City of Duvall

Surface and Stormwater Management Plan

Adopted June 19, 2018

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ABBREVIATIONS

BMP: Best Management Practice
CIP: Capital Improvement Program
CIPP: Cured-In-Place-Pipe
CITY: City of Duvall
CPI-U: Consumer Price Index for All Urban Consumers
DMC: Duvall Municipal Code
ECOLOGY: Washington State Department of Ecology (DOE)
EPA: Environmental Protection Agency
ERU: Equivalent Residential Unit
ESA: Endangered Species Act
FEMA: Federal Emergency Management Agency
FY: Fiscal Year
GFC: General Facility Charge
GIS: Geographic Information System
GMA: Growth Management Act
GSI: Green Stormwater Infrastructure
HPA: Hydraulic Project Approval
HSG: Hydrologic Soil Group
IDDE: Illicit Discharge Detection and Elimination
KCSWDM: King County Surface Water Design Manual
LID: Low Impact Development
NFIP: National Flood Insurance Program
NPDES: National Pollutant Discharge Elimination System
NRCS: National Resources Conservation Service
PAU: Project Assessment Unit
PGIS: Pollution Generating Impervious Surface
PSP: Puget Sound Partnership
PWDDS: Public Works Development Design Standards
ROS: Rain on Snow
SBPP: Snohomish Basin Protection Plan
SBSRF: Snohomish Basin Salmon Recovery Forum
SCSWM: Snohomish County Surface Water Management
SDOT: Seattle Department of Transportation
SEPA: State Environmental Protection Act
SF: Square Feet

SFR: Single Family Residence
SMA: Shoreline Management Act
SMP: Shoreline Master Program
STORM: Stormwater Outreach for Regional Municipalities
SWMP: Stormwater Management Program
TESC: Temporary Erosion and Sediment Control
TIR: Technical Information Report
TMDL: Total Maximum Daily Load
TSS: Total Suspended Solids
UGA: Urban Growth Area
UGAR: Urban Growth Area Reserve
WDFW: Washington State Department of Fish and Wildlife
WRIA: Water Resources Inventory Area
WSDNR: Washington State Department of Natural Resources
WSUE: Washington State University Extension
WWHM: Western Washington Hydraulic Model

EXECUTIVE SUMMARY

Plan Purpose and Intent

This Surface and Stormwater Management Plan (Plan) is an update of the City of Duvall's (City) 1997 Stormwater Management Plan, and was developed with grant funding from the Washington State Department of Ecology's (Ecology) National Estuary Program (NEP).

This Plan describes the City's stormwater system, operations and maintenance of the system, funding and financing program, includes a low impact development (LID) best management practices (BMPs) toolbox, and system needs and recommendations. It also includes five pre-design retrofit reports and an updated Capital Improvement Program (CIP) project list to horizon year 2035. The 6-year CIP project list is updated annually by City Council. As a part of the City's Comprehensive Planning update process, this Plan will be updated every five to eight years, or as otherwise directed by the City Council. This Plan does not include a detailed utility based asset management program.

This Plan update highlights changes to the means and methods in which surface and stormwater has been managed since 1997 as well as project and systemwide accomplishments, and recommends future actions to adapt to changing regulations. Major changes are summarized below:

- Regulatory requirements for the management of stormwater have become more thorough since Ecology issued the Western Washington Phase II National Pollution Discharge Elimination System (NPDES) Permit to the City in 2007.
- New City programs such as annual pipe replacement, Cured-In-Place-Pipe (CIPP) Program, Root removal program, General Old Town Water Quality Improvements Program, and an emphasis on the incorporation of LID BMPs.
- Climate forecasts and studies indicate changing climate conditions that are still uncertain. Planning is required to affectively operate and manage a stormwater utility that protects public health and safety, the environment, and is affordable to operate and maintain.

A detailed framework for the management of the surface and stormwater system and changes since 1997 can be found in Chapter 2.

This Plan is intended to support the adopted goals and policies established by the City's Comprehensive Plan, Watershed Plan, Sensitive Area Ordinance, and Tree Protection Policy. This Plan is an update of (and supersedes) the City's 1997 Stormwater Management Plan. The objectives for this update include:

- NEP Grant Scope of Work:
    - Identify Target Retrofit Subbasins
    - Facilities Mapping & Identification
    - Facilities Analyses and Priority Project Identification (Chapter 5 and Appendix A)
    - Evaluation and Prioritization

    - Conceptual Design Reports for 5-Priority Projects
    - Capital Improvement Program Update (Chapter 7)
    - Funding and Financing Program (Chapter 6)
    - Stormwater Element Document Development and Review (This Plan)
- Review and update operating processes to ensure consistency with the City's:
    - Comprehensive Plan;
    - Watershed Plan;
    - Sensitive Area Ordinance;
    - Tree Protection Policy;
    - Relevant Duvall Municipal Code and Public Works Development Design Standards; and
    - Other Utility operations, management, and funding options.
- Review of regulatory requirements such as the Clean Water Act, Endangered Species Act, and NPDES Permit requirements.

The City's stormwater management systems are key infrastructure resources for the community, wildlife habitat, and the environment. As of 2017, stormwater infrastructure includes over 40 miles of conveyance pipes and ditches along with approximately 170 public and private stormwater facilities and over 2,500 public and privately-owned catch basins. Proper stormwater management provides protection of public health and safety, public and private property, reduction in localized nuisance flooding, enhanced resilience in the face of climate change, and improvements in surface and groundwater quality, and the ecological functions of natural drainage systems.

Plan Use

This Plan is intended to be used by City staff, developers, consultants, residents, business owners, and other interested parties and is adopted by reference in the City's 2015 Comprehensive Plan. By providing strategic direction for effectively managing stormwater facilities and conveyance infrastructure, this Plan will support the City in meeting policy objectives and regulatory standards as new development and redevelopment occurs, as well as allocating capital resources towards system improvements. Along with sensitive areas standards for wetlands, streams, landslide and erosion hazard areas, tree protection standards, and other development standards, this Plan supports the City's watershed based approach for achieving environmental protection, efficient operation and maintenance of stormwater infrastructure, and sustainable growth.

CHAPTER 1. INTRODUCTION

Surface watercourses and stormwater infrastructure support nearly all aspects of stormwater management within the City of Duvall (City). Movement of storm runoff through the landscape from ditches, pipes, and streams to the Snoqualmie River and associated aquifers directly supports fish and wildlife habitats, diverse vegetation, and other environmental features.

Drainage infrastructure within developed areas of the City ensures that storm flows are conveyed away from homes, commercial buildings, schools, and other structures allowing for ongoing use and activity even during Fall and Winter rainstorms. Many of these developed areas have replaced native soils and vegetation with impervious surfaces including roadways, parking lots, roofs and sidewalks. Runoff from these impervious surfaces is concentrated and impacted by pollution from cars and other human activities. For these areas, storm drainage infrastructure has the important role of slowing and treating runoff before it is discharged to wetlands, streams, and ultimately the Snoqualmie River.

This Surface and Stormwater Management Plan is the implementing document for several elements of the City's 2015 Comprehensive Plan. The intent of this Plan is to be consistent with applicable adopted 2015 to 2035 goals and policies which focus on stormwater, watershed and sensitive areas management, while also meeting development and land use goals. This Surface and Stormwater Management Plan will assist the City in maintaining and advancing stormwater infrastructure and low impact development (LID) approaches that meet the 2015 Comprehensive Plan objectives while also addressing existing stormwater needs, supporting the overall vision of the community.

1.1 WHY A SURFACE AND STORMWATER MANAGEMENT PLAN?

The City's stormwater management systems are key infrastructure resources for the community, wildlife habitat, and the environment. As of 2017, stormwater infrastructure includes over 40 miles of conveyance pipes and ditches, approximately 170 public and private stormwater facilities (vaults, detention pipes, ponds, bioswales, and Stormfilter), and over 2,500 public and private catch basins. The Surface and Stormwater Management Plan is a functional document that provides direction for the management of stormwater runoff entering surrounding receiving waters. Proper stormwater management provides protection of public health and safety, public and private property, reduction in localized nuisance flooding, enhanced resilience in the face of climate change, and improvements in surface and groundwater quality, and the ecological functions of natural drainage systems.

1.2 HISTORY OF STORM AND SURFACE WATER MANAGEMENT

The City has evolved from a sparsely populated area of homes and businesses, concentrated around the Old Town center with surrounding farms and rural forest lands, to a developed (and still developing) suburban community in northeastern King County. Before the early 1990's, most residential development occurred without the benefit of formalized stormwater systems. Throughout much of the downtown area, there are no systems that detain or treat storm runoff; flows are conveyed via roadside ditches and pipes to two primary outfalls directly into the Snoqualmie River.

Residential development within the City has significantly expanded since the 1990's. These developments have been required to design and construct stormwater facilities in accordance with the King County Stormwater Design Manual (KCSWDM) as adopted by the City. Early systems provided some amount of storm runoff detention, with very little water quality treatment. Although early systems were adequate for development at the time, rapid residential development within the eastern portion of the City has increased runoff rates beyond capacities of downstream systems, or has changed the timing and volumes (hydroperiods) of conveyance to small, tributary streams within the City, such as Coe-Clemmons Creek and Thayer Creek.

In 1994, the City formed a Storm Drainage Utility, as codified within Duvall Municipal Code (DMC) Chapter 9.06. The Utility was established shortly before Public Works first efforts to complete a Stormwater Management Plan, which was adopted in 1997.

What is Low Impact Development?

Low Impact Development (LID) is a stormwater and land use management strategy that strives to mimic pre-development hydrologic processes (i.e., infiltration into the ground, evaporation and transpiration by plants, and storage in wetlands, floodplains and the ground) by emphasizing conservation and use of on-site natural features, site planning, and distributed stormwater management practices that are integrated into project design.

The City became a National Pollutant Discharge Elimination System Phase II Permit (NPDES Permit) holder in 2008. Coverage under the Phase II NPDES Permit authorizes discharge of stormwater to waters of the United States in accordance with the Federal Clean Water Act. Discharges covered under the NPDES Permit must effectively prohibit non-stormwater discharges into storm sewers that drain to surface waters and must apply controls to reduce the release of pollutants. Additional NPDES Permit requirements include illicit discharge detection and elimination (IDDE), implementation of updated requirements for new development and redevelopment, and requirements for operations and maintenance. By the time the NPDES Permit was reissued in August 2013, overall thinking about stormwater management had shifted to an emphasis on LID. Consistent with this emphasis, the City requires new development to consider LID stormwater best management practices (BMPs) consistent with the 2016 KCSWDM, and has developed this Plan to provide additional tools for appropriate use of LID BMPs.

Regional and national changes have occurred in the way surface and stormwater are managed, with a clearer recognition of impacts to natural resources and aquatic species. The 1999 listing of Puget Sound Chinook Salmon as a threatened species under the Endangered Species Act (ESA) resulted in widespread regional surface water management changes to prevent the further decline of the species, and promote salmon population recovery. With an eye toward environmental protection and meeting Washington State Growth Management Act (GMA) requirements, the City completed comprehensive updates to Sensitive Area protection policies for streams and wetlands in 2005, including standards for surface and stormwater management facilities and discharges to these natural surface water features. The City completed additional updates to Sensitive Area and Tree Protection policies in 2018.

In a continued effort to comply with policies and regulations, DMC Chapter 9.06 has been revised several times to incorporate use of the current KCSWDM. Additionally, this chapter establishes a system of development fees and service charges to support Public Works implementation of Strom Drainage Utility programs. Many of the recommended capital projects listed in the 1997 Stormwater Management Plan have been implemented, and the City has grown significantly in the last 20 years. Residential subdivision has continued to occur throughout City limits, with corresponding increases in the network of stormwater management facilities and conveyance infrastructure.

The Storm and Surface Water Plan is organized as follows:

Chapter 1 - Introduction: Describes the purpose of this Plan, the history of storm and surface water management in the City, and the policy and regulatory setting.

Chapter 2 - Storm and Surface Water Management Background: Provides an overview of the City's current Stormwater Program and NPDES Phase II Permit compliance, accomplishments since adoption of the 1997 Stormwater Management Plan, and an introduction to the challenges and opportunities of stormwater management.

Chapter 3 - Watershed and Land Cover Conditions: Presents information on the City's subbasins, surface waters, geologic and soil conditions, and other natural resources; summarizes existing land cover and subbasin alterations, and retrofit opportunities based on subbasin conditions.

Chapter 4 - Storm and Surface Water System Description: Inventory of existing flow control and water quality facilities, conveyance systems, and drainage/erosion/water quality concerns.

Chapter 5 - System Analysis: Summary of analysis completed in support of stormwater infrastructure assessment and prioritization of retrofit actions; introduction of retrofit options useful within the City; and summary of prioritized retrofit project evaluations and predesign efforts.

Chapter 6 - System Improvements: The Capital Improvement Program (CIP) project list, estimated cost, and action options useful for each*;* and implementation schedule, performance measures, and strategies for CIP effectiveness.

Chapter 7 - Funding and Financing Program: Summary of existing fiscal policies and utility status, revenue requirements, and recommendations.

Chapter 8 - Operations and Maintenance: Overview of ongoing O&M, review of O&M best management practices, and recommendations.

Chapter 9 - Policies and Regulation: Overview of existing stormwater policies and recommendations for programmatic opportunities for surface and stormwater management.

1.3 POLICY AND REGULATORY FRAMEWORK

This section provides a summary of the policy and regulatory basis under which the Surface and Stormwater Management Plan was developed. In addition to complying with **NPDES Municipal Stormwater Permit Requirements**, the City recently adopted the **2015 Comprehensive Plan** and **2015 Watershed Plan**. These planning documents provide goals, policies, and action for management of surface waters and stormwater within the City. In addition, previously adopted priorities and policies in the existing **1997 Stormwater Management Plan** are summarized.

This Plan is intended as an implementing tool to meet City-adopted surface and stormwater policy and regulatory requirements. Chapter 9, Section 9.1.1 details the policies summarized in this section.

1.3.1 NPDES MUNICIPAL STORMWATER MANAGEMENT PROGRAM

The City is a Phase II community under the NPDES Western Washington Municipal Stormwater Permit (Washington State Department of Ecology (Ecology) permit through the United States Environmental Protection Agency [U.S. EPA]). As a permittee, the City must create and implement a Stormwater Management Program (SWMP) which addresses five required program elements:

1. Construction Site Run-Off
2. Illicit Discharge Detection and Elimination
3. Operations and Maintenance of Post Construction Stormwater Facilities
4. Public Education and Outreach
5. Public Involvement and Participation

The City maintains a Stormwater System Information webpage, which includes SWMP Annual Reports and other resources related to the City's stormwater systems. Ecology also maintains a resource webpage for each of the five required SWMP elements. The 2018 NPDES Permit requires permittees to require LID principles and LID BMPs. The intent of this requirement is to make LID the preferred and commonly-used approach to site development.

1.3.2 2015 Comprehensive Plan

The City's recently adopted 2015 Comprehensive Plan includes goals and policies that are directly relevant to the management of surface and stormwater infrastructure. These goals and policies, along with NPDES Phase II Permit requirements, provide the primary framework guiding development of the Surface and Stormwater Management Plan Update. The primary goal and associated policies for stormwater management is included in the Capital Facilities Element - Chapter 7:

Goal CF-8: Duvall's stormwater management system is effective, efficient, and enhanced to meet present and future population needs.

Additional relevant goals and policies are included in the Land Use Element (Chapter 2) and the Environment and Sustainability Element (Chapter 8) of the 2015 Comprehensive Plan. For some of the goals, only one or two of the underlying policies are relevant. All relevant goals and policies from the 2015 Comprehensive Plan are listed in Section 9.1.1 of this Plan.

1.3.3 2015 Watershed Plan

The 2015 Watershed Plan (WSP) provides guidance for improving stormwater management in the City based on watershed assessment results and the subbasin management groups established by that Plan (Figure 1-1). Subbasin management groups provide a system for regulating land use and associated development that protects and mitigates allowed impacts for high-functioning watershed processes, and that facilitates more intense land use activities to less sensitive subbasins.

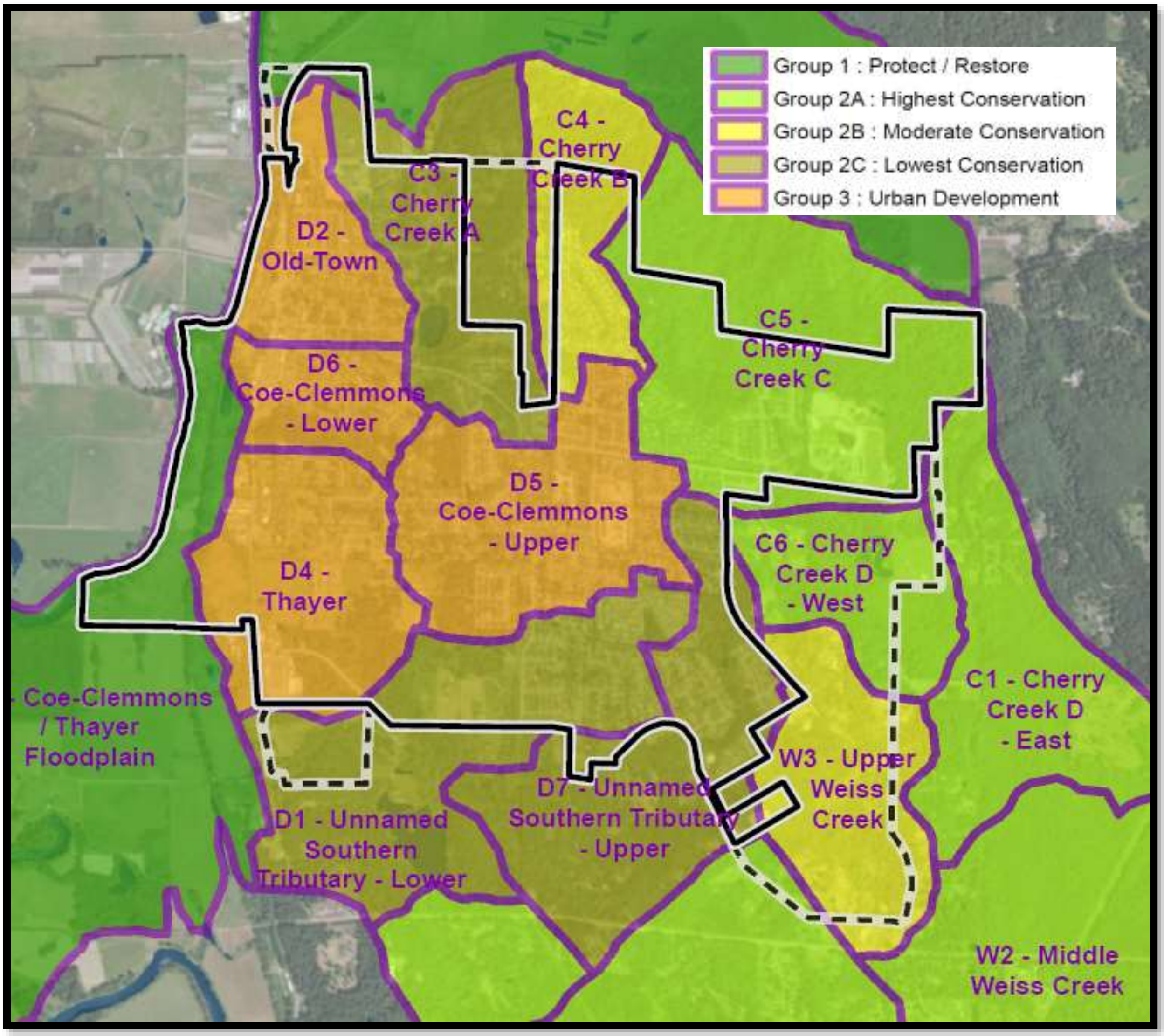

Figure 1-1. City of Duvall Watershed Plan - Subbasin Management Designation

The WSP establishes policies and prioritized actions relying on the subbasin management group framework. Each action was reviewed by a project Advisory Committee (including City staff from Public Works and Planning, and City Council and Planning Commission representatives) and ranked by feasibility and importance for achieving the City's watershed management goals. A series of actions were identified as directly relevant to management of surface and storm water from both existing uses and future development:

- Actions SW-1 and SW-3: Defining and requiring the most useful and applicable LID BMPs in new development activities, including consideration of site/development scale.
- Action SW-2: Improve soil amendment BMPs established by City code for ease of understanding and enforcement.

- Action SW-4: Establishing an expanded flow control exemption for portions of the City that are predominantly built-out and already drain directly to the Snoqualmie River through pipe and/or ditch infrastructure.
- Action SW-5: In UGAs, explore opportunity for centralized stormwater facilities to off-set onsite detention requirements.
- Action SW-6: Incentivize stormwater LID standards.
- Action SW-7: Adjust the landscape strip for street trees to be a minimum of 6-8 feet in width to ensure adequate space for successful growth, and encourage even wider landscape strips with integrated stormwater treatment and infiltration through incentives.
- Action SW-8: Specific suggestions for enhancement of the current City NPDES educational outreach program.

1.3.4 1997 Stormwater Management Plan

Although dated, the City's 1997 Stormwater Management Plan was reviewed for identified goals and policies. The following Water Quality Program goals were established and emphasized given "enforcement by the U.S. EPA of the NPDES Permits as a requirement of Clean Water Act":

1. Identify and document the locations, sources, and magnitude of water quality problems within the existing drainage system.
2. Institute a program of water quality source control measures, including an expanded operation and maintenance program, regulation of development and private property, and public education with respect to water quality issues.

CHAPTER 2. SURFACE AND STORMWATER MANAGEMENT BACKGROUND

2.1 CURRENT STORMWATER MANAGEMENT PROGRAM OVERVIEW

This section provides a summary of current SWMP components, consistent with adopted Storm Drainage Utility (DMC Chapter 9.06) and NPDES Permit requirements. Additionally, this section summarizes connections to other related programs and requirements under which operations and maintenance, capital improvements, new development, and redevelopment activities must be completed.

The SWMP is implemented consistent with NPDES Permit Section S5.A. The SWMP is designed to reduce the discharge of pollutants from City infrastructure, to the maximum extent practicable, and to protect water quality.

2.1.1 PROGRAM COMPONENTS

The following sections detail current SWMP components, as required by the NPDES Permit and as currently implemented within the City.

Public Education and Outreach

The City's SWMP includes an education program aimed at residents, businesses, elected officials, and City staff. The goal of the education program is to reduce or eliminate behaviors and practices that contribute to adverse stormwater impacts. Public Works staff coordinate with the Snoqualmie Watershed Forum (interagency collaboration with King County Water & Land Resources Division and Snoqualmie Valley cities), King Conservation District, Riverview School District, and non-governmental organizations – namely, Stewardship Partners.

The City has developed and maintains a stormwater webpage to help increase public awareness of stormwater related issues and provide links to useful information from other sources (City of Duvall, 2018).

Public Works staff track and maintain records of public education and outreach activities, including documentation in SWMP Annual Reports. Recent and ongoing public education and outreach activities include:

- Educational activities for children and adults at Earth Day and Public Works Open House events.
- Presentations to local elementary school classes.
- City newsletter information and education updates.

- Distributing information at City Hall and specific events (Duvall Days, Farmers Market).
- Education and outreach information and links on the City's Stormwater webpage.
- Annual City-sponsored recycling event including used motor oil and household hazardous waste recycling.
- Collaboration with the Stormwater Outreach for Regional Municipalities (STORM) campaign.
- Summarizing public education and outreach activities in the SWMP annual report.
- Utility bill inserts to reach households within the City, addressing various topics including:
    - Landscaping and Yard Care design, plant selection, mulch, fertilizers, pesticides, herbicides, and compost/disposal.
    - Car washing
    - Proper disposal of household waste, recycling, storm drain awareness, and proper disposal of hazardous household waste (paint, hydrocarbons, and antifreeze).
- Strategies to track outreach and education program success, including:
    - Community surveys (including previous comprehensive Stormwater Community Survey Program with other NPDES municipalities; (Klima & Buttenob, 2009)).
    - Utility billing questionnaires.

Potential Future Activities: In recent years, the City has considered implementation of additional public education and outreach activities such as:

- Installing storm drain buttons and completing storm drain stenciling including "Adopt a Drain" neighborhood stenciling and "Puget Sound Starts Here" storm drain button programs.
- Developing an Illegal Dumping and Littering program including additional awareness, signage, and trash receptacles.
- Developing natural yard care education programs.

Public Involvement and Participation

All updates to the City's SWMP and adopted Storm Drainage Utility standards over the last 20 years have been reviewed and adopted through required public involvement and participation. City Council consideration of new or updated policies include opportunity for public comment prior to Council action. In addition, recent development of the City's 2015 Watershed Plan included public and stakeholder participation through an Advisory Committee, Open House, Planning Commission review, public workshops, City Council review, survey input, and public hearings. Similar public involvement and participation efforts were completed prior to adoption of the 2015 Comprehensive Plan. As such, policies related to surface and stormwater management within the Watershed Plan and the Comprehensive Plan (detailed in Chapter 9) were adopted after opportunities for public input.

This Plan highlights the City's most recent effort to include public involvement and participation. Plan development, including analysis and prioritization for retrofit of existing facilities and strategies for future development, included input from a technical stakeholder group. This stakeholder group included City staff, technical advisors, elected officials, and members of the public. Four stakeholder group meetings were held in 2017 with additional input throughout Plan development from the group and at City Council and Planning Commission presentations.

Illicit Discharge Detection and Elimination (IDDE)

The City's SWMP includes an ongoing program to detect and remove illicit connections and discharges as defined in the Code of Federal Regulations (40 CFR 122.26(b)(2)). The IDDE program addresses improper dumping and disposal including any spills into stormwater infrastructure owned and operated by the City.

Public Works has ongoing Geographic Information System (GIS) map data collection and digitization procedures in place. Through recent efforts, the City's current stormwater system has been completely mapped and attributed within a GIS geodatabase. Updating stormwater system mapping and attributes will continue as additional system data is collected and as new development and redevelopment projects are completed in the City. The stormwater geodatabase is used by Public Works to identify upstream sources of illicit discharge, when detected.

Public Works maintenance crew personnel actively search out illicit connections during catch basin cleaning as well as respond to:

- clogged storm drains;
- accidental spills; and
- other illicit discharges.

Staff Training: The City ensures that all Public Works Maintenance Crew personnel who are responsible for identification, investigation, cleanup, and reporting of illicit discharges are trained to conduct these activities. Annual training is provided as needed to address changes in procedures, techniques or requirements. The City documents and maintains records of staff trained.

Controlling Runoff from New Development, Redevelopment, and Construction Sites

The City enforces standards to reduce pollutants in stormwater runoff from new development, redevelopment and construction site activities consistent with NPDES Permit requirements. DMC 9.06.030 adopts the current edition of the KCSWDM (King County, 2016b). The City supplements the adopted KCSWDM with Duvall-specific requirements for small (DMC 9.06.040) and large (DMC 9.06.050) parcels. This gives the City Engineer additional authority to ensure that detention and water quality approaches mitigate potential downstream impacts to the maximum extent feasible.

Summary of Review, Permitting and Inspection Process: Public Works staff complete plan review, inspection, and enforcement for all project types using qualified personnel as defined by the NPDES Permit. The following steps are a general representation of these procedures:

1. Review of all stormwater site plans for proposed development activities, including Temporary Erosion and Sediment Control (TESC) Plans for construction activities, as well as drainage plans and supporting Technical Information Reports (TIRs) for the proposed development.
2. Inspect, prior to clearing and grading, all known development sites that have a potential for sediment transport.
3. Inspect all known permitted development sites during construction to verify proper installation and maintenance of required TESC BMPs. Enforce as necessary based on the inspection.
4. Inspect all permitted development sites upon completion of construction and prior to final approval or occupancy to ensure proper installation of permanent stormwater BMPs.
5. As part of stormwater site plan review and approval, verify an operations and maintenance plan is completed and responsibility for maintenance and ownership is assigned. Enforce as necessary based on inspection.
6. Document completion of all inspections.

Municipal Operations and Maintenance

In accordance with Section S5.C.5 of the NPDES Permit, the SWMP includes a pollution prevention and operation and maintenance program for municipal operations. This City program went into effect prior to the February 15, 2010 permit deadline and includes established operational BMPs and a training component with the goal of preventing or reducing runoff from municipal operations. The City program to control runoff from municipal operations is summarized in Appendix D of the City's 2017 SWMP Report (City of Duvall, 2018b). Operations and maintenance is discussed in more detail in CHAPTER 8.

Compliance with TMDL Requirements

Total Maximum Daily Load (TMDL) requirements from Section S7 of the NPDES Permit do not apply to the City because there are no TMDL's listed for the City (Ecology, 2018d).

Monitoring

Public Works is not required to implement a program of monitoring for the SWMP, because the City's population is less than 10,000 residents, and there are no listed TMDL's for the City. The City participates in SWMP effectiveness monitoring as part of the "Stormwater Monitoring Work Group" (Ecology, 2018).

Potential Future Activities: In previous annual SWMP reports, the City has considered implementing the following additional monitoring activities:

- Identifying outfalls or conveyances where stormwater sampling (flow, temperature, etc.) may be conducted.
- Summarizing monitoring activities in future annual SWMP reports.

Annual Reporting Requirements

During the first quarter of each year, Public Works staff submit an annual SWMP report to Ecology to meet NPDES Permit reporting requirements for the previous year. Public Works staff ensure that annual SWMP reports and all other records related to NPDES Permit requirements are made available to Ecology and the public for at least the five most recent years (City of Duvall, 2017a).

Each annual SWMP report includes the following information:

- Reference to the City's current adopted SWMP, storm drainage utility standards, and administrative rules relevant to NPDES Permit compliance.
- Status of implementation of each component of the SWMP consistent with NPDES Permit requirements (Sections 1 to 6), including assessment of progress towards meeting minimum measures associated with each Section.
- Description of activities implemented to comply with each component of the SWMP, including details on inspections, enforcement actions, public education and outreach activities, and IDDE (reporting includes numbers and types for all activities).
- An assessment of the relevance of BMPs identified by Public Works for each NPDES Permit requirement, and documentation and rationale of any changes made, or anticipated to be made, to BMPs that were previously selected to implement the SWMP.
- Details on implementation schedule and plans for meeting NPDES Permit deadlines for all NPDES Permit requirements where minimum measures have not been achieved.
- Any updated information to supplement prior annual reports, and any new relevant information received during the reporting period. Including any storm and/or surface water monitoring or studies conducted by Public Works or other entities for subbasins within Duvall and urban growth areas.
- Notification of any annexations, incorporations or jurisdictional boundary changes and inclusion of implications for SWMP.
- Certification and signature pursuant to the NPDES Permit, and notification of any changes to authorization.

2.1.2 COORDINATION WITH OTHER PROGRAMS AND PERMIT REQUIREMENTS

A variety of land use and resource management regulations and permit requirements contribute to planning and designing stormwater infrastructure. Table 2-1 provides a summary of applicable regulations, permit requirements, and programs, and their relevance to the City.

Table 2-1. Summary of Federal, State, and City implemented regulations and programs related to surface and stormwater management.

Law	Program	Intent	Relevance to the City's Stormwater Program
Clean Water Act / Federal	NPDES Phase II MS4 Permit (Ecology, 2018a)	Regulate stormwater and wastewater discharges to waters of the state, to protect and restore surface water quality.	The NPDES Permit authorizes the discharge of stormwater to surface and ground waters from Duvall's storm drainage system. The 2013-2018 NPDES Permit is in effect as of August 1, 2013 with the latest modifications effective as of January 16, 2015. The permit requires that the City implement a Stormwater Management Program and submit annual progress reports to the Ecology (City of Duvall, 2017a).
	Water quality standards (303(d) list) (Ecology, 2018b)	Protect and restore waters so they are suitable for fishing and swimming.	Every two years, states are required to submit a Water Quality Assessment for surface waters in the state to the EPA. The Ecology compiles water quality data and waters impaired by pollutants are placed on the 303(d) list. Water bodies on the list require a water cleanup plan, typically a total maximum daily load (TMDL) prepared by the Ecology, for each pollutant at levels greater than the water quality standards. TMDL projects can impose additional requirements on NPDES permittees. The City does not currently have any waters on the 303(d) list.
	Sections 401 (Ecology, 2018c) and 404	Protect water quality during project construction and operation in waterways	Activities that may discharge dredge or fill materials to Waters of the United States require a Section 404 permit from the U.S. Army Corps of Engineers. Any applicant for this permit must also obtain a 401 Water Quality Certification issued by the Ecology to confirm that the discharge will comply with state water quality standards.

Law	Program	Intent	Relevance to the City's Stormwater Program
Tribal Agreements and Related Case Law / Federal	Tribal Consultation, for In-Water work, Biological Assessments, and other planning efforts and permits in Duvall	Protect fisheries and other natural resources / tribal resources	The City seeks input from Environmental and Natural Resources of the Snoqualmie Tribe during SEPA review and Shoreline Permit review for development proposals and programs with the potential to affect fish habitat and water quality such as projects involving in-water work and/or new stormwater outfalls. A representative of the Snoqualmie Tribe was a member of the Watershed Planning Advisory Group, which contributed to the development of the City's Watershed Plan, which informed the City's Comprehensive Plan Update process.
National Flood Insurance Act, Flood Disaster Protection Act / Federal	National Flood Insurance Program (NFIP) (FEMA, 2018)	Reduce threats to property and public safety from flooding.	The City administers regulations on development within the floodplain, primarily through DMC Chapter 14.84, but the NFIP identifies minimum standards that must be met to maintain program participation. In exchange for the City adopting these requirements, property owners can purchase flood insurance at considerably reduced rates.
Endangered Species Act (ESA) - Federal	Listing of Chinook salmon, steelhead, and bull trout as threatened species.	Prevent further decline of the species by regulating or prohibiting "take" of the species, and designating the species' critical habitat	Chinook salmon, steelhead and bull trout are federally listed as threatened species (since 1999, 2007, and 1999, respectively). All three species of fish are present in the Snoqualmie River. The City participates in Water Resources Inventory Area (WRIA) 7 salmon conservation planning through the Snoqualmie Watershed Forum and other programs. Surface and stormwater management implications for Chinook salmon, bull trout, Coho and other salmonid population habitats include: water temperature, pollutant loading, hydrologic changes, and spread of invasive/noxious plant species.

Law	Program	Intent	Relevance to the City's Stormwater Program
	Snohomish Basin Protection Plan SBPP (Snohomish County Surface Water Management, King County Snoqualmie Watershed Forum, Tulalip Tribes Natural Resources Department, 2015).	Provide direction on recovery actions that will protect fish and wildlife habitat by protecting hydrology.	The 2015 SBPP examined tools that help support the goal of improving hydrologic processes, focusing on protection, not restoration. The City utilized this approach and protection tools by incorporating a watershed planning effort. The 2015 Comprehensive Plan contains goals and policies supporting salmon habitat, including removing existing (and preventing future) fish barriers.
	Snohomish River Basin Salmon Conservation Plan (Snohomish County Department of Public Works, Surface Water Management Division, 2005)	Develop a local salmon recovery response in coordination with regional efforts, focused on habitat protection and restoration.	The City is a member of the Snohomish Basin Salmon Recovery Forum (SBSRF), which adopted the Plan in 2005. The Plan presented a 50-year vision for salmon recovery and focused on specific goals to be accomplished over ten years. It contains specific recommendations for managing stormwater for salmon habitat and water quality protection.
State Environmental Policy Act (SEPA) - State		Identify and analyze probable environmental impacts of a proposal and modify or deny a proposal to avoid, reduce, or mitigate for these impacts.	The City reviews proposals and issues SEPA determinations. Any agency "action" that is not categorically exempt requires SEPA environmental review. Actions can include specific project actions such as the construction of a City facility, and non-project actions such as updates to stormwater regulations.
Shoreline Management Act (SMA) - State	City of Duvall Shoreline Master Program (SMP) (City of Duvall, 2016)	Protect shoreline resources (ecological, economic, aesthetic) and encourage shoreline land uses that enhance and conserve shoreline functions and values. Implemented by DMC Chapter 14.78.	The City is in the process of updating its Shoreline Master Program, last updated in 1974, to comply with SMA requirements. The SMP contains regulations for managing shoreline in the City. This includes where stormwater facilities may be located and measures required to minimize impacts of stormwater runoff within shoreline jurisdiction.
Hydraulic Code – State	Revised Code of Washington	Protect fish and their habitat	Since 1943, hydraulic projects that will "use, divert, obstruct, or change the natural flow or bed of state waters" must obtain a Hydraulic Project Approval (HPA) from Washington Department of Fish and Wildlife WDFW (Washington Department of Fish & Wildlife, 2018).

Law	Program	Intent	Relevance to the City's Stormwater Program
Growth Management Act – State	City Comprehensive Plan, City zoning and critical areas regulations	Regulate land use and growth while providing essential public facilities and services and protecting sensitive environmental resources	The 2015 Duvall Comprehensive Plan and supporting municipal code regulations address surface and stormwater goals, BMPs, and regulations.
Puget Sound Partnership (PSP) - State	Action Agenda (Puget Sound Partnership, 2016)	Protect and restore habitat and economic resources in Puget Sound	The Action Agenda outlines strategies and specific actions needed to protect and restore water quality, quantity, and habitat, in Puget Sound, and the entire watershed. One of the Strategic Initiatives of the Action Agenda's Implementation Plan is to prevent pollution from stormwater runoff. Although the PSP has no regulatory authority, it creates funding incentives for advancing Puget Sound recovery goals. For example, stormwater retrofit efforts prioritizing restoration of natural stream flows and cool, unpolluted waters would contribute directly to meeting recovery targets established in the Action Agenda.

2.2 ACCOMPLISHMENTS SINCE 1997 STORMWATER MANAGEMENT PLAN

The following highlights City efforts, investigations, and capital improvements completed in the last 20 years:

2003: NPDES Permit regulations went into effect.

2003: City removed two Thayer Creek culverts in the Snoqualmie floodplain (within McCormick Park), restoring channel and surrounding riparian vegetation, replacing the culverts with precast concrete bridge spans.

2005: City installed two beaver deceivers in Coe-Clemmons Creek to discourage beaver dam construction that can obstruct fish migration in the stream.

2007: Ecology issued the Western Washington NPDES Permit. Requirements are phased in throughout the five-year permit period. Permit was modified in 2009 to be effective through July 31, 2013. Duvall implemented the following programs and policies as required by the NPDES Permit:

- Public education and outreach program to lessen behaviors and practices that cause or contribute to adverse stormwater impacts.

- Illicit Discharge Detection and Elimination (IDDE) Program, including components for the public and Public Works Municipal Operations & Maintenance activities.
- Additions to the City's reporting efforts included: Public involvement and participation program, public hotline comment and reporting number, and the City's stormwater web page. Also included in these efforts - completing public notices, City Council presentations, and other public presentations; to collect, document, and implement public feedback.

August 2009: Adopted City Ordinance No. 1090, DMC Section 9.06.35, which addresses runoff from new development, redevelopment, and construction sites, while also prohibiting illegal discharges, and/or dumping into the stormwater system.

- Implemented a training program for staff responsible for implementing these new regulations.

August 2010: Adopted City Ordinance No. 1098 – adopting the 2009 KCSWDM.

2010: City received a grant from Snoqualmie Watershed Forum to remove knotweed along the Snoqualmie and in the floodplain.

2011: Carrie Rae Pond Retrofit. Utilized $155,020 in Stormwater Retrofit grant funding from Ecology. This project included retrofitting a 4,000-square foot pond that was constructed as a flow-through stormwater facility in 1985 and provided no water quality improvement or detention. The retrofit increased pond depth and volume to provide water quality and flow control within the existing pond footprint. Construction of this project began in 2012.

2011: Provided and maintained a non-emergency email reporting link on City's Stormwater/NPDES web page.

2011: Revised DMC Section 9.06.125 (Service Charges) to provide a stormwater fee discount for non-residential sites utilizing pervious surfacing and documenting annual maintenance of on-site stormwater facilities.

August 1, 2013: 2013 to 2018 NPDES permit went into effect. Requires an increased frequency of catch basin inspections, among other requirements.

2013: Preparedness Calendar: included a month dedicated to Stormwater education. Calendar was mailed to approximately 7,900 households in Duvall and the surrounding Snoqualmie Valley area.

2015: Taylor Park Wall Stabilization - Coe-Clemmons Creek flows through a ravine in Taylor Park with forested steep slopes. Upstream increases in runoff from developed areas have led to increased channel erosion and slope failure near a playground and basketball court in the park. The project installed a soldier pile wall immediately behind the top of the slope to stabilize the park area.

2015: Adoption of 2015 Watershed Plan and 2015 Comprehensive Plan addressing surface and stormwater goals, BMPs, and regulations.

2015: Completed SR-203 Coe Clemons Creek Culvert replacement project in partnership with WSDOT. Project included removal of 6-foot wide sediment-filled box culvert and replacement with 25-foot wide fish-passable culvert.

2016: King County updated their Surface Water Design Manual, effective April 24, 2016, with new standards for low impact development (LID). Duvall Code adopts the "current version" of the Manual. Manual updated to "improve the clarity and cost effectiveness of its requirements" and be equivalent with the state's 2012 Stormwater Management Manual for Western Washington (amended in December 2014).

2016/2017: Bowe Court (private residential development) incorporated LID elements throughout – such as drywells, pervious pavers, and bioretention swales – to significantly reduce runoff from impervious surfaces, eliminating the need for a detention facility. This project, along with other initial development projects implementing LID approaches in the City, have been approved by Public Works. Integration of LID elements as privately owned stormwater BMPs requires implementation of an operations & maintenance program that is the responsibility of the developer.

2016/2017: Parkwood Estates Pond Retrofit project: Retrofit of an existing flow through stormwater pond that was originally constructed in 1986 as a single cell, asphalt-lined pond with little or no water quality BMPs. The new design included a water quality wetpond, removal of the pavement liner and replacement with vegetated slopes, a biofiltration swale to improve water quality, and retention of existing mature conifers.

February 21, 2017: Adopted Ordinance No. 1214 to DMC 9.06 (Storm Drainage Utility). Updated Stormwater regulations and restrictions to incorporate and require LID principles and LID BMPs, as required by the NPDES permit.

2017: Completed Thayer Creek Culvert replacements at SR-203 (Main Street) and NE 143rd Place crossings as part of the City of Duvall Main Street South reconstruction project. The project included removal of a 24-inch diameter culvert on SR-203 and a 30-inch diameter culvert on NE 143rd Place and replacement with 7-foot wide fish passable culverts at both locations.

Ongoing projects, programs, or partnerships:

- Snoqualmie floodplain wetland and stream restoration efforts:
  - There are several completed and ongoing restoration projects. Objectives include restoring shoreline bank conditions; removing invasive plants; installing native plants; enhancing fish habitat; improving water quality and hydrology functions in tributary streams; reducing sediment loading, erosion, and stormwater impacts to creeks; and stabilizing banks at key locations.
  - Restoring lower Coe-Clemens Creek and associated wetlands. Planting native vegetation in wetland and stream buffers (**2009**: planted a half acre of wetland and stream buffer along Depot Creek. Included a pervious concrete walkway.)
- Updating the GIS stormwater and facilities geodatabase.

- Stormwater Outreach for Regional Municipalities (STORM) – education and outreach.
    - Formed the "Puget Sound Starts Here" campaign with Puget Sound Partnership.
    - Continued installation of "Puget Sound Starts Here" storm drain buttons.
- Growing network of stormwater facilities and catch basins (Table 2-2).

Table 2-2. Known (inventoried within City stormwater geodatabase) facility and catch basin counts, by year.

Year	Known Facilities	Known Catch Basins[1]
2010	82	1,590
2012	89	1,640
2014	100	1,871
2015	100	1,890
2016	125	2,206
2017	170	2,500

2.3 Challenges and Opportunities for Surface and Stormwater Management

The following section provides an overview of the complexities of managing stormwater within the City. This includes existing development and infrastructure, redevelopment, new development, and integration of LID or green infrastructure approaches.

2.3.1 Aging Infrastructure and Asset Management

Repair and replacement of aging and failing infrastructure is important to prevent catastrophic failures that may cause flooding or public safety hazards. The City implements facility inspection and maintenance consistent with NPDES Permit requirements (see summary in 2.1.1 for details). Opportunities for a more systematic, proactive asset management would support Public Works in maintenance and completing improvements to aging stormwater infrastructure. Approaches could include:

[1] The increase in known catch basins is attributed to improved mapping as well as installation of new catch basins as part of public and private projects throughout the City.

- Implementing a City-wide asset management software tool.
- Standardized and digitized field inspection forms (tablet-based), linked to stormwater infrastructure database or software tool.
- Including long-term asset management costs in requirements for new facilities, through incentives encouraging LID or green infrastructure approaches.

This Plan is also implementing analysis to prioritize stormwater facility retrofit actions in areas of greatest need (see Chapter 5 - System Analysis for details). For other recommendations focusing on inspection, maintenance, and repair of infrastructure; see Chapter 8 - Operations and Maintenance.

2.3.2 A Shift Toward Low Impact Development

The NPDES Permit now requires permittees to adopt LID site-scale standards and update development related codes requiring use of LID principles and facilities. In addition, adoption of the Ecology's 2012 Stormwater Management Manual for Western Washington or approved equivalent is required (2016 KCSWDM is an approved equivalent). These manuals emphasize the incorporation of LID standards and have a new flow control performance standard for small projects of 2,000-square feet of new or replaced impervious surface. The City took initial steps toward compliance with new NPDES Permit requirements with adoption of Ordinance No. 1214 in early 2017, and is taking additional steps through development of this Plan.

The use of LID for stormwater management presents a significant shift from a purely structural approach for detention and treatment of runoff, to a source reduction approach (Washington State University Extension; Puget Sound Partnership, 2012). Traditional "grey" infrastructure does not encourage use of integrated site planning, resulting in significant impervious surface coverage which routes or conveys storm runoff through inlets, catch basins, and pipes to a centralized facility.

In urban developed areas, impervious surfaces such as parking lots, streets, sidewalks, and roofs have replaced areas that historically stored and infiltrated precipitation. Precipitation sheds off impervious surfaces and is collected in conveyance pipes, which is then routed to a facility or discharged directly to a receiving water body. Unless this runoff is properly managed, it contributes to high flow rates during storm events; increasing flooding, and threatening private property, roads, utilities, and other important infrastructure. High flows also damage and destabilize stream banks and habitat, making conditions less suitable for fish spawning, rearing and migration. Stormwater runoff also picks up pollutants from pollution generating impervious surfaces such as parking areas, roads, etc., degrading water quality when discharged directly to water bodies.

Alternatively, LID approaches emphasize site planning as an integral part of stormwater management. The intent of LID is maintaining "a more hydrologically functional landscape even in denser settings" (Washington State University Extension; Puget Sound Partnership, 2012). Figure 2-1 illustrates the differences in how precipitation moves through a natural, undeveloped area as opposed to typical developed areas. Integrating LID BMPs into developed areas restores some of the natural hydrologic functions resulting in improved water quality, reduced flooding, and reduced stream erosion.

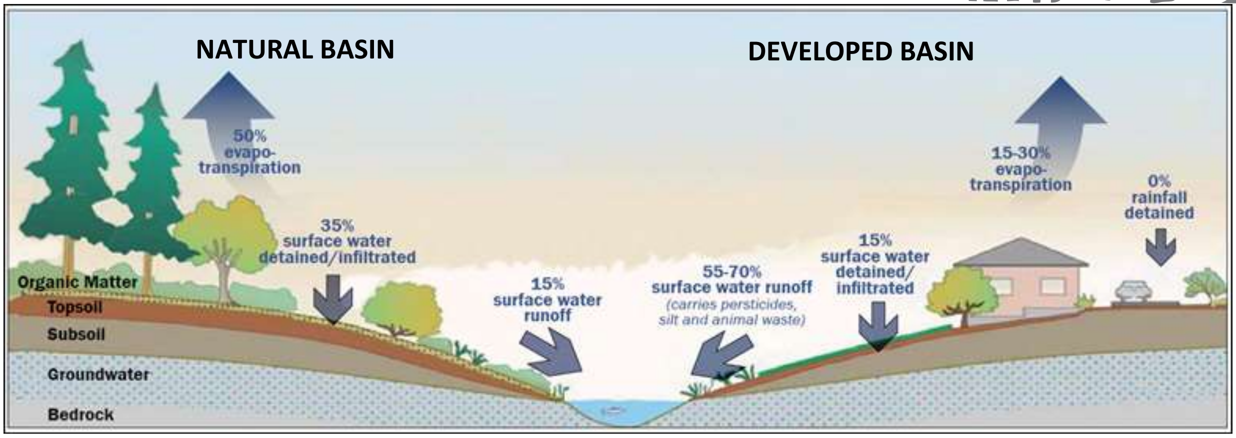

Figure 2-1. Water budget for Puget Sound lowlands, within a natural forested area and within a developed area (Washington State University Extension; Puget Sound Partnership, 2012)

2.3.3 ESTABLISH FLOW CONTROL EXEMPTION

Section 1.2.3 of the KCSWDM allows a flow-control "Direct Discharge" exemption for projects that are within a quarter mile of a listed receiving water body and comply with several other requirements intended to minimize downstream impacts. Creating an extended flow control exemption in the City is consistent with policy recommendation SW-4 from the City's Watershed Plan and allowances provided by KCSWDM and NPDES Permit. This would affect portions of the City that are predominantly built-out and already drain directly to the Snoqualmie River through pipe or ditch conveyance.

2.3.4 INVASIVE SPECIES MANAGEMENT

Invasive and noxious plant species are common in stormwater facilities. The King County Noxious Weed Control Board requires the control of several species of noxious weeds that may be found in facilities within the City, such as:

- purple loosestrife (*Lythrum salicaria*)
- policeman's helmet (*Impatiens glandulifera*).

Other invasive plants, not listed, can be damaging to the functioning of stormwater facilities including:

- Himalayan blackberry (*Rubus armeniacus*)
- Reed canarygrass (*Phalaris arundinacea*)
- Japanese knotweed (*Polygonum cuspidatum)*

Stormwater conveyance systems and stream corridors can be a vector for the spread of invasive plant species. Typical travel routes are from developed areas to downstream waters, or from agricultural areas into the City. Therefore, managing current invasive plants that are prevalent, and recognizing risks from other invasive species, is an important component of maintaining vegetated facilities. Control of invasive plant species maintains the proper function of facilities, and prevents spread to other aquatic resources.

New Zealand mudsnail (a potential future threat): As of 2017, the New Zealand mudsnail has not been found in the Snoqualmie Watershed. However, they have been identified within several nearby areas (including in the lower Snohomish River near Everett, and in multiple basins draining to Lake Washington). The New Zealand mudsnail, as seen in Figure 2-2, is a non-native species that has no natural predator, parasite, or disease to control population size in North America. Although the full understanding of implications for Puget Sound lowland streams remains unknown, the species can multiply very quickly and has the potential to become a serious economic and ecological problem (King County, 2016). They are known to reproduce to extremely high densities, crowding out native vegetation, insects, fish, and potentially changing water chemistry. City staff should continue to monitor the presence of New Zealand mudsnails within vicinity streams and basins. Coordination with King County to take necessary preventative steps to minimize potential for spread into the Snoqualmie River and tributary basins is recommended.

Figure 2-2. Invasive New Zealand mudsnail. Photo: Elaine Thompson, AP

2.3.5 TARGETED RESIDENTIAL PROPERTY OWNER OUTREACH

The City currently implements public education and outreach that targets property owners. Review of current efforts, and focused updates to target residential property owners may be the most effective way to improve stormwater practices and reduce runoff from areas of existing development. Single family homes are by far the most prevalent throughout the City. Potential approaches could include:

- New guidance and outreach focused on natural yard care, including integration of stormwater pollution prevention information sheets for residential uses developed by King County (King County, 2016a).
- Implementing rain garden resources and incentives program (in partnership with Stewardship Partners).
- Supporting pilot projects with interested property owners, with agreement to serve as educational examples for others.

CHAPTER 3. WATERSHED AND LAND COVER CONDITIONS

Duvall is located immediately east of the Snoqualmie River within the lower Snoqualmie River Valley. The 692-square mile lower Snoqualmie River Watershed, and the Skykomish River Watershed to the northeast, make up Water Resource Inventory Area (WRIA) 7. These two rivers converge approximately five miles north of Duvall, forming the Snohomish River, which flows into Puget Sound at Everett.

The 2.5-square mile City is surrounded by unincorporated areas of King County, with agricultural areas and open space floodplain to the west and north, and forested rural lands to the south, east, and southeast. The basins of four small tributaries to the Snoqualmie River are located within or partially within the City and urban growth area (UGA) boundaries: Thayer Creek, Coe-Clemons Creek, Cherry Creek, and Weiss Creek. The City's Watershed Plan further divided these basins into subbasins, representing relatively small catchments where precipitation and groundwater move through natural features and stormwater infrastructure.

This chapter assesses Duvall's basins and subbasins, including consideration of surface waters and other natural resources, geologic conditions, land cover, and known basin alterations. This chapter concludes with identification of prioritized subbasins for surface and stormwater retrofit actions.

3.1 GEOLOGIC CONDITIONS

Geologic conditions are a key element determining how surface water moves through the hydrologic cycle, Figure 3-1. The specific land form and soil conditions affect how much precipitation infiltrates and how much runs off into surface waters. Additional geologic processes such as groundwater aquifer recharge, soil erosion, and landslides are also key geologic considerations related to surface and stormwater management.

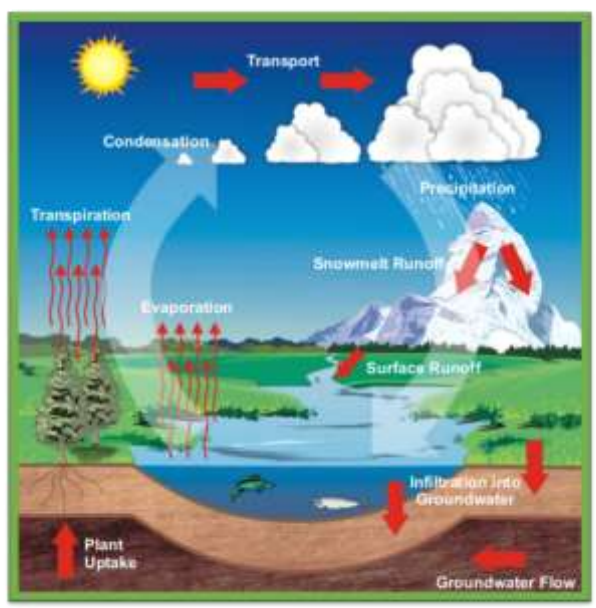

Figure 3-1. Hydrologic Cycle

According to the report titled *Geohydrology and Ground-Water Quality of East King County* (Turney, Kahle, & Dion, 1995), the topographic surface of the area surrounding the City is the result of erosion and deposition from the Vashon Stade of the Fraser Glaciation which ended approximately 15,000 years ago. Topography of the 1-mile wide Snoqualmie River

Valley is a result of recent erosion and deposition of alluvial sediments associated with the river since deglaciation.

Duvall is located on the east valley slope of the lower Snoqualmie River, which flows northward past the community. In general, the City slopes down to the west from an upland plateau at approximately elevation of 500 feet above sea level to the Snoqualmie River floodplain at approximate elevation of 50 feet above sea level.

Approximately 138 acres of the City is located within the Snoqualmie River floodplain; these areas are predominantly City-owned open space and park lands with very little pollution generating impervious surfaces (PGIS). The remainder of the City includes residential, commercial, and undeveloped properties. The western and northern slope of the City transition from Puget Sound lowlands to the foothills of the Cascades.

3.1.1 Soil Conditions

Mapped soils are consistent with this characterization of the geologic history. According to recent geologic mapping by the Washington State Department of Natural Resources (Dragovich, et al., 2010), soils within the Snoqualmie River floodplain include alluvium (Qa) composed of sand and silt and peat (Qp) deposited since deglaciation (Figure 3-2).

Extremely compacted glacial deposits can be found at the surface east of the Snoqualmie River in a mapped geologic cross-section located south of the City, which is likely similar to subsurface conditions within the City. Deposits from glaciation and subsequent events occur as layered lenses that outcrop on the surface at different elevations and locations. These deposits sit in relatively thin lenses above older glacial (Pre-Fraser) and nonglacial deposits and bedrock.

The dominant sedimentary deposit in the City east of the Snoqualmie River is Vashon lodgment till (Qgtv), a mixture of clay, silt, sand, and gravel that was deposited beneath, and consolidated by, glaciers as they advanced to the south across the Puget Sound lowlands. At the northern slopes of the City the glacial till is underlain by Vashon advance outwash (Qgav), composed of sand and gravel deposited in meltwater streams and deltas and then consolidated during glacial advance. The glacial till and Advance Outwash are underlain by Advance glaciolacustrine deposits (Qglv), which include silt and clay that were deposited in lakes and other bodies of water in front of advancing Vashon glaciers.

Less common geologic deposits include recessional deposits such as Ice-contact kame deposits (Qgik) with generally higher sand, gravel, and cobble gravel soil that were deposited as the Vashon glaciers receded. Areas along the northern slopes are also mapped as Landslide deposits (Qls) since deglaciation.

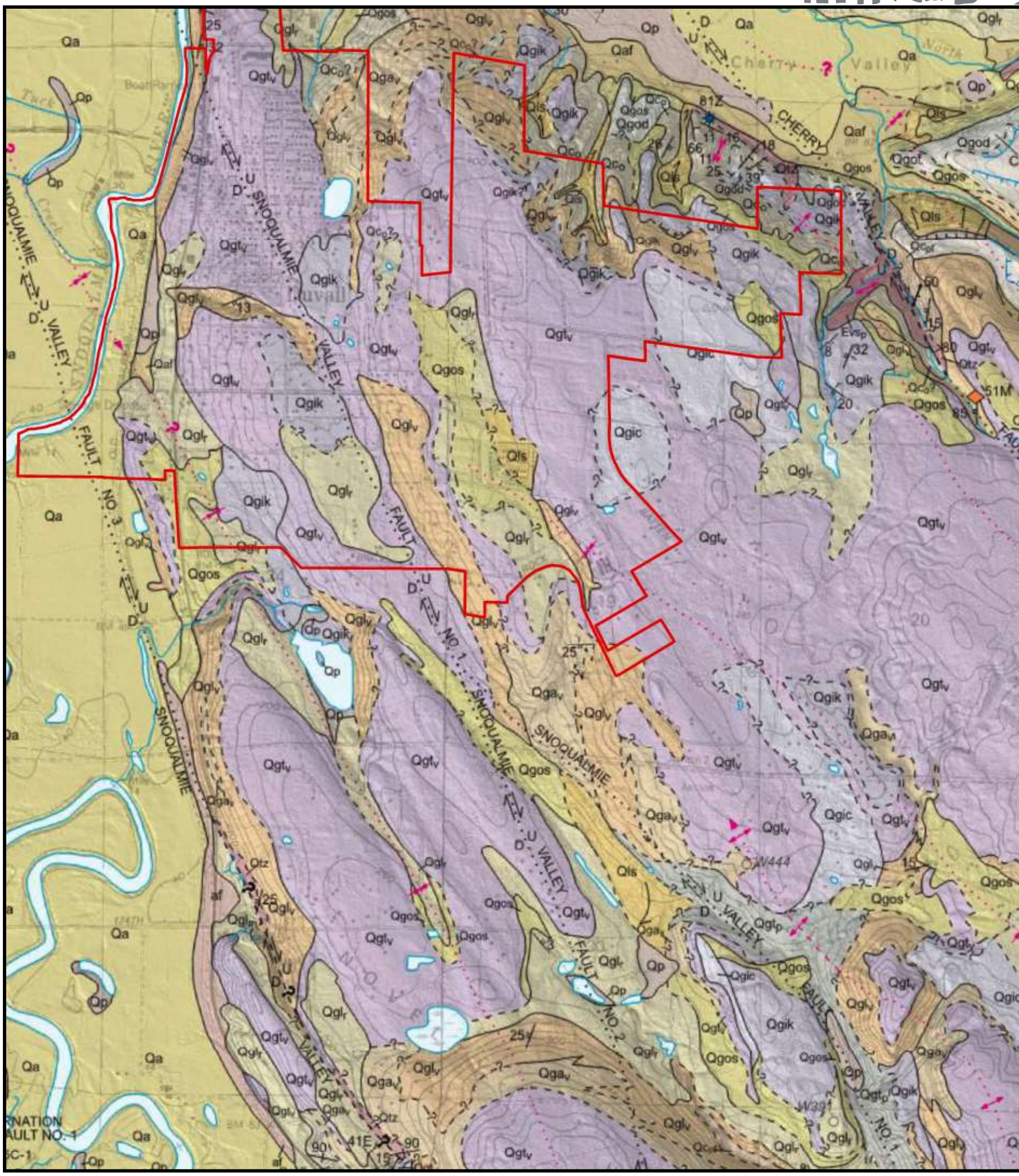

Figure 3-2. Geologic Map with Duvall City limits (in red) and surrounding area; the dominant geologic deposits across Duvall and surrounding areas east of the Snoqualmie River Valley are Vashon lodgment till (Qgtv, extending through purple shaded areas).

According to the Natural Resources Conservation Service (NRCS) soil survey, the dominant surface soil type in the City is Tokul gravelly medial loam. This soil is categorized in Hydrologic Soil Group B, which represents soils with moderate infiltration ability. The soil survey also indicates that this soil group is subject to a relatively shallow soil restrictive layer (NRCS). Previous site-specific studies performed in the City identified porous outwash soil above fractured bedrock and alluvium along major streams, as well as alluvium throughout the floodplains of the Snoqualmie River and Cherry Creek (City of Duvall, 2015).

3.1.2 Erosion and Landslide Hazards

Soil erosion is a natural geologic process by which individual soil particles are detached and moved by agents such as wind, rain, frost action, or surface water flows. Mass erosion, such as landslides, is also a natural geologic process. Erosion and movement of sediment through the landscape and within surface waters is an essential process that supports creation of stream, wetland, floodplain and riparian habitats.

In developed areas, however, erosion can be exacerbated by changes in land cover and concentration of storm runoff. Erosion and landslides adjacent to developed areas can also be a safety hazard. Runoff from impervious surfaces results in concentrated storm flows which in turn can result in excess eroded sediment entering surface waters. Excess eroded sediment can negatively impact ecosystem functions, adding additional fine sediments to stream beds that degrade salmon spawning habitats. Increased stream sediment loads can also plug culverts at road crossings, limiting conveyance capacity, restricting fish passage, and increasing the potential for infrastructure damage during storm events. A recent example of this was the undersized, 6-foot by 6-foot culvert where Coe-Clemmons Creek crosses beneath Main Street, Figure 3-3. The culvert was too small for the size of the stream flow through the culvert was further restricted by increased sediment and debris loads from upstream erosion within Taylor Park until the culvert was replaced in October 2015 with a much larger (25-feet wide by 12-feet high) culvert.

Figure 3-3. 2012 Coe-Clemmons Creek culvert replacement project under SR-203. Inset: Old Coe-Clemmons Creek fish barrier culvert, prior to project.

Recent Sensitive Areas inventory updates completed by the City have identified known landslide hazard areas, and other potential landslide and erosion hazard areas within and surrounding the City (Figure 3-5).

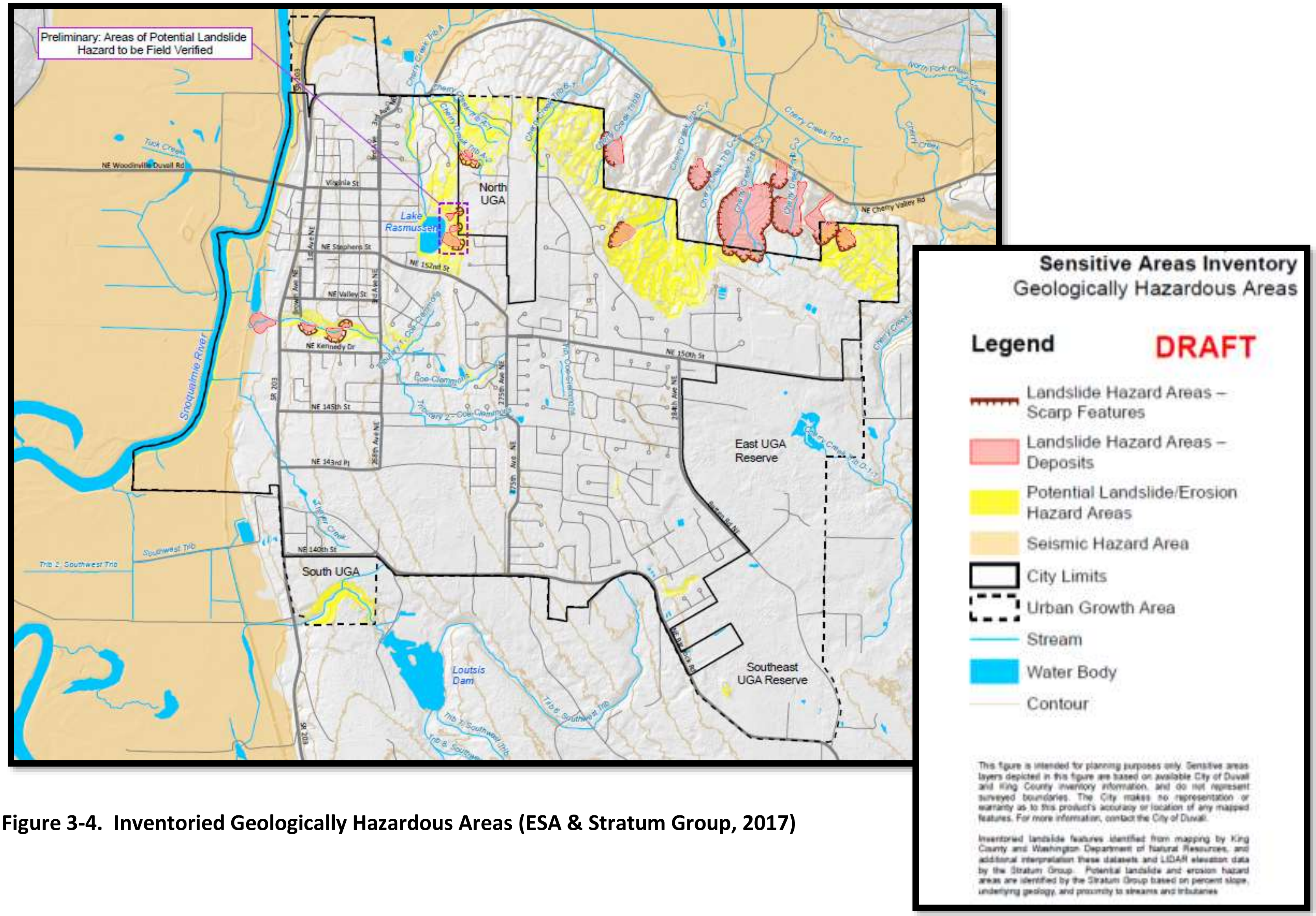

Figure 3-4. Inventoried Geologically Hazardous Areas (ESA & Stratum Group, 2017)

Areas of higher potential for land erosion hazard areas occur within the City, in UGAs, and in surrounding rural areas. The largest concentration on steeper slopes along the northeastern edge of City limits, as well as the Coe-Clemmons Creek ravine.

King County has mapped some areas inside and outside of City limits as being prone to landslides (Dragovich, et al., 2010); (King County, 2017). Additional areas with a history of shallow landslides and inventoried erosion hazards are in Taylor Park where stream incision and stream bank erosion along Coe-Clemmons Creek resulted in recent ravine slope failures. Similar features are present along similar ravine slopes in lower reaches of the Unnamed Southern Tributary to the south of City limits. There are no other significant mapped landslide hazard areas located elsewhere within the City or UGAs.

3.1.3 Constraints and Opportunities for Surface and Stormwater Management

Key geologic considerations for stormwater and surface water management include the following:

Limited opportunity for full infiltration LID approaches – Generally, the predominance of relatively low-permeability till soils in Duvall does not support full infiltration BMPs. However, infiltration is feasible in areas of advance outwash and other relatively permeable deposits. These areas have the dominant soil type, Tokul gravelly medial loam, and having adequate depth may accommodate an engineering stormwater design. Experience from project-specific geotechnical explorations suggest that in many areas of the City adequate depths are not available to provide full stormwater infiltration. However, it has been determined by City staff that limited infiltration techniques can be incorporated into stormwater design based on site specific characteristics.

In many areas of the City, the subsurface low permeability glaciolacustrine and till deposits inhibit deeper infiltration from Tokul gravelly medial loam surface soils into the subsurface, and in certain instances may also limit opportunities for underground injection approaches. In several areas of the City infiltrated water is conveyed laterally within shallow advance outwash lenses confined by relatively impermeable till and glaciolacustrine deposits, resulting in springs and seeps emerging on hillslopes and ravines along the northern and western sides of the City. In some locations, the underlying bedrock is likely to be fissured, allowing for deep groundwater recharge at relatively low, variable, infiltration rates.

Erosion potential – Presence of erosive soils and landslide hazard areas heighten the need for effective stormwater flow control approaches and facilities in the Cherry Creek tributary basins and the Coe-Clemmons Creek basin. There are several resources that are susceptible to impacts from erosion and sedimentation including tributary streams, floodplain habitats, and the mainstem Snoqualmie River.

There are also steep, erosive slopes along the northern edge of the City, and incised streams forming ravines along the western boundary. Excessive water flowing down these slopes can form gullies and increase ravine erosion, which may result in soil wasting, downstream sedimentation, habitat degradation, and infrastructure impacts.

Protection of headwater features – Areas within the City and the associated UGAs have mapped surface soils that include higher amounts of silt, clay, organic silt-clay, and minor peat content. These soil types are generally appropriate for wetland formation. Correlation between geologic mapping of these areas and areas of known depressional wetlands within the upper portions of the City's subbasins has not been reviewed. It remains important to ensure future development maintains soils that could support headwater wetlands. This action will reduce peak flows to downstream channels and provide important habitat and water quality functions.

3.2 CLIMATE

The region has a temperate, maritime climate. Winters are cool and wet, while there is typically a drought period in the summer and early fall. The climate is influenced by Puget Sound to the west and the Cascade Mountains to the east. Average annual precipitation ranges from approximately 30 inches near Puget Sound to 90 inches in the Cascade foothills, with the area surrounding the City averaging 49 inches. Figure 3-5 shows average monthly precipitation as well as low and high temperatures near the City. Most precipitation falls between October and March, where summers typically remain relatively dry. In Duvall and other lowland areas, winter temperatures dip below freezing and snow may occur but are usually of short duration (Franklin & Dyrness, 1987).

Runoff processes influencing surface and stormwater systems are a function of the timing and type of rainfall. Well upstream of Duvall in the Cascade Mountains, Snoqualmie River headwater streams receive a large proportion of their total annual runoff from snowmelt. At mid to high elevations within the watershed between 1,500 and 4,500 feet elevation, rain on snow (ROS) events play an important role in runoff. Below approximately 1,500 feet elevation, including the Snoqualmie Valley basins, rainfall is the principal source of precipitation (Brunengo, Smith, & Bernath, 1992); (Bethel & Solomon, 2004).

Increases in rainfall intensity and altered seasonal precipitation patterns are anticipated within the next several decades due to accelerated climate change. Climate change in the overall Snoqualmie Basin has been modeled extensively by the University of Washington Climate Impact Group and the National Oceanic and Atmospheric Administration (Battin, et al., 2007); (Yang, Wang, Voisin, & Copping, 2015). Predicted effects include increases in the magnitude of peak flows, changes in the timing of seasonal flow peaks, prolonged and persistent low flows, reductions in summer flows, and increased stream temperatures. These effects would place even greater strain on water quality, threatened salmon populations, drinking water supplies, and flood prone areas.

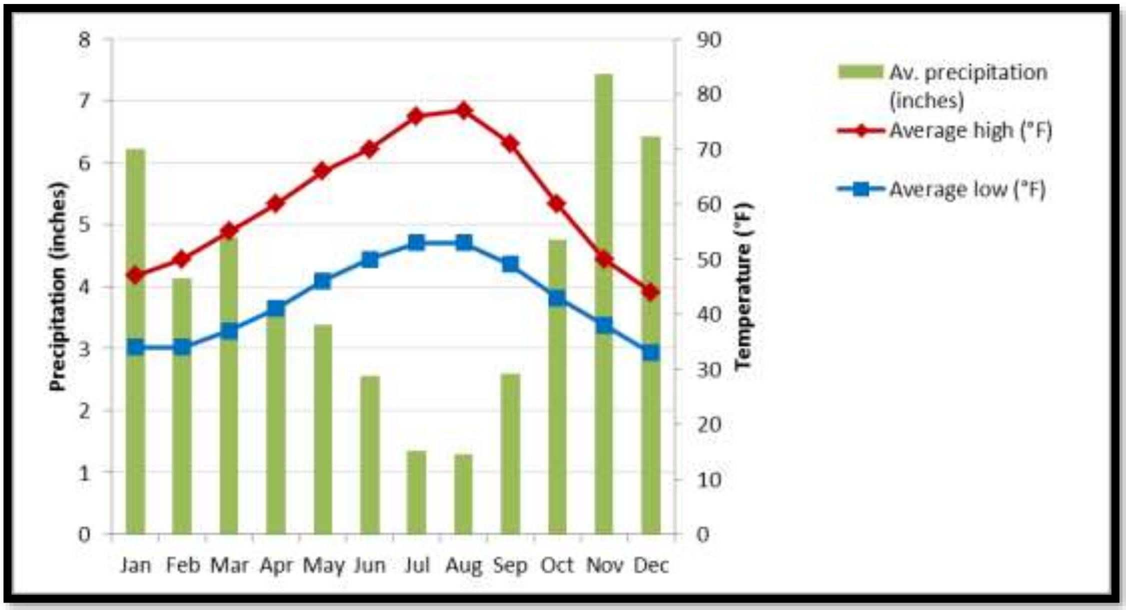

Figure 3-5. Average monthly precipitation and low/high temperatures in the Duvall vicinity (U.S. Climate Data, 2018).

3.3 LAND COVER

Land cover plays an important role in protecting and maintaining watershed processes. Native vegetation provides habitat, reduces erosion, intercepts runoff, and provides water quality benefits. Additionally, significant trees and tree cover are an important part of the City's rural character. The City has recognized the importance of preserving and replacing trees and other native vegetation in various policy documents, including the KCSWDM, adopted by reference, the Watershed Plan (City of Duvall, 2015), and 2018 Tree Protection Policy (DMC 14.40).

3.3.1 HISTORIC CHANGES TO LAND COVER

The hydrology and ecology of the study area have been shaped by historical landscape use. European settlers were drawn to the area starting in the 1870's for its timber resources and used the Snoqualmie River to transport logs downstream to commercial markets. The railroad was constructed in the 1890's on a 12- to 15-foot-tall fill berm that stretched along the eastern edge of the Snoqualmie River, adjacent to the City's modern day Main Street. In the following decades, bridges were constructed over the Snoqualmie River along with roads built on fill berms in the floodplain to connect the area with Lake Sammamish and Lake Washington. The growth of the timber industry and the expanded population brought about rapid changes in vegetative cover and character. These changes included clearing of forest to create agricultural fields and harvesting of old-growth forest and establishment of second-growth forest. Population growth continued through the 1920's, after which the decline of the timber industry in the area minimized the need for laborers.

After the 1920's the pattern of alterations to the Snoqualmie Valley landscape was characterized by clearing native shrubs and riparian vegetation, ditching of streams, land clearing to create pasture, and bank hardening along the Snoqualmie River. In the last 50 years, expanding suburban development from Seattle and Bellevue have led to growth in the City and throughout the Snoqualmie Valley. Agricultural activities are an important component of the economy and land use, with cattle and dairy operations, produce and crop farms, and greenhouse operations extending up and down the Valley. These activities have increased residential housing and associated businesses that have come to characterize the City and other urbanized areas of the watershed.

3.3.2 VEGETATION

Protecting native trees and contiguous forest areas benefits multiple watershed processes, including water flow, water quality, and habitat. All aspects of water flow processes, including delivery, surface storage, recharge, and discharge benefit from increased canopy cover and more mature vegetation. Vegetation improves water quality processes by increasing the opportunity for filtration and reducing the potential for erosion and sedimentation. This is particularly important in sensitive areas such as stream buffers and wetlands.

Riparian vegetation consists of the plants that grow along the margin of streams, lakes, and wetlands. Out of 107 miles of riparian area surveyed in the Snohomish basin, it was found that nearly two-thirds of the riparian vegetation consisted of grass, brush, or sparse trees. The loss of riparian vegetation within the City has impacted salmonid habitat by reducing the food supply for fry, increasing solar heating of the water, and reducing cover and refuge habitat.

3.4 DUVALL BASINS AND SUBBASINS

3.4.1 SURFACE WATERS AND NATURAL RESOURCES

The City delineated 17 subbasins to more precisely characterize watershed conditions as part of the City of Duvall Watershed Plan, as seen in Figure 1-1 of this Plan (City of Duvall, 2015). The current study focuses on those subbasins that include City limits and UGAs. These basins range in size from 98 to 457 acres, varying in forest and impervious surface cover, and generally correspond to first-order streams and specific topographic boundaries as summarized in Table 3-1.

The primary basins making up much of the City and surrounding areas include the: Cherry Creek basin; Duvall Tributaries (Coe-Clemmons Creek, Thayer Creek, and an unnamed tributary); and Weiss Creek basin. These basins ultimately drain to the Snoqualmie River.

The shape and size of the subbasins are related to the morphology of the subbasin and its drainage pattern. Several subbasins extend outside of City or UGA boundaries. Areas outside of UGA boundaries were included in the Watershed Plan analysis to help understand the connection between actions taken either inside or outside the City's jurisdiction and watershed processes. The areas outside of City limits are either headwaters or receiving waters. Headwater areas can provide information on the quality or quantity of water coming into the City or UGA, while receiving water areas are impacted by actions occurring within City and UGA boundaries.

For the City's Watershed Characterization, an evaluation of water flow (hydrologic) processes was completed for all subbasins based on the Washington State Department of Ecology's Puget Sound Characterization model (City of Duvall, 2015). Relative importance and degradation of water flow processes were determined for key water flow processes.

Table 3-1. Subbasin Summary

Subbasin Name	Landscape Position	Total Area (acres)	Percent Within City*	Forest Cover (%)	Impervious Surface (%)
Cherry Creek Tributaries Basin					
Cherry Creek Floodplain	Floodplain	865	1%	5%	3%
Cherry Creek A*	**Slope / Ravine**	**264**	**55%**	**44%**	**24%**
Cherry Creek B*	**Slope / Ravine**	**158**	**46%**	**62%**	**15%**
Cherry Creek C*	**Slope / Ravine**	**457**	**59%**	**71%**	**11%**
Cherry Creek D – East	Slope / Ravine	288	< 1%	56%	4%
Cherry Creek D – West	Terrace	166	< 1%	55%	6%
Duvall Tributaries Basin					
Old Town*	**Slope / Ravine**	**146**	**88%**	**11%**	**43%**
Coe-Clemons – Lower*	**Slope / Ravine**	**98**	**100%**	**27%**	**43%**
Coe-Clemons – Upper*	**Terrace**	**273**	**100%**	**26%**	**43%**
Thayer*	**Slope / Ravine**	**235**	**92%**	**24%**	**29%**
Coe-Clemons / Thayer Floodplain*	**Floodplain**	**663**	**13%**	**7%**	**3%**
Unnamed Southern Tributary – Lower*	**Slope / Ravine**	**373**	**42%**	**40%**	**17%**
Unnamed Southern Tributary – South	Slope / Ravine	158	0%	70%	7%
Unnamed Southern Tributary – Upper*	**Terrace**	**327**	**36%**	**54%**	**18%**
Weiss Creek Basin					
Weiss Creek – Upper*	**Terrace**	**207**	**4%**	**42%**	**11%**
Weiss Creek – Middle	Slope / Ravine	587	0%	54%	8%
Weiss Creek – Lower	Slope / Ravine	1273	0%	63%	7%

*Subbasins within the City and associated UGAs are highlighted and shown in **Bold**

3.4.2 CHERRY CREEK BASIN

Cherry Creek is the lowest significant tributary of the Snoqualmie River and the only significant tributary that drains areas of the City. The Cherry Creek watershed covers approximately 32,000 acres, but less than 2% (percent) of the total watershed falls within City and UGA boundaries. Cherry Creek tributaries drain the northeastern portion of the City to the north mainstem creek.

Alterations to the tributaries of Cherry Creek within the City and UGA can impact the high conservation value mainstem and associated floodplain to the north. High to moderate degradation is observed in tributaries A and B, where development is more extensive as summarized in Table 3-2. Tributaries C and D still have low levels of development and many watershed processes are still intact.

Table 3-2. Cherry Creek Subbasin Summary

Subbasin Name	Watershed Plan Management Group	Area (acres)		Impervious Surface within the City (%)			
		City	UGA	non-PGIS	PGIS	Total	Directed to a Stormwater Facility
Cherry Creek A	Lowest Conservation (2C)	146	64	15%	15%	30%	80%
Cherry Creek B	Moderate Conservation (2B)	72	23	46%	62%	15%	100%
Cherry Creek C	Highest Conservation (2C)	272	20	59%	71%	11%	100%
Cherry Creek D - West	Highest Conservation (2C)	0.3	129	NA - very small area within the City			100%

Note: non-PGIS (pollution generation impervious surface) includes walkways/sidewalks, roofs, patios/concrete pads, and decks; PGIS includes roadways, driveways, and parking lots.

Cherry Creek A

Subbasin Characterization	
Acres	264
Within City	55%
Within UGA	24%
Predominant uses	Single-family residential; rural residential and vacant lots in North UGA
Streams	Cherry Creek Tributary A (flows from Lake Rasmussen), Tributaries A-1 and A-2
Soils and Geology	Some steep slopes and moderately well drained soils categorized in Hydrologic Soil Group (HSG) B.
Erosion and Landslide Hazard Areas (within City and UGA)	28% mapped as erosion hazard, extending from Lake Rasmussen to northern City limits, and into North UGA along tributary channels. No mapped landslide hazards.

Subbasin Cherry Creek A is located on the northern edge of the City, extending through residential areas to the southeast and north of Lake Rasmussen, and north into agricultural areas of King County outside of City jurisdiction. The subbasin also includes the majority of the North UGA, including forested areas, tributary stream channels, and wetlands.

Basin topography slopes generally north down to the Cherry Creek Valley. The southern portion around Lake Rasmussen occurs as a terrace, and slopes increase moving north.

The following summarizes existing conditions and importance for key processes relevant to surface and stormwater management as summarized from the City of Duvall Watershed Plan (City of Duvall, 2015):

Surface Storage: Subbasin features provide moderate surface storage during storm events, mostly provided by the man-made, 5.5-acre Lