (Current)	Overall Rank.FO (Current)
35	NW Riverfront St Outfall 128 Retrofit and System Rehabilitation	Retrofit	*51.0*	1
42	Downtown Pedestrian Safety Drainage Improvements Program	Drainage	*45.5*	2
44	Drake Park Outfall 018 Retrofit and Stormwater Pipe Access Project	Retrofit	*36.0*	3
14	NW Congress Drainage Improvement	Drainage	*34.0*	4
46	NW Vicksburg Ave Drainage Improvement	Drainage	*34.0*	4
47	NW Galveston Ave Outfall 020 Retrofit	Retrofit	*33.0*	6
48	NW 12th St Outfall 020 Retrofit and Pipe Repair	Retrofit	*32.5*	7
12	Columbia Park Outfall 024 Retrofit	Retrofit	*29.5*	8
45	TBD - Additional Outfall 024 Retrofit	Retrofit	*28.5*	9
1	SE Dove Lane Drainage Improvement	Drainage	*27.5*	10
43	NW Saginaw Ave Outfall 013 Retrofit	Retrofit	*26.0*	11
16	W Campbell Rd Drainage Improvement	Drainage	*23.0*	12

Other Capital Programs

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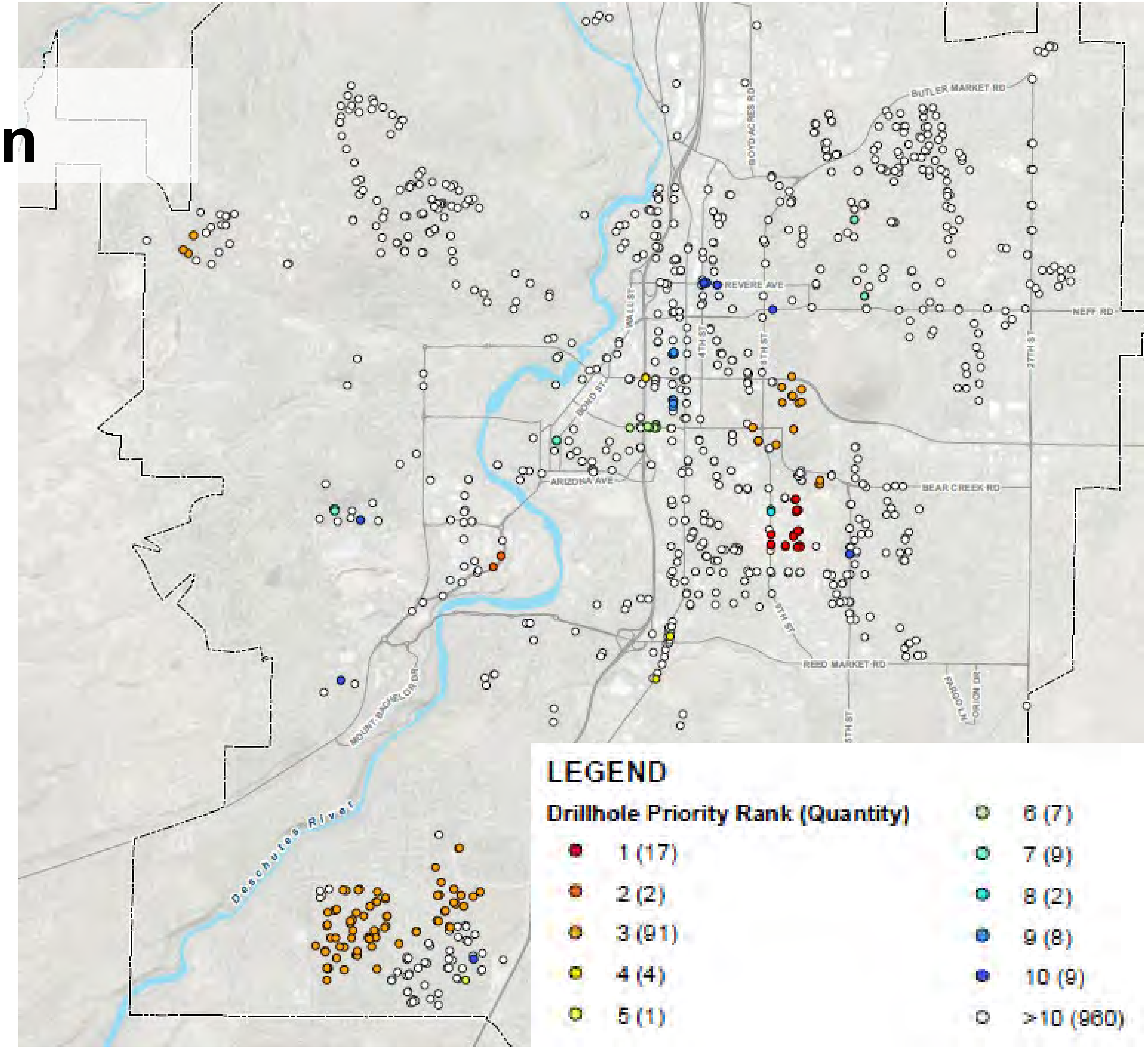
Drillhole Rehab and Retrofit Prioritization

- 17 drillholes identified as priorities
- They could pose a risk to groundwater resources because they lack separation from groundwater and do not have pre-treatment or spill control



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Failing UICs Program

- Replace drillholes or drywells that no longer function with drywells or deep drywells
- Some more complex / highest priority failing UICs are included in the Drainage Capital Projects.
- This list contains the less complex / lower priority failing UICs.
- Some of these can be implemented by City personnel, and some will be implemented by consultants and contractors.

Major Maintenance Program

- Existing program of Bend’s EIPD
- Moderately complex repair, replacement, or drainage projects
- May be implemented with in-house personnel but are often implemented by consultants and contractors

Discussion

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Water Advisory Group

April 2, 2025 • 11 am–1 pm

Hybrid Meeting • MS Teams or Bend Utilities Department Deschutes Conference Room

Lori Faha, PE, Environmental Resources Manager
Dan Denning, Water Conservation Program Manager
Carlos Bustos, Conservation Rate Research Consultant Lead
Austin Somhegyi, PE, Stormwater Master Plan Project Manager
Trista Kobluskie, Stormwater Master Plan Consultant Lead
Aubrie Koenig, Facilitator

Purpose & Agenda

Introduce planned conservation rate research and discuss approaches and benefits of budget-based rates. Introduce feedback request on draft drainage and density policy memo.

Part I: 11am-12:30pm

1. Welcome & Introductions
2. Water Conservation Rate Research
    - Research overview
    - Types of budget-based rates
3. Discussion & Feedback

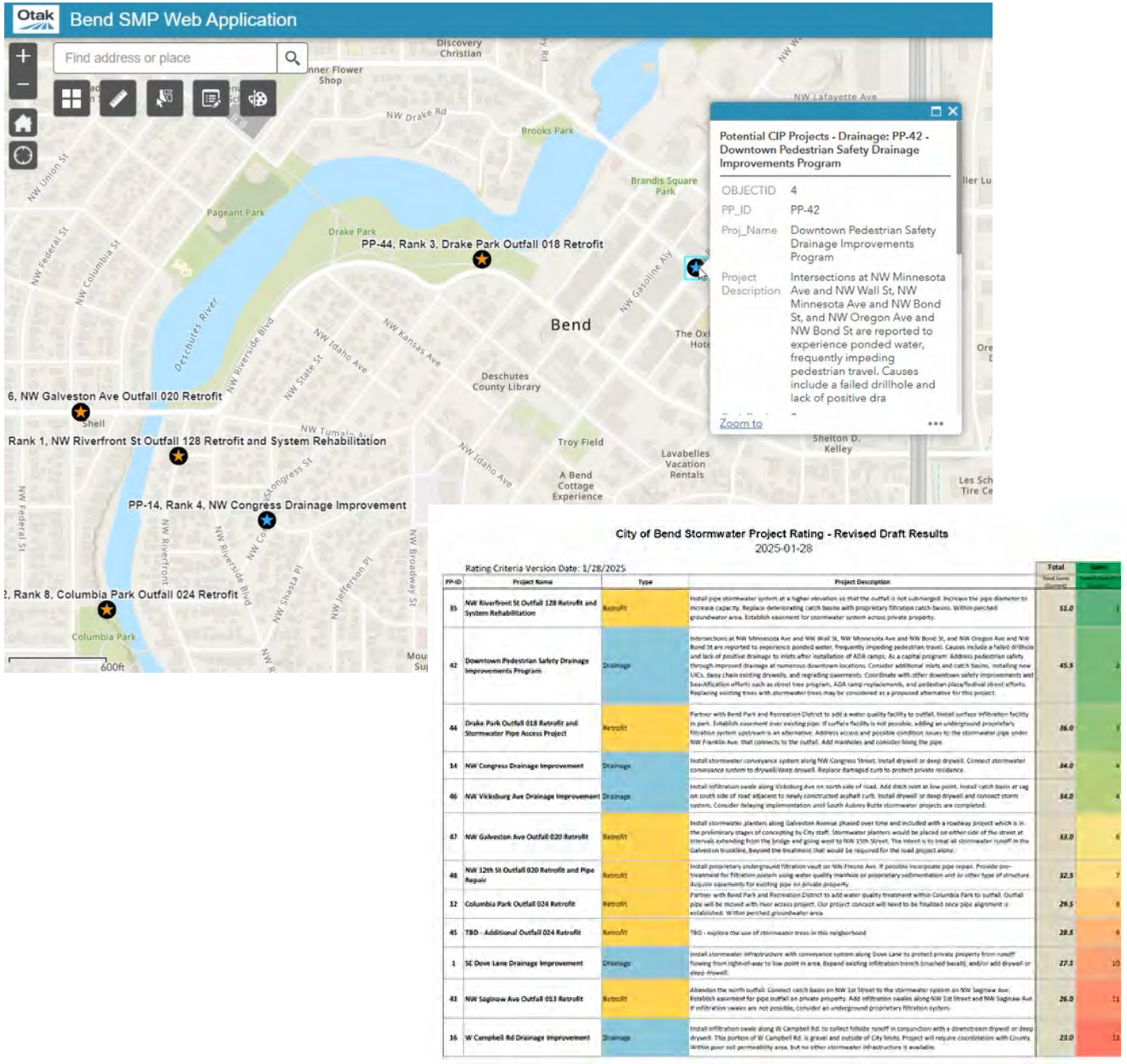
Part II: 12:30-1pm

1. Stormwater Master Plan
    - Planning update
    - Drainage and density memo
2. Summary & Closing

Meeting reflections

Stormwater priorities feedback:

- Capital project list looks good
- Priorities seem well balanced (water quality and quantity, geographic distribution, range of project types)



Potential CIP Projects - Drainage: PP-42 - Downtown Pedestrian Safety Drainage Improvements Program

OBJECTID	4
PP_ID	PP-42
Proj_Name	Downtown Pedestrian Safety Drainage Improvements Program
Project Description	Intersections at NW Minnesota Ave and NW Wall St, NW Minnesota Ave and NW Bond St, and NW Oregon Ave and NW Bond St are reported to experience ponded water, frequently impeding pedestrian travel. Causes include a failed drillhole and lack of positive dra

Zoom to

City of Bend Stormwater Project Rating - Revised Draft Results
2025-01-28

Rating Criteria Version Date: 1/28/2025

PP-ID	Project Name	Type	Project Description	Total	[illegible]
35	NW Riverfront St Outfall 128 Retrofit and System Rehabilitation	Retrofit	Install pipe stormwater system at a higher elevation so that the outfall is not submerged. Increase the pipe diameter to increase capacity. Replace deteriorating catch basins with proprietary filtration catch basins. Within perched groundwater area. Establish easement for stormwater system across private property.	52.0	1
42	Downtown Pedestrian Safety Drainage Improvements Program	Drainage	Intersections at NW Minnesota Ave and NW Wall St, NW Minnesota Ave and NW Bond St, and NW Oregon Ave and NW Bond St are reported to experience ponded water, frequently impeding pedestrian travel. Causes include a failed drillhole and lack of positive drainage to inlets after installation of ADA ramps. As a capital program: Address pedestrian safety through improved drainage at numerous downtown locations. Consider additional inlets and catch basins, installing new UICs, daisy chain existing drywells, and regrading pavements. Coordinate with other downtown safety improvements and beautification efforts such as street tree program, ADA ramp replacements, and pedestrian plaza/festival street efforts. Replacing existing trees with stormwater trees may be considered as a proposed alternative for this project.	45.5	2
44	Drake Park Outfall 018 Retrofit and Stormwater Pipe Access Project	Retrofit	Partner with Bend Park and Recreation District to add a water quality facility to outfall. Install surface infiltration facility in park. Establish easement over existing pipe. If surface facility is not possible, adding an underground proprietary filtration system upstream is an alternative. Address access and possible condition issues to the stormwater pipe under NW Franklin Ave. that connects to the outfall. Add manholes and consider lining the pipe.	36.0	3
14	NW Congress Drainage Improvement	Drainage	Install stormwater conveyance system along NW Congress Street. Install drywell or deep drywell. Connect stormwater conveyance system to drywell/deep drywell. Replace damaged curb to protect private residence.	34.0	4
46	NW Vicksburg Ave Drainage Improvement	Drainage	Install infiltration swale along Vicksburg Ave on north side of road. Add ditch inlet at low point. Install catch basin at sag on south side of road adjacent to newly constructed asphalt curb. Install drywell or deep drywell and connect storm system. Consider delaying implementation until South Aubrey Butte stormwater projects are completed.	34.0	4
47	NW Galveston Ave Outfall 020 Retrofit	Retrofit	Install stormwater planters along Galveston Avenue phased over time and included with a roadway project which is in the preliminary stages of concepting by City staff. Stormwater planters would be placed on either side of the street at intervals extending from the bridge and going west to NW 15th Street. The intent is to treat all stormwater runoff in the Galveston trunkline, beyond the treatment that would be required for the road project alone.	33.0	6
48	NW 12th St Outfall 020 Retrofit and Pipe Repair	Retrofit	Install proprietary underground filtration vault on NW Fresno Ave. If possible incorporate pipe repair. Provide pre-treatment for filtration system using water quality manhole or proprietary sedimentation unit or other type of structure. Acquire easements for existing pipe on private property.	32.5	7
12	Columbia Park Outfall 024 Retrofit	Retrofit	Partner with Bend Park and Recreation District to add water quality treatment within Columbia Park to outfall. Outfall pipe will be moved with river access project. Our project concept will need to be finalized once pipe alignment is established. Within perched groundwater area.	29.5	8
45	TBD - Additional Outfall 024 Retrofit	Retrofit	TBD - explore the use of stormwater trees in this neighborhood	28.5	9
1	SE Dove Lane Drainage Improvement	Drainage	Install stormwater infrastructure with conveyance system along Dove Lane to protect private property from runoff flowing from right-of-way to low point in area. Expand existing infiltration trench (crushed basalt), and/or add drywell or deep drywell.	27.5	10
43	NW Saginaw Ave Outfall 013 Retrofit	Retrofit	Abandon the north outfall. Connect catch basin on NW 1st Street to the stormwater system on NW Saginaw Ave. Establish easement for pipe outfall on private property. Add infiltration swales along NW 1st Street and NW Saginaw Ave. If infiltration swales are not possible, consider an underground proprietary filtration system.	26.0	11
16	W Campbell Rd Drainage Improvement	Drainage	Install infiltration swale along W Campbell Rd. to collect hillside runoff in conjunction with a downstream drywell or deep drywell. This portion of W Campbell Rd. is gravel and outside of City limits. Project will require coordination with County. Within poor soil permeability area, but no other stormwater infrastructure is available.	23.0	12

Stormwater Master Plan Drainage and Density Follow-up Discussion

Draft Findings

Next Steps

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WAG discussion questions

- Do you support eliminating barriers to managing stormwater in a more centralized fashion within subdivisions, rather than on each lot?
- Would the Bend community support allowance for some private runoff to be managed in public streets in facilities owned and operated by the City, especially residential runoff?
- In your experience outside of Bend, are you aware of a regional stormwater facility constructed by a City that is used to meet stormwater requirements for redevelopment projects?

Drainage and Density

Stormwater Management Options for Increasingly Dense Development

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Context

- Rapid growth
- Need for diversity of housing options
- Increasing density of development overall
- Economic development

Otak

Bend Stormwater Master Plan

Drainage and Density: Stormwater Management Options for Increasingly Dense Development

Draft – March 2025

Lot-Scale Stormwater Management (SWM) - Default

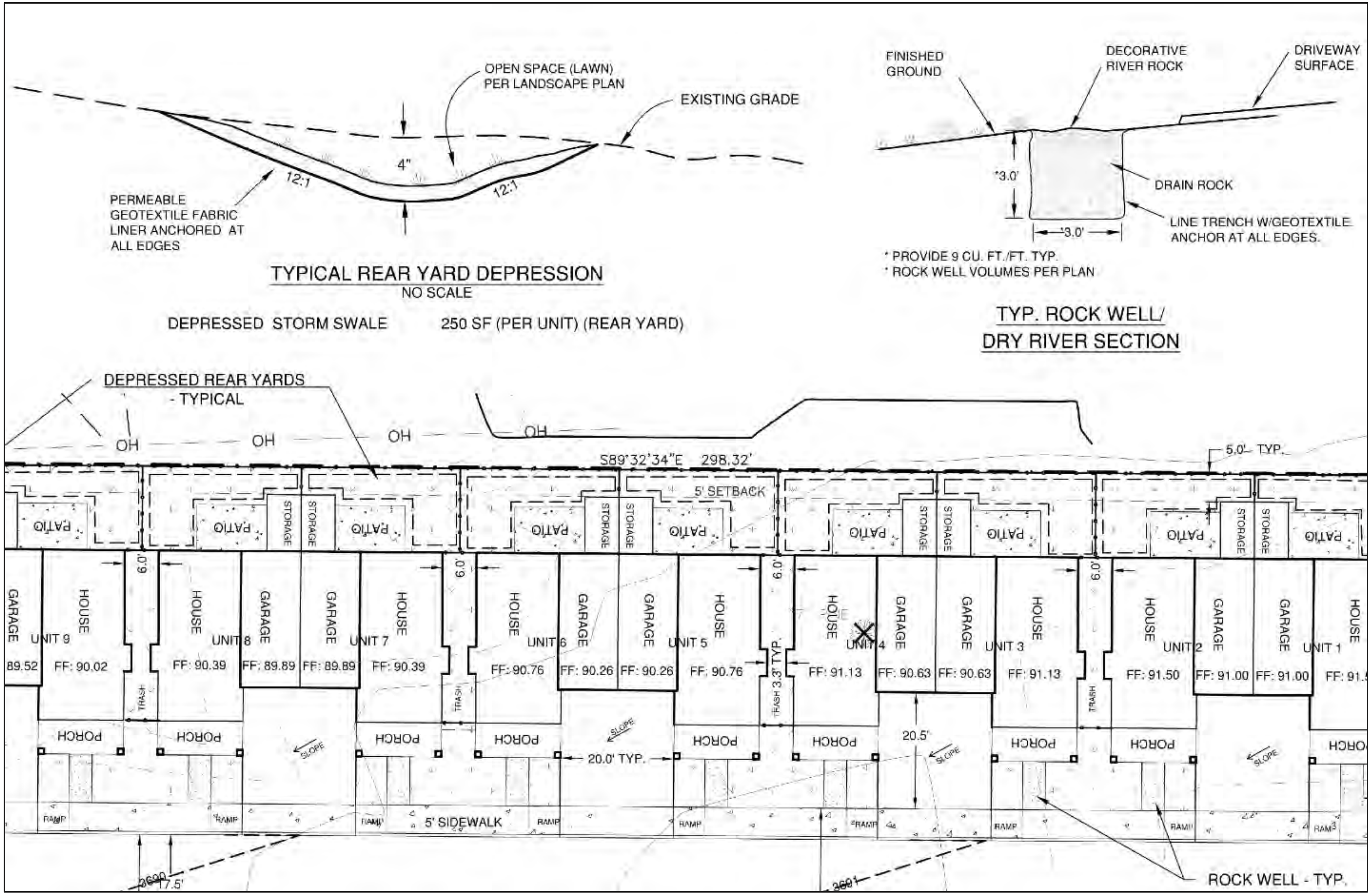
Development Type	Location of Stormwater Facility	Who is Draining	Facility Owner
Residential Subdivision	Lot / Homesite	Private	Individual Property Owner
Non-Residential Site Development*	Lot / Parking or Landscaping	Private	Commercial Property Owner
Infill	Lot / Homesite or Commercial	Private	Individual Property Owner or Commercial Property Owner or HOA
Public Projects	ROW	Public	City

*Includes multi-family for purposes of this topic

Limitations of Lot-Scale SWM

- Siting
    - Small residential lots have little room for lot-by-lot stormwater facilities
    - Small residential lots end up with stormwater facilities but no yard
    - Central Core zero lot line development and some infill not compatible
- Permitting
    - Simplified calculations and assumptions used for numerous small facilities
    - Cost of lot-by-lot field tests and inspections could be prohibitive
    - Lot SWM facilities constructed by builders
- Operation
    - Individual homeowners are left in charge of underground stormwater facilities such as drywells and infiltration trenches that are not easy to see, inspect, or clean
    - Individual landowners are left in charge of small surface stormwater facilities that are easily mistaken for landscaping that can be changed or filled in

Example - Woodhaven



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Centralized On-site SWM Options

Development Type	Location of Stormwater Facility	Who is Draining	Facility Owner	Proposed Approval Process
Residential Subdivision	Tract, or individual lot, or combination	Private and Street	HOA	Typically Type II
Non-Residential Site Development	Lot	Lot	Commercial property owner	Typically Type II
Infill	TBD	TBD	TBD	TBD
Public Projects	Negotiated	City and other agency	Negotiated	Negotiated

Examples

Barriers to Centralized On-site SWM

- Procedures
  - BMC 16.15.040.A.4, 6, and 8 allow stormwater runoff to leave the lot of origin and be managed elsewhere, especially in residential subdivisions, under certain circumstances (BMC 16.15.040.A.4, 6, and 8).
    - We are still studying why these provisions are not used often; there may be procedural barriers.
  - Pre-Application forms do not include mention of stormwater
  - Are WAG members aware of other procedural barriers?
- Funding
  - When the developer sells the lots to builders, there is a financial disincentive to centralize SWM
  - When the developer also builds all the houses, there is no funding barrier

Barriers to Centralized On-site SWM

- Current Code and Standards
  - Title 16 emphasizes that runoff must remain on the lot of origin. It offers other options when circumstances do not allow runoff to remain on lot of origin.
  - Master plans seem to limit comingling of private with public runoff to residential roof runoff, omitting driveways, etc.
  - Possible longer review times for master planned developments than typical residential subdivision
  - When the developer sells the lots to builders, the City may lack code provisions to adequately ensure centralized SWM facilities are protected from sedimentation during construction. We are still studying this.

Public Street Rights-of-Way (ROW) SWM Options

Development Type	Location of Stormwater Facility	Who is Draining	Facility Owner	Approval Process
Infill	Public Street ROW	Lots	City	TBD; not currently approvable
Public Facilities	Public Street ROW	City and other agency	Negotiated	Intergovernmental Agreement

Barriers to ROW SWM

- Current Code and Standards
  - Title 16 emphasizes that runoff must remain on the lot of origin. It offers other options when circumstances do not allow runoff to remain on lot of origin.
  - BMC 16.15.040.A.4 allows drainage from private property to enter the ROW when the City is compensated for constructing and operating SWM facility, BUT City has no mechanism for calculating or collecting such a fee.
- Procedures
  - Pre-Application forms do not include mention of stormwater
- Funding
  - Stormwater fee charged to developed properties is only source of operational funds for public SWM

Regional SWM Study

- Regional stormwater facility
  - Large stormwater management solution
  - Situated and designed to serve multiple properties
  - Optimize stormwater management as part of a multi-phase or large development project or to facilitate redevelopment
- Regional stormwater strategy
  - Plan that addresses conveyance, water quantity control, and water quality treatment through a planned set of public, private, and/or public and private stormwater infrastructure
  - could include several types of solutions to manage runoff in a coordinated manner as opposed to site-by-site

Regional SWM Advantages

- Can support redevelopment and economic development
- Lower design and construction costs
- Reduced operation and maintenance costs
- Visibility
- Higher utilization of developable land
- Integration of stormwater solutions
- Community benefits

Summary

- Centralized on-site stormwater management is allowable under many circumstances, and the policy, procedural, and technical updates needed to support more frequent use of this pattern are relatively minor.
- ROW stormwater management is allowable under limited circumstances, but the City lacks a reimbursement mechanism for managing private runoff in the ROW and may lack procedural mechanisms for approving applications. ROW stormwater management is also complicated by possible utility conflicts and capacity of existing systems.
- Implementing regional SWM requires more study and could be useful in the Central Core and Midtown.
- Adding tools to the toolbox could reduce conflicts of stormwater management with increasing density.

Recommended Next Steps - Draft

- Policies and Procedures
  - Consider adding stormwater to pre-application materials
  - For infill housing, explore establishing a fee in lieu that would allow runoff to be managed in the ROW in a City-owned facility (BMC 16.50.040.A.4). Set a standard for eligibility, set other technical standards such as classification of the street, and research a fair cost.
  - Consider adopting the flexible stormwater options codified in seven master planned developments (BDC 2.7) for residential developments city-wide with a Type II administrative land division.
  - Coordinate with other departments and BURA to explore options for developing regional stormwater strategies for the Central Core, including the ongoing public improvements in Midtown, and other areas of City focus on economic development.

Recommended Next Steps - Draft

- Technical Standards
  - Establish standards for use of deep drywells and stormwater trees on private property and in ROW.
  - Establish criteria for demonstrating compliance with BMC 16.15.040A.4, 16.15.040.A.6, and 16.15.040.A.8 when centralized or ROW stormwater management options are proposed.
- Evaluate Tradeoffs
  - Further evaluate the impacts to funding, operation and maintenance workload, plan review procedures, and staffing if the City wishes to promote the available options for centralized on-site stormwater management and/or increase the options for centralized and ROW stormwater management.

Look ahead

May 7, 2025: Draft Stormwater Master Plan & Stormwater Standards Updates
11am-12:30pm   Hybrid Meeting (Boyd Acres or MS Teams)

Outcome: *Collect feedback on master plan and new standards.*

June 4, 2025: In-person Tour
11am-12:30pm   Location TBD

bendoregon.gov/government/departments/utilities/utilities-public-advisory-group

Thank you!

Accommodation Information for People with Disabilities

To obtain this information in an alternate format such as Braille, large print, electronic formats, etc. please contact Lori Faha at lfaha@bendoregon.gov or (541) 317-3025; Relay Users Dial 7-1-1.

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Water Advisory Group

May 7, 2025 • 11 am–12:30 pm

Hybrid Meeting • MS Teams or Bend Utilities Department Deschutes Conference Room

Lori Faha, P.E., Environmental Resources Manager

Austin Somheygi, P.E. Stormwater Master Plan Project Manager

Trista Kobluskie, Stormwater Master Plan Consultant Lead

Purpose & Agenda

Collect feedback on draft Stormwater Master Plan and Level of Service.

1. Welcome & Introductions
2. April Meeting Reflections
3. June Tour Information
4. Stormwater Master Plan Feedback
5. Discussion & Feedback
6. Summary & Closing

April meeting reflections: Water Rates

- Discussed Challenges, Benefits & Key Objectives for Evaluating Water Budget Based Rates
- Financial sufficiency, sustainability, regulatory compliance, affordability, predictability are all important
- Received Input on Questions For Other Utilities:
    - How do other agencies calculate and verify indoor water use, especially in areas with high vacancy rates?
    - What are the implementation and maintenance costs, including staffing needs, for managing water budgets?
    - How do other utilities approach funding reserve policies?
    - How do they find the balance between level of detail vs cost/complexity in the structure?
    - How to incorporate fairness, equity, affordability, simplicity?

- Water Utilities Interview List

1. Irvine Ranch, CA
2. East Bay Municipal District, CA
3. City of Santa Barbara, CA
4. Fort Collins Utilities, CO
5. Albuquerque, NM
6. Otay Water District, CA
7. San Antonio Water System, TX
8. Rancho California Water District, CA
9. Santa Fe, NM
10. Hillsboro, OR

April Meeting Reflections: Drainage & Density

- If some private runoff will be managed in public facilities, consider the equity questions. There should be a technical feasibility reason to allow it.
- Examine impacts on monthly stormwater charge of allowing comingled facilities.
- Could stormwater charges be divided based on flow rate contributions to comingled facilities?

June 4 WAG Tour – Overturf Park

- 11 am tour start at NW Skyliner Summit Loop at the Cascade Highlands Trail
- Walking tour of City of Bend water site
- Topic: How to better integrate Firewise landscape management recommendations with goals for waterwise/native landscapes, erosion control and tree protection
- 12:30 pm lunch at the reservoir tanks

Look for more RSVP info soon!

Stormwater Master Plan Recommendations and Adoption

Recap Planning Process

SMP Recommendations

Review & Adoption Process

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WAG focus questions

- Overall comments on the CIP projects.
- Does Bend’s stormwater “level of service” fall below your expectations, meet your expectations, or exceed your expectations?
  - Key maintenance practices like street sweeping?
  - Addressing nuisance flooding concerns?
  - Thinking about water quality of the river?
  - Erosion control on construction sites?
  - Public education items?
- What is the strongest argument if the City would want to consider raising rates for stormwater?

Stormwater Master Plan Recap

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Stormwater Master Plan purpose and overview

- Update conveyance and drainage projects from 2014 Stormwater Master Plan
- Identify and assess new conveyance/drainage issues
- Create a long-term plan for reducing risk to groundwater from drill holes and drywells (UICs)
- Create a plan for improving the quality of runoff discharged to the Deschutes River through the City's outfalls
- Develop a capital program incorporating conveyance/drainage projects, UIC retrofits, and outfall retrofits

Stormwater Master Plan purpose and overview

- Review the state of the practice among stormwater utilities for climate change resilience
- Explore options for facilitating denser development, such as:
  - Allowing stormwater runoff from private properties to be managed in the rights-of-way
  - Considering regional stormwater management facilities – placement and necessary policies to support and fund

Stormwater Master Plan development and areas for WAG input

- Visioning – what is most important to you and the community?
- Visioning – what is the story of stormwater in Bend?
- Solution Priorities – how will we prioritize stormwater capital improvements?
- Policy Solutions – what are the opportunities and impediments to regional facilities?
- Policy Solutions – what are the opportunities and impediments to managing runoff from private properties in the rights-of-way?
- Policy Solutions – how much emphasis on climate change in the next SMP?

Project Timeline - Updated

At-a-glance

PLANNING

Define the project scope, objectives, and deliverables.

Communications planning.

Manage the project over time.

2024

Jan – Closeout

DISCOVERY

Intake data and reports.

Assess existing conditions & identify issues to be solved.

Study outfall retrofits.

Study drywells and drill holes.

Study climate change.

2024

Feb - Sept

VISIONING

Assess and document values surrounding stormwater and goals for plan among various groups, including staff, stakeholders, and community.

Use values and goals to prioritize issues, capital projects, and inform policy recommendations.

2024

Feb - Dec

SOLUTIONS

Select capital improvement projects (CIPs).

Develop CIP fact sheets.

Develop policy white papers.

2024 - 2025

Jun – Jun

IMPLEMENT

Write and deliver Stormwater MP.

Develop content for implementation tracking web page.

Final public review.

City Council adoption.

2025

May – Sept

UIC Priorities

Recommendations

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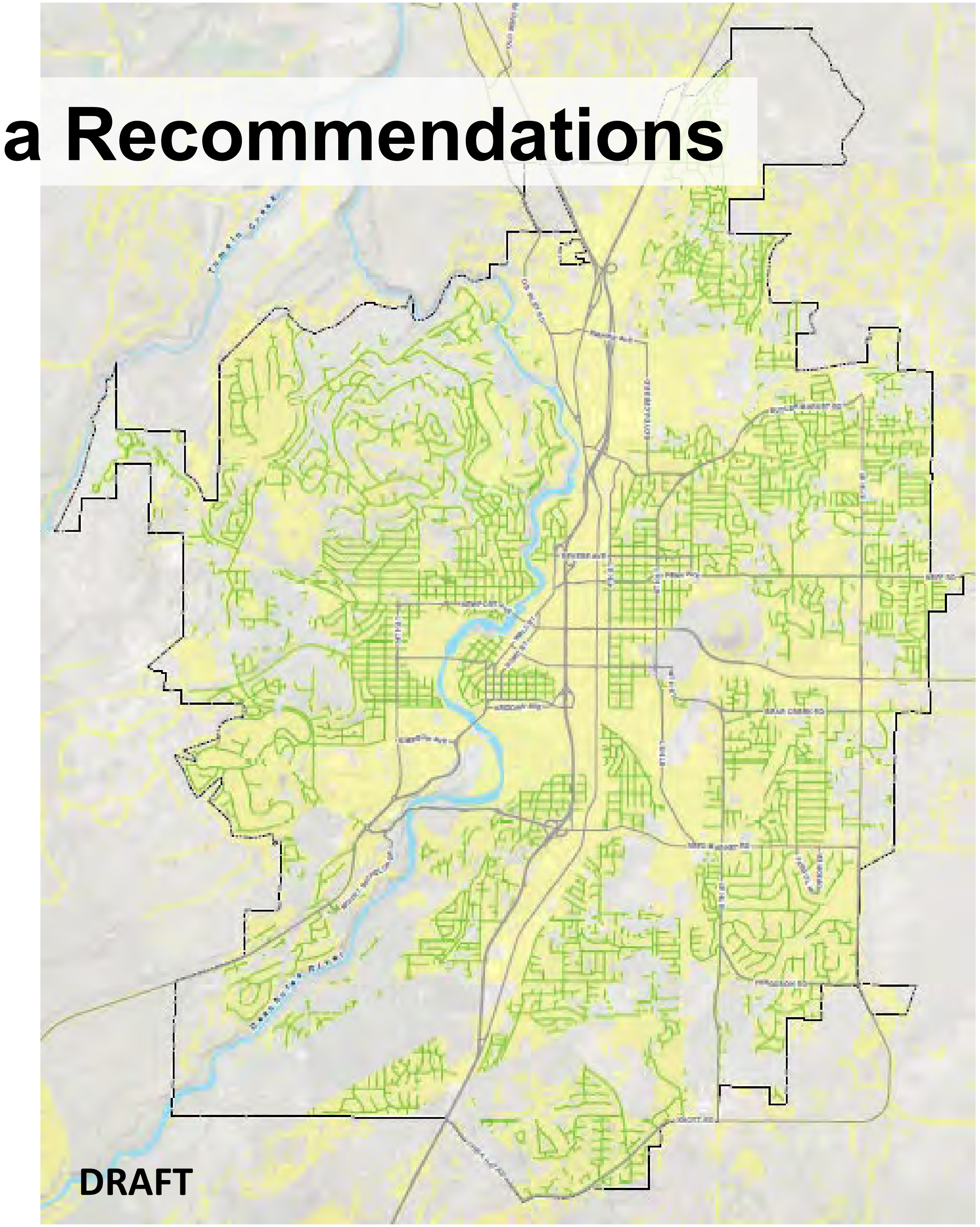
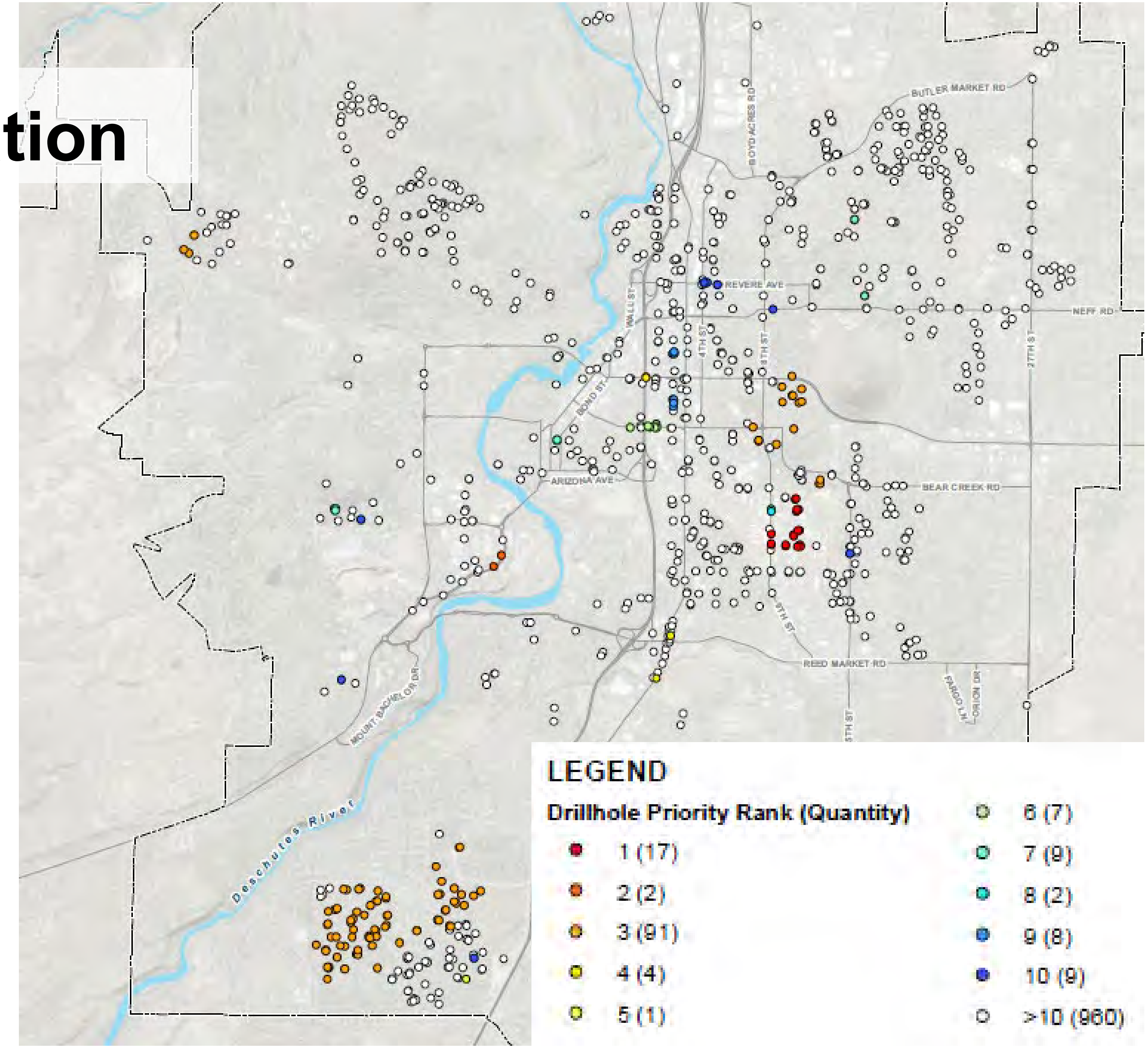
Modified Drywell Siting Criteria Recommendations

- Modified Drywell = Deep Drywell
  - Can reach 100+ feet
- The SMP will recommend allowing deep drywells where there is sufficient vertical separation to groundwater and where likelihood of pollution is low (green)



Drillhole Prioritization

- Drillholes that may pose a risk to groundwater were prioritized
- 17 were identified as highest risk
- The SMP will recommend decommissioning or retrofitting these over a 5 to 10-year period
- Costs are still being developed for this program



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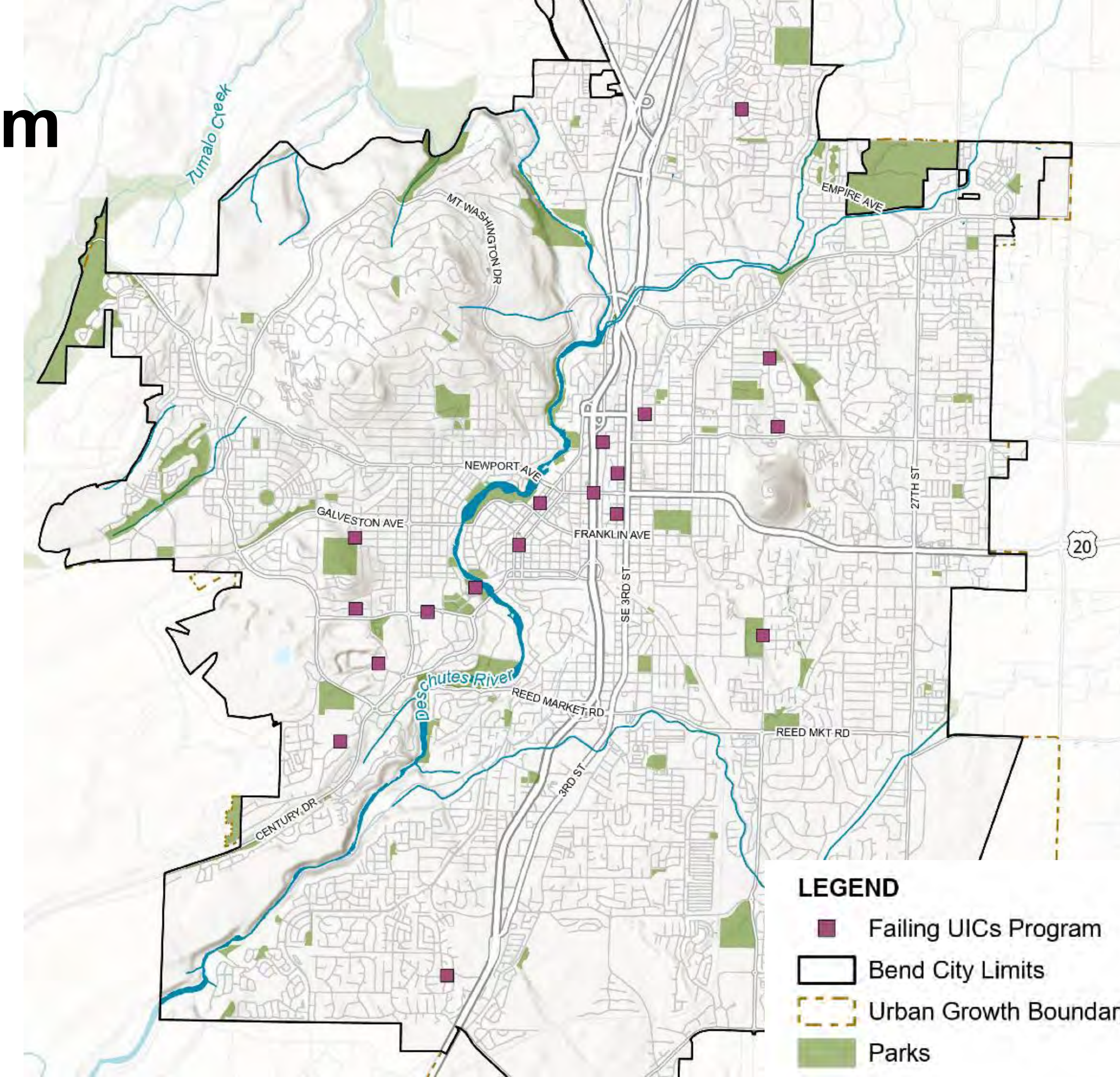
Failing UICs Program

- The City’s failing UICs often have a simple solution of replacing the UIC with a new drywell or removing fouled drain rock from a drywell and replacing it.
- The two options cost about the same.
- The SMP identified 18 failing UICs.
- These may be addressed with the existing “Major Maintenance” annual line item.



Capital Improvement

Recommendations and Costs

Capital Project Prioritization

Visioning

Issue Screening and Selection

Prioritization Criteria

Select Priority Projects

Prioritization Criteria Category Scores

Category	Maximum Score
Conveyance and Flooding	20
Water Quality Improvements	20
Multiple Benefits	20
Recognized Priority Projects	10
Feasibility and Cost	10
Total Points Available	**80**

Ranked Projects

ID	Project Name	Type	Total	Rank
35	Riverfront Street Stormwater Outfall 128 Retrofit and Drainage Improvements	Retrofit	*51.0*	1
42	Downtown Pedestrian Safety Drainage Improvements	Drainage	*45.5*	2
44	Drake Park Stormwater Outfall 018 Retrofit and Pipe Repair	Retrofit	*36.0*	3
14	Congress Street Drainage Improvements	Drainage	*34.0*	4
46	Vicksburg Avenue Drainage Improvements	Drainage	*34.0*	4
47	Galveston Stormwater Outfall 020 Retrofit	Retrofit	*33.0*	6
48	Fresno Ave Stormwater Outfall 020 Retrofit & Drainage	Retrofit	*32.5*	7
12	Columbia Park Outfall 024 Retrofit	Retrofit	*29.5*	8
45	12th Street Stormwater Outfall 024 Retrofit	Retrofit	*28.5*	9
1	Dove Lane Drainage Improvements	Drainage	*27.5*	10
43	Saginaw Avenue Stormwater Outfall 013 Retrofit	Retrofit	*26.0*	11
16	Campbell Road Drainage Improvements	Drainage	*23.0*	12

Example Project Fact Sheet

Outfall 128 Retrofit & NW Riverfront Street Drainage Improvement

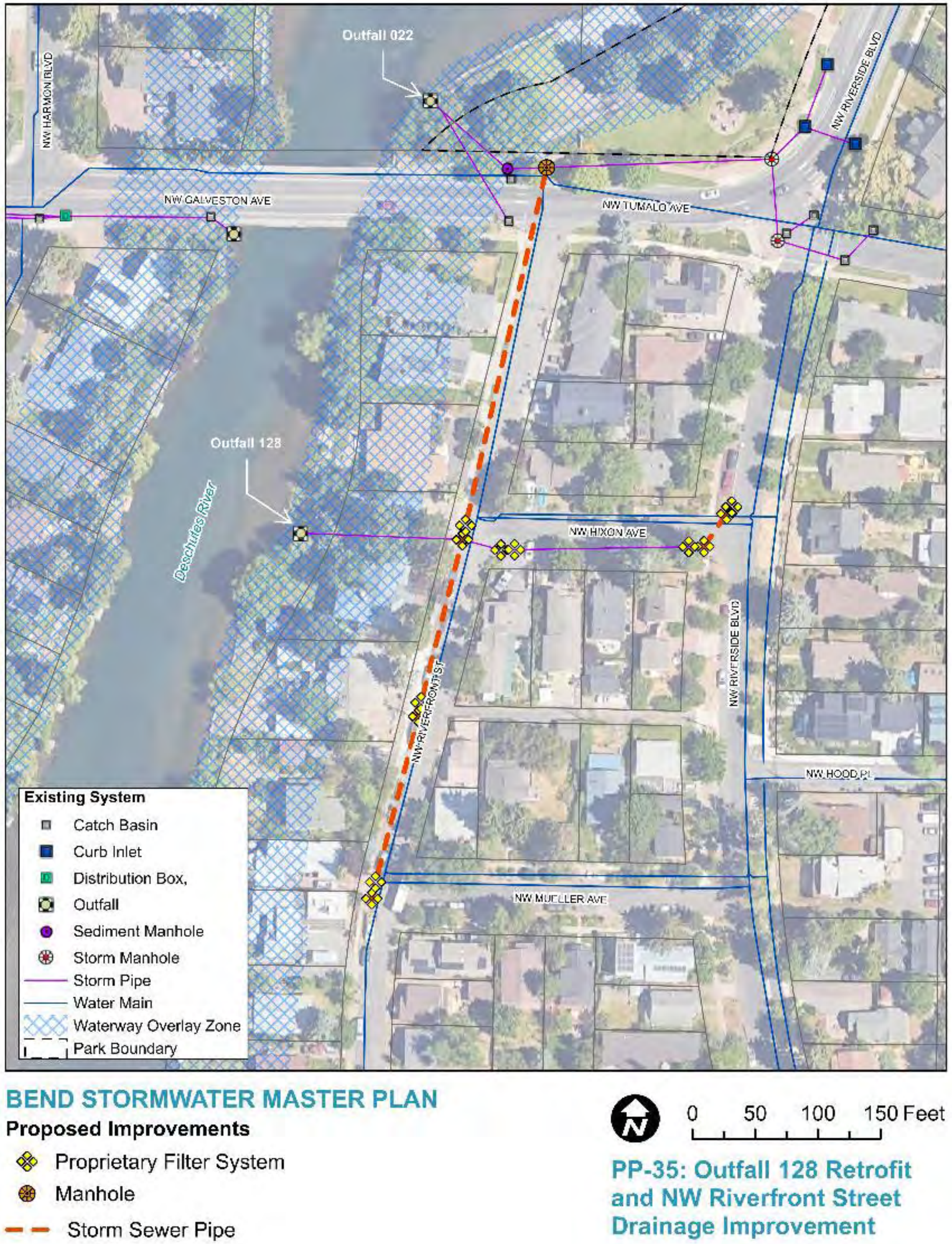
Capital Improvement Project Fact Sheet

Location	**NW Riverfront St & NW Hixon Ave**		
ID	**PP-35**	*Rank*	**1**

Photos of Project Area

NW Riverside looking east down NW Hixon

NW Hixon looking north down NW Riverside



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Example Tool Kit Fact Sheet

Description

Deep Drywell is a subsurface concrete structure with an integrated pre-treatment device and a drilled shaft extending up to 100 feet underground. The purpose of this tool is to prevent localized flooding by collecting runoff from streets and other surfaces. Integrated pre-treatment protects the shaft from sedimentation and protects groundwater quality.

Deep Drywells manage runoff by allowing stormwater to soak into the ground, filtering stormwater through the soil, and recharging groundwater. Deep Drywells are regulated as "Class V Injection Wells" under the federal Safe Drinking Water Act.

Compared to typical drywells, Deep Drywell manages stormwater in a smaller footprint. Because they require drilling equipment and extend deep into the ground, careful siting is necessary to avoid overhead utilities and prevent groundwater contamination.

Uses

Deep Drywells are best used in the following situations:

- Areas with poor infiltration rates at shallow depths, but excellent infiltration capacity at greater depths
- Away from drinking water wells
- Away from areas where pollutants from industry, railroads, and high-traffic roads are present

Benefits

The benefits include:

- Reduce localized flooding
- Integrated pre-treatment is space-efficient
- Groundwater recharge
- Allow development where a municipal storm conveyance system is lacking
- Manage runoff in a smaller footprint than typical drywells

Maintenance needs for Deep Drywells are limited. Periodic inspection is recommended to ensure proper function. Typical maintenance includes removing debris, unclogging inlets, and removing sediment from the sump.

Images (clockwise from top):

1. Drilling deep drywell in Bend
2. Deep drywell installation in progress
3. Completed deep drywell after road surface restoration

Deep Drywell

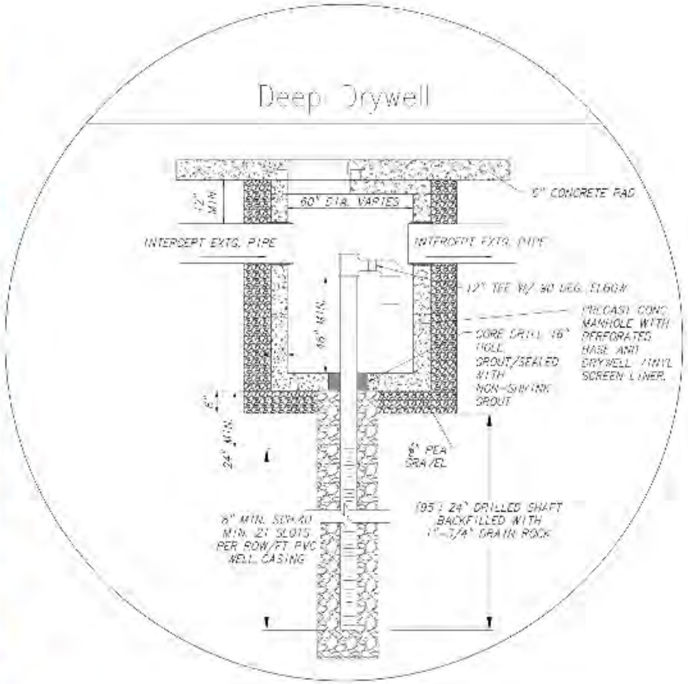
Stormwater Tool Kit Fact Sheet

Drywell is each installed

d for one deep drywell with a 60-
tegrated pre-treatment, with an
deep drilled shaft.

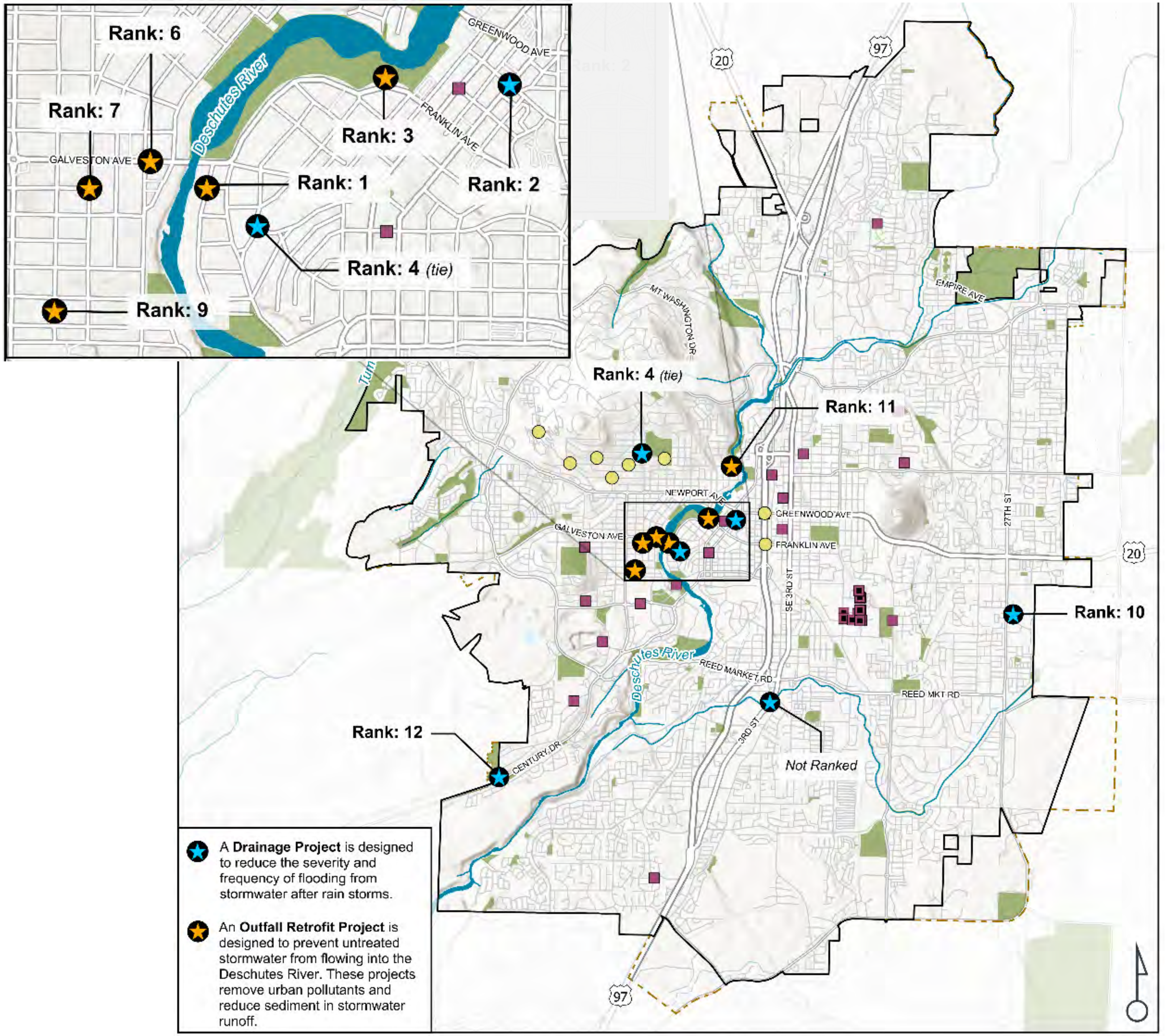
		Unit	Unit Price	Amount
		CY	$150	$4,500
		CY	$120	$1,080
		CY	$120	$1,200
		EA	$14,700	$14,700
		LF	$500	$47,500
12-in Tee with 90 Deg. Elbow	1	EA	$1,050	$1,050
6-in Concrete Pad	1	EA	$2,000	$2,000
Misc. Items	1	EA	$2,500	$2,500
Total				**$74,530**

Per Deep Drywell (Rounded)	**$75,000**



CIP Map

- New Capital Projects
- In Progress Stormwater Capital
- UIC Priorities



A **Drainage Project** is designed to reduce the severity and frequency of flooding from stormwater after rain storms.

An **Outfall Retrofit Project** is designed to prevent untreated stormwater from flowing into the Deschutes River. These projects remove urban pollutants and reduce sediment in stormwater runoff.

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Project Cost Summary – First Draft

Rank	PP-ID	Project Name	Cost (2025 $)
1	PP-35	Riverfront Street Stormwater Outfall 128 Retrofit and Drainage Improvements	$ 930,000
2	PP-42	Downtown Pedestrian Safety Drainage Improvements	$ 800,000
3	PP-44	Drake Park Stormwater Outfall 018 Retrofit and Pipe Repair	$ 4,350,000
4	PP-14	Congress Street Drainage Improvements	$ 1,540,000
4*	PP-46	Vicksburg Drainage Improvements	$ 148,000
6	PP-47	Galveston Stormwater Outfall 020 Retrofit	$ 6,110,000
7	PP-48	Fresno Avenue Outfall 020 Retrofit & Neighborhood Drainage	$ 4,100,000
9**	PP-45	12th Street Stormwater Outfall 024 Retrofit	$ 990,000
10	PP-1	Dove Lane Drainage Improvements	$ 420,000
11	PP-43	Saginaw Avenue Stormwater Outfall 013 Retrofit	$ 2,770,000
12	PP-16	Campbell Road Drainage Improvements	$ 170,000
		Total	**$ 22,328,000**

* There was a tie for 4th place, so there is no 5th place.

** The 8th place project was later removed from consideration because we learned it is infeasible after discussing options with Bend Park and Recreation District.

WAG focus question

- Overall comments on the CIP?

Policy Recommendations

Climate Change

Drainage and Density

Level of Service

Projected Climate Changes in Bend

Increases (~6%) in overall annual precipitation by 2100

- Less precipitation: April – October
- More precipitation: December – March
- More rain and less snow in winter

Increase in frequency and intensity of storms

- Especially during winter months
- Increased intensity of atmospheric rivers

Decline in snowpack

- Decrease in overall mountain snowpack
- Earlier snowmelt means decreased streamflow in summer

Increased severity and duration of drought

- Increased annual number of dry days (from 186 in 1990s to 192 by 2050)

Source: Oregon Watershed Enhancement Board. (September 2023). *Region 4 Observed & Projected Climate Changes.* https://www.oregon.gov/oweb/Documents/climate-R4-variables.pdf

Climate Change Challenges to Bend's Stormwater System

Inappropriately sized design storms for existing conditions

Climate change causing increased intensity and frequency of storm events

Drier summer impacts on water quality

Sedimentation from winter road sanding

Winter precipitation and ice storms clogging drain inlets and causing flooding

Increasing rapid urban development exacerbating impacts

Climate Change – Takeaways & Recommendations

- Build accurate historical rainfall data:
  - Increase data collection with more gauges
  - Build a robust monitoring network.
- Integrate climate change precipitation with downscaled data
- Update design standards; requires time, expertise, and resources.
- An interim approach and prioritization of key projects based on city objectives can help where resources are limited.
- Combine multiple approaches, both quantitative and qualitative.
- Work regionally, across jurisdictions, with universities and Federal agencies to pool resources and coordinate research.
- The science and data is continually evolving and improving. Now is the time to begin!

Drainage & Density Draft Findings Summary

- Centralized on-site stormwater management is allowable under many circumstances, and the policy, procedural, and technical updates needed to support more frequent use of this pattern are relatively minor.

- ROW stormwater management is allowable under limited circumstances, but the City lacks a reimbursement mechanism for managing private runoff in the ROW and may lack procedural mechanisms for approving applications. ROW stormwater management is also complicated by possible utility conflicts and capacity of existing systems.

- Implementing regional SWM requires more study and could be useful in the Central Core and Midtown.

- Adding tools to the toolbox could reduce conflicts of stormwater management with increasing density.

Drainage & Density Examples

Drainage & Density - Recommended Next Steps - Draft

- Policies and Procedures
    - Consider adding stormwater to pre-application materials
    - For infill housing, explore establishing a fee in lieu that would allow runoff to be managed in the ROW in a City-owned facility (BMC 16.50.040.A.4). Set a standard for eligibility, set other technical standards such as classification of the street, and research a fair cost.
    - Consider adopting the flexible stormwater options codified in seven master planned developments (BDC 2.7) for residential developments city-wide with a Type II administrative land division.
    - Coordinate with other departments and BURA to explore options for developing regional stormwater strategies for the Central Core, including the ongoing public improvements in Midtown, and other areas of City focus on economic development.

Drainage & Density - Recommended Next Steps - Draft

- Technical Standards
    - Establish standards for use of deep drywells and stormwater trees on private property and in ROW.
    - Establish criteria for demonstrating compliance with BMC 16.15.040A.4, 16.15.040.A.6, and 16.15.040.A.8 when centralized or ROW stormwater management options are proposed.
- Evaluate Tradeoffs
    - Further evaluate the impacts to funding, operation and maintenance workload, plan review procedures, and staffing if the City wishes to promote the available options for centralized on-site stormwater management and/or increase the options for centralized and ROW stormwater management.

Level of Service

Drainage Response

Maintenance & Repair

Vegetation Management

Inspection

Water Quality

Capital Programs Implementation

Level of Service

- What is level of service?
- What is Bend's current level of service for stormwater management?
- What are the tradeoffs for higher and lower levels of service?
- Which facilities should be publicly maintained?
- What are the next steps?
- When will funding be reviewed?

WAG focus question - survey

- Does Bend’s stormwater “level of service” fall below your expectations, meet your expectations, or exceed your expectations?
  - Key maintenance practices like street sweeping?
  - Addressing nuisance flooding concerns?
  - Thinking about water quality of the river?
  - Erosion control on construction sites?
  - Public education items?

Stormwater Master Plan

Next Steps and Adoption

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Draft Stormwater Master Plan

- Drainage & Density and LOS Recommendations finalized
- Draft plan to be submitted summer 2025
- Will be circulated to WAG
- Available on web site

Adoption and Implementation

- City Council presentation & adoption in fall
- 2026 Fiscal Year EIPD capital budget (draft request) already includes some of the capital priorities to be recommended in the plan
- Begin budgeting for policy recommendations and continued study, where needed
- Begin rate study in late summer
- Permanent SMP web site with implementation tracking

WAG focus question

- What is the strongest argument if the City would want to consider raising rates for stormwater?

Look ahead

June 4, 2025: In-person Tour
11am-12:30pm   Overturf Park

Outcome: *See and discuss practices and standards in the field. Discuss how to better integrate Firewise landscape management with goals for water conservation, native landscapes, erosion control, tree protection.*

July-August, 2025: Summer Break

September 3 & October 1, 2025
11am-12:30pm   Hybrid Meetings (Boyd Acres or MS Teams)

November 5, 2025

11am-12:30pm   New Public Works Building location!!

Thank you!

Accommodation Information for People with Disabilities

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Stormwater Master Plan Update

The City of Bend is updating its Stormwater Master Plan. The updated plan will guide priorities and strategies for managing stormwater as Bend continues to develop while climate change creates more dramatic storm events. Development of this plan will help the City achieve the Council's goal to "ensure water, wastewater and stormwater systems are aligned with the needs of a growing city" and "Protect our watershed through conservation and water stewardship".

The last Stormwater Master Plan, from 2014, identified multiple stormwater flood control and water quality improvement projects. Some of the projects were implemented, but many were not due to limited resources, and in the ensuing 10 years the City has grown, and some infrastructure condition has worsened.

The Stormwater Master Plan update will consider increasing urban density, climate change, our unique geology and high desert geography, and create an updated framework for managing the City's stormwater challenges.

The Stormwater Master Plan update began in spring 2024, with an anticipated adoption of the new plan by the Bend City Council in early summer 2025.

What is Stormwater?

Stormwater is precipitation such as rain, snow, or sleet that collects on and runs off the land. The City's Stormwater Utility Department works to prevent and minimize flooding and protect the quality of water resources, such as the Deschutes River and groundwater.

Community Values

The Deschutes River and surrounding natural environment are cherished resources in Central Oregon. High quality water in the Deschutes River, Tumalo Creek, and in our underlying groundwater aquifer supports a high quality of life for Bend residents, visitors, businesses and fish and wildlife. Appropriate stormwater management is essential to protecting our water resources.

Proper management of stormwater is essential to protecting our community health, infrastructure and property from risks posed by storm events.

CITY OF BEND

Stormwater Challenges

- **Protecting Water Quality**

  Minimizing pollutants in stormwater runoff is one important way to protect our valuable water resources. The City implements protective measures in accordance with discharge permits from the Oregon Department of Environmental Quality (DEQ). Stormwater runoff can carry pollutants such as sediment, oils, herbicides, metals, pesticides, tire and brake pad particulates, and other chemicals from any property or street. The solutions are diverse and involve resources and efforts from the City, Bend citizens, and businesses.

- **Flooding Issues**

  The City has made progress in addressing and actively responding to chronic flooding issues however, certain areas such as the Franklin and Greenwood underpasses require major capital improvements to fully resolve chronic flooding, and many new and smaller flooding issues are causing inconvenience, safety concerns, and occasional property damage throughout Bend.

  Flooding of critical streets and in some neighborhoods continues to be a concern during significant precipitation events. Existing pipes and drainage facilities are aging and in need of repair or replacement. The City must also comply with state and federal permitting regulations that maintain a high standard for protecting water quality.

- **Impacts of Population Growth and Urban Density**

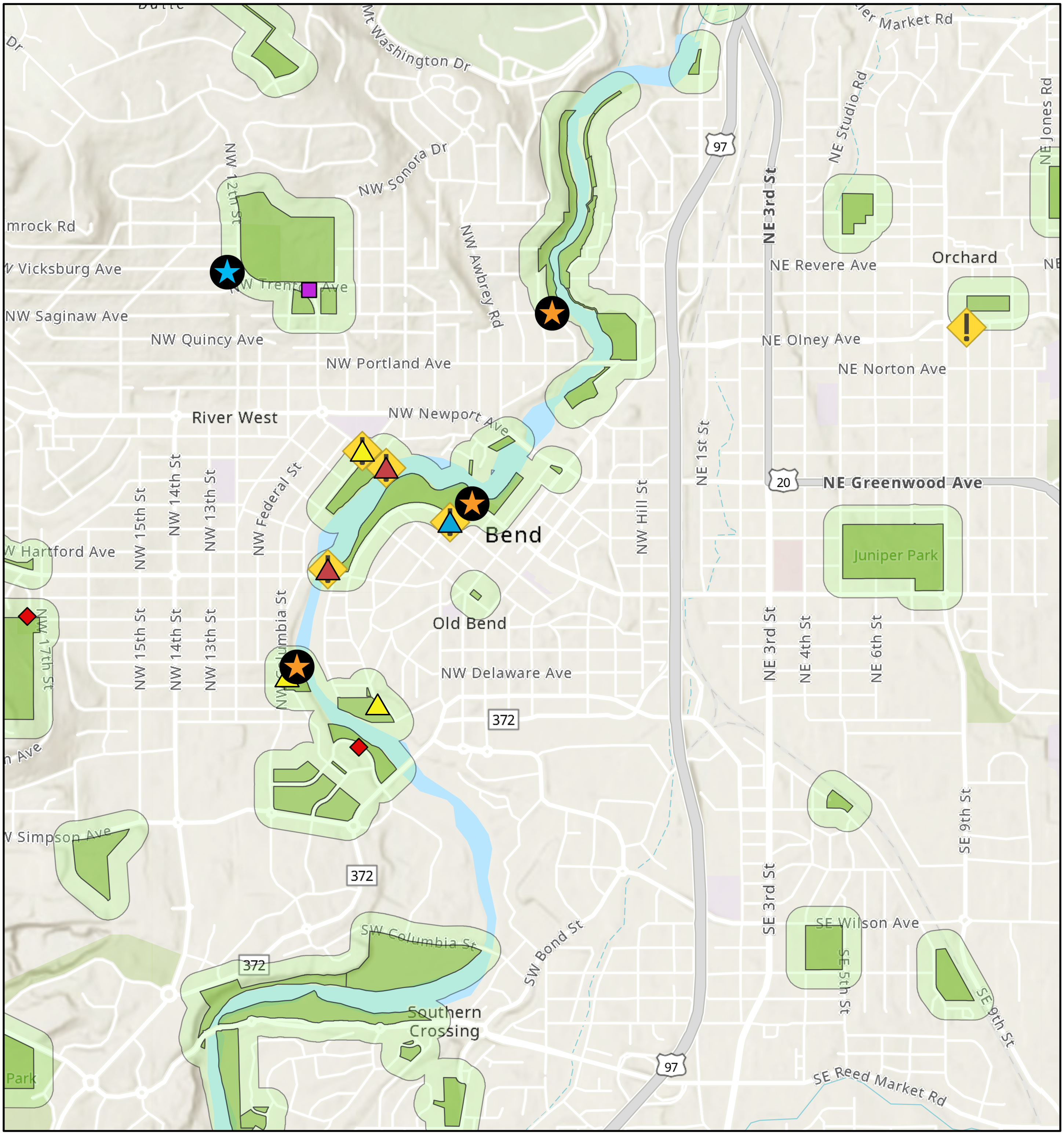
  Bend's population growth and development means there is less open land to absorb precipitation and less space on development sites to install stormwater management facilities, creating more stormwater runoff and a need for new strategies to manage runoff in this increasingly urban environment.

CONTACT

Austin Somhegyi, Sr. Project Engineer | Email: asomhegyi@bendoregon.gov | 541-323-8555

Accommodation Information for People with Disabilities
To obtain this information in an alternate format such as Braille, large print, electronic formats, etc. please contact Austin Somhegyi at asomhegyi@bendoregon.gov or 541-323-8555; Relay Users Dial 7-1-1.

Bend Stormwater Master Plan
Parks and Stormwater Issues/Project Synergy - Discussion Draft



Legend

- 🟪 CIPs In Progress
- ★ Potential CIP Project - Outfall Retrofit
- ★ Potential CIP Project - Drainage
- ◆ Major Maintenance Projects
- ◆ Failing UICs Program
- 🟩 Parks Owned by BPRD
- 🟩 250 ft. Park Buffer

Known Issue Point, by Type

- △ Maintainability
- ▲ Condition
- ▲ Drainage

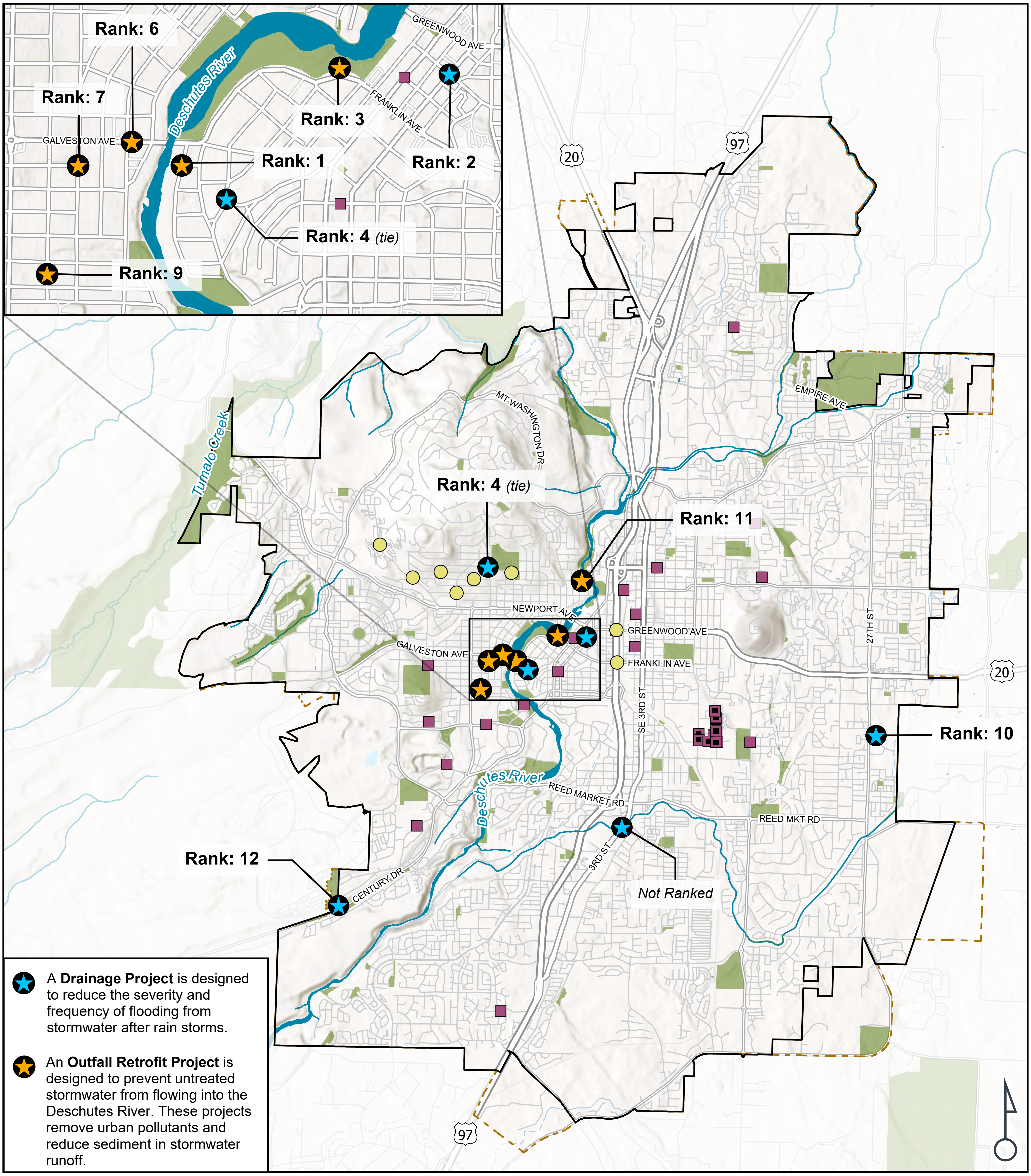
0 0.17 0.35 0.7 mi

0 0.3 0.6 1.2 km

Esri, NASA, NGA, USGS, Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

March 2025

Otak, Inc.



★ A **Drainage Project** is designed to reduce the severity and frequency of flooding from stormwater after rain storms.

★ An **Outfall Retrofit Project** is designed to prevent untreated stormwater from flowing into the Deschutes River. These projects remove urban pollutants and reduce sediment in stormwater runoff.

STORMWATER CAPITAL IMPROVEMENT PROJECTS

BEND STORMWATER MASTER PLAN

BEND, OREGON

Data Sources: City of Bend, Deschutes County, USGS, Google Maps.
Date: 4/22/2025
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

LEGEND

- ★ Stormwater CIP Project - Drainage
- ★ Stormwater CIP Project - Outfall Retrofit
- ● Stormwater CIP Projects (In Progress)
- ▣ Drillhole Retrofit and Rehab
- ■ Failing UICs Program
- ☐ Bend City Limits
- ┅ Urban Growth Boundary
- — Streams

CITY OF BEND

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Appendix G:

Bend SMP Financial Plan

Appendix G

Introduction

This chapter was prepared by FCS, a Bowman company, to provide a financial program that allows the City of Bend (City) stormwater utility to remain financially viable during the planning period. This financial viability analysis considers the current and identified operations and maintenance (O&M) needs, and the financial impacts of capital projects identified in this Stormwater Master Plan (SMP).

Financial Plan

As currently organized and practiced the stormwater utility is responsible for generating revenue to meet all its projected annual costs. The primary source of funding is derived from ongoing monthly service charges, with additional revenue coming from new customer set up fees and investment interest. The City controls the level of stormwater rates and, with City Council approval, can adjust rates as needed to meet financial, strategic and/or policy objectives.

The financial plan can only confirm financial feasibility if it considers the total system cost of providing stormwater services, including both operating and capital. To meet these objectives, the following elements have been completed.

1. **Capital Funding Plan**. Identifies the total capital improvement plan (CIP) obligations of the planning period. The plan defines a strategy for funding the CIP, including an analysis of available resources from rate revenues, existing reserves, debt financing, and any special resources that may be readily available (e.g., grants, developer contributions, etc.). The capital funding plan impacts the financial plan through the assumed rate revenue made available for capital funding and the use of debt financing (resulting in annual debt service).
2. **Financial Forecast**. Identifies future annual non-capital costs associated with the operations, maintenance, and administration of the stormwater system. Included in the financial plan is a reserve analysis that forecasts cash flow and fund balance activity, along with testing for satisfaction of actual or recommended minimum fund balance policies. The financial plan ultimately evaluates the sufficiency of utility revenues in meeting all obligations, including cash uses such as operating expenses, debt service, capital outlays, and reserve contributions, as well as any coverage requirements associated with long-term debt. The plan also identifies the future adjustments required to fully fund all utility obligations in the planning period as defined in the stormwater master plan.

Capital Funding Plan

To properly evaluate future capital funding needs, capital costs were escalated between 3.00 and 3.20 percent annually to the year of planned spending for the majority of capital projects, based on recent trends associated with the Engineering News Record Construction Cost Index. The CIP developed for this SMP identifies $53.1 million in escalated project costs over the 10-year planning horizon from FY2026 - FY2035. The 20-year period through 2045 includes $91.3 million in total escalated project costs.

A summary of the 10-year and 20-year CIPs is shown in **Table 1**. As shown, each year has varied capital cost obligations depending on construction schedules and infrastructure planning needs.

Table 1
10-Year and 20 Year CIPs

Year	Unescalated $	Escalated $
2026	$ 7,807,500	$ 7,807,500
2027	8,850,000	9,070,800
2028	6,950,000	7,275,120
2029	2,950,000	3,049,105
2030	1,950,000	1,950,000
2031	3,665,000	3,995,912
2032	6,355,000	7,153,078
2033	3,405,000	3,629,931
2034	4,450,000	4,861,697
2035	3,895,000	4,345,836
10-Year Total	**$ 50,277,500**	**$ 53,138,978**
2036 - 2045	32,085,000	38,224,688
20-Year Total	**$ 82,362,500**	**$ 91,363,666**

Capital Financing Strategy

An acceptable best practice for capital financing would include the use of grants and low-cost loans when debt issuance is required. However, these resources are very limited and competitive in nature and do not provide a reliable source of funding for planning purposes. It is recommended that the City pursue these funding avenues but assume revenue bond financing to meet the needs which cannot be met by available cash resources. The capital financing strategy developed to fund the CIP identified in this SMP assumes the following funding resources:

- Accumulated cash reserves,
- Transfers of excess cash (over minimum balance targets) from the Operating Fund,
- Interest earned on Capital Fund balances, and
- Future debt issuances.

Capital project funding is split between cash and debt resources with 45 percent of the long-term capital plan funded through cash resources and the remaining 55 percent funded through future debt issuances. **Table 2** presents the 10-year and 20-year capital financing strategy.

Table 2
10-Year and 20-Year Capital Financing Strategy[1]

Year	Capital Expenditures Escalated	Debt Funding	Cash / Reserve Funding	Total Financial Resources
2026	**$ 7,807,500**	$ 3,000,000	$ 4,807,500	**$ 7,807,500**
2027	**9,070,800**	6,500,000	2,570,800	**9,070,800**
2028	**7,275,120**	5,000,000	2,275,120	**7,275,120**
2029	**3,049,105**	1,000,000	2,049,105	**3,049,105**
2030	**1,950,000**	1,950,000	-	**1,950,000**
2031	**3,995,912**	320,912	3,675,000	**3,995,912**
2032	**7,153,078**	7,153,078	-	**7,153,078**
2033	**3,629,931**	179,931	3,450,000	**3,629,931**
2034	**4,861,697**	4,861,697	-	**4,861,697**
2035	**4,345,836**	395,836	3,950,000	**4,345,836**
Subtotal	**$ 53,138,978**	**$ 30,361,453**	**$ 22,777,525**	**$ 53,138,978**
2036 - 2045	38,224,688	19,774,688	18,450,000	38,224,688
Total	**$ 91,363,666**	**$ 50,136,141**	**$ 41,227,525**	**$ 91,363,666**

[1] Fiscal years (FY) with zero cash/reserve funding include projected revenue bond issuances. It is assumed that all capital expenditures will be debt funded in those years.

Financial Forecast

The financial forecast, or revenue requirement analysis, forecasts the amount of annual revenue that needs to be generated by stormwater service rates to meet proposed obligations within the stormwater master plan. The analysis incorporates operating revenues, O&M expenses, existing and new debt service payments for debt-financed capital projects, rate-funded capital needs, and any other identified revenues or expenses related to operations. The objective of the financial forecast is to evaluate the sufficiency of the current level of rates. In addition to annual operating costs, the revenue needs also include debt covenant requirements and specific fiscal policies and financial goals of the City.

For this analysis, two revenue sufficiency tests have been developed to reflect the financial obligations of the City: cash needs must be met; and debt coverage requirements must be realized. To operate successfully with respect to these obligations both tests of revenue sufficiency must be met.

Cash Test – The cash flow test identifies all known cash requirements for the City for each year of the planning period. Typically, these include O&M expenses, debt service payments, directly funded capital outlays, and any additions to specified reserve balances. The total annual cash needs of the City are then compared to projected cash revenues using the current rate structure. Any projected revenue shortfalls are identified, and the rate increases necessary to make up the shortfalls are established.

Coverage Test – The coverage test is based on a commitment made by the City when issuing revenue bonds and other forms of long-term debt. For the purposes of this analysis, revenue bond debt is assumed for any future debt issuance, outside of the confirmed Department of Environmental Quality (DEQ) loan secured for the South Aubrey Butte infrastructure investments. As a security condition of issuance, the City would be required, per covenant, to agree that the revenue bond debt would have a higher priority for payment (a senior lien) compared to most other expenditures; the only outlays that are higher in the bond declaration flow of funds payment order are O&M expenses. Debt service coverage is expressed as a multiplier of the annual revenue bond debt service payment. The current rate covenant for the City's current outstanding bonds state the net revenue generated in any fiscal year must at least equal a) 1.25 times annual bond debt service due in that fiscal year, b) 1.15 times annual bond debt service due in that fiscal year, excluding SDC fees (if applicable), c) 1.0 times the annual bond debt service due in that fiscal year for any subordinated obligations (e.g. low interest loans) and d) any amounts owed by the City to a credit provider for surety premium payments. The excess cash flow derived from the added coverage, if any, can be used for any purpose, including funding capital projects.

The City has a fiscal policy for the stormwater fund of maintaining a minimum debt coverage ratio of 1.50 or "at a level sufficient to protect the credit rating of the system." Along with monitoring the required debt ratios identified in the bond covenant, the financial analysis uses and satisfies the higher 1.50 minimum city policy target.

In determining the annual revenue requirement, both the cash and coverage sufficiency tests must be met, and the test with the greatest deficiency drives the level of needed rate increase in any given year. If a test is failed and no rate action is taken, changes to the operating forecast or capital project timeline would be necessary to achieve sufficiency.

Financial Forecast

The financial forecast is primarily based upon the City's budget through FY 2027 and takes into consideration other key factors and assumptions needed to develop a complete portrait of the City's annual stormwater utility financial obligations. The following is a list of the key revenue and expense factors and assumptions used to develop the financial forecast.

- **Customer Growth –** Rate revenue is escalated utilizing a 1.00 percent growth rate developed based on actual historical trends within the City.
- **Revenue –** The stormwater fund has two general revenue sources: 1) stormwater service charges (rate revenue); and 2) miscellaneous (non-rate) revenue. In the event of a forecasted annual shortfall, rate revenue can be increased to meet the annual revenue requirement. For the purpose of this financial forecast, rate revenues are forecasted to increase with customer growth. Non-rate revenues consist mainly of interest earnings which are calculated based on projected balances and assumed investment rates.
- **Expenses –** O&M expense projections are based on the City's budget through FY 2027 with the following inflationary factors applied:
  - General cost inflation increases of 2.40 percent,
  - Labor cost inflation of 5.26 percent,
  - Benefit cost inflation of 2.40,

- Electricity cost inflation of 3.30 percent,
- Chemical cost inflation of 4.00 percent,
- Investment interest of 2.93 percent in FY 2027, dropping to 1.20 percent thereafter.

Development of the future expense forecast relies on inflationary assumptions that compound annually and can be volatile in nature. In addition to the compounding effects of annual inflation rates, the operating forecast is also driven by internal transfers to fund the new Public Works campus construction as well as rising Public Employees' Retirement System (PERS) rates.

- **Existing Debt –** The stormwater utility has three outstanding Department of Environmental Quality (DEQ) loans and three outstanding Full Faith and Credit (FF&C) loans. The total annual existing debt service obligations begin FY 2026 at $1.7 million and decrease to $1.3 million by FY 2045 as the 2018 and 2021 FF&C loans are repaid. All existing debt will be fully repaid by FY 2047.
- **Future Debt –** The capital funding strategy developed for this SMP forecasts the need for an additional DEQ issuance to fund the South Aubrey Butte project of $15.5 million and three additional revenue bond issuances in FY 2030, FY 2032 and FY 2034, adding $14.9 million in additional debt within the ten-year planning period. Annual new debt service payments are forecast to increase from $1.1 million with the first issuance in FY 2030 to $2.2 million by FY 2035. To fully fund the capital program identified in this SMP, additional debt issuances are required from FY 2036-FY 2045.
- **Transfers to Capital –** Operating fund balance above the minimum requirement is assumed to be available to fund capital projects and projected to be transferred to the Capital Fund each year, if needed. In total, the utility is forecast to fund $12.7 million in capital projects from excess operating fund cash within the 10-year forecast period.

Although the financial plan is completed through FY 2045, the rate strategy focuses on the shorter-term planning period of FY 2026 through FY 2035. As is the current practice, the City will revisit the proposed rates each year to ensure that the rate projections developed remain adequate. The City examines its revenue forecast, operational needs, and capital needs in accordance with its annual rate discussions. Additional financial planning should be performed to reflect any significant changes, and future rates should be adjusted as needed.

Table 3, following, summarizes the annual revenue requirements based on the forecast of revenues, expenditures, fund balances, and fiscal policies.

Table 3
10-Year Financial Forecast

Revenue Requirement	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Revenues										
Rate Revenues Under Existing Rates	$ 6,134,508	$ 6,195,854	$ 6,257,812	$ 6,320,390	$ 6,383,594	$ 6,447,430	$ 6,511,904	$ 6,577,023	$ 6,642,794	$ 6,709,222
Non-Rate Revenues	1,529,300	354,900	112,500	96,219	135,669	90,347	209,081	78,828	166,314	89,241
Total Revenues	**$ 7,663,808**	**$ 6,550,754**	**$ 6,370,312**	**$ 6,416,609**	**$ 6,519,263**	**$ 6,537,777**	**$ 6,720,985**	**$ 6,655,852**	**$ 6,809,108**	**$ 6,798,462**
Expenses										
Cash Operating Expenses	$ 5,962,500	$ 5,536,700	$ 5,698,713	$ 6,113,343	$ 6,656,802	$ 7,110,851	$ 7,502,556	$ 7,391,038	$ 7,833,694	$ 8,143,917
Existing Debt Service	1,732,109	1,658,169	1,658,260	1,569,016	1,568,766	1,568,588	1,568,375	1,568,227	1,568,044	1,567,826
New Debt Service	-	-	-	-	1,097,110	1,155,042	1,568,403	1,755,470	2,051,837	2,185,958
Dedicated Rate Funded Capital	-	-	-	-	-	-	-	-	-	-
Total Expenses	**$ 7,694,609**	**$ 7,194,869**	**$ 7,356,973**	**$ 7,682,359**	**$ 9,322,679**	**$ 9,834,480**	**$ 10,639,335**	**$ 10,714,734**	**$ 11,453,575**	**$ 11,897,701**
Total Surplus (Deficiency)	**$ (30,801)**	**$ (644,115)**	**$ (986,661)**	**$ (1,265,750)**	**$ (2,803,415)**	**$ (3,296,704)**	**$ (3,918,349)**	**$ (4,058,883)**	**$ (4,644,467)**	**$ (5,099,238)**
Annual Rate Adjustment	**8.00%**	**9.90%**	**9.90%**	**9.90%**	**9.90%**	**9.90%**	**5.25%**	**5.25%**	**5.25%**	**5.25%**
Cumulative Annual Rate Adjustment	**8.00%**	**18.69%**	**30.44%**	**43.36%**	**57.55%**	**73.15%**	**82.24%**	**91.80%**	**101.87%**	**112.47%**
Rate Revenues After Rate Increase	$ 6,625,269	$ 7,353,982	$ 8,162,847	$ 9,060,679	$ 10,057,263	$ 11,163,461	$ 11,867,038	$ 12,614,958	$ 13,410,016	$ 14,255,182
Net Cash Flow After Rate Increase	**$ 459,960**	**$ 514,014**	**$ 918,374**	**$ 1,474,539**	**$ 870,253**	**$ 1,419,327**	**$ 1,436,784**	**$ 1,979,052**	**$ 2,122,755**	**$ 2,446,722**

The financial forecast indicates that at existing rate levels the utility will be deficient in FY 2026 as the growth of budgeted expense levels outpaces the growth of revenues. This operational deficiency grows to $1.3 million by FY 2029. In addition to operating expense growth, the utility is planning for future debt service expenses of $1.1 million in FY 2030, growing to $2.2 million by FY 2035. To fully fund the capital program, a total of $12.7 million in rate revenue and reserve funding will be needed over the next ten years.

The financial forecast has incorporated the adopted and implemented 8.00 percent increase for FY 2026. To resolve the remaining forecasted deficiency, rates will need to increase by 9.90 percent annually from FY 2027 through FY 2031, before dropping to 5.25 percent annual increases from FY 2032 to FY 2035.

Current and Projected Rates

The existing stormwater rate is a monthly flat rate that is charged to each customer per equivalent residential unit (ERU). Each single-family customer is considered one ERU. All non-residential customers are charged based on the total amount of impervious surface area on site, which is measured using satellite images. The average single-family residential lot is assumed to be 3,800 square feet of impervious surface coverage. To calculate a non-residential charge, the total impervious surface area of the lot is divided by 3,800 to determine the applicable number of ERUs for the site.

The financial forecast discussed above indicates that the utility will need rate action to satisfy all operating and capital requirements. Rates were approved to increase 8.00 percent in FY 2026. Projected annual increases of 9.90 percent are forecasted from FY 2027 through FY 2031, and 5.25 percent annual increases from FY 2032 through FY 2035.

Table 4 provides a summary of the existing and projected stormwater rates as well as the monthly rate increase per ERU. Based on the projected rate increases, monthly rate impacts range from a high of $1.18 per month to a low of $0.69 per month.

Table 4
Existing and Projected Rates

Projected Stormwater Rates	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Rate per Equivalent Residential Unit (ERU)	$ 8.16	$ 8.97	$ 9.86	$ 10.83	$ 11.90	$ 13.08	$ 13.77	$ 14.49	$ 15.25	$ 16.05
Total Monthly $ increase per ERU		**$ 0.81**	**$ 0.89**	**$ 0.98**	**$ 1.07**	**$ 1.18**	**$ 0.69**	**$ 0.72**	**$ 0.76**	**$ 0.80**

Summary

The results of this analysis indicate that annual rate increases are needed to provide revenue sufficient to cover all financial obligations of the utility, as outlined in the SMP. Beyond the already approved 8.00 percent increase in FY 2026, rate increases are proposed at 9.90 percent annually from FY 2027 through FY 2031, and 5.25 percent annually from FY 2032 through FY 2035.

The analysis performed in this appendix assumes revenue growth and expense inflationary factors discussed previously. If the forecasting factors change significantly, the existing rate strategy will need to be updated and revised.

The rate and capital funding strategy discussed in this financial plan is a planning level document that outlines the revenue levels needed to fund forecasted operating and capital costs. As is the City's practice, the key underlying assumptions that comprise the multi-year financial plan will continue to be updated and revised at least annually, to ensure that adequate revenues are collected to meet the City's total financial obligations. During this annual rate setting process, the City will review capital project implementation timing, operating and maintenance strategies and leadership's general tolerance for rate increases before developing a proposal for consideration. Rate increases are only implemented after executive leadership and Council approval.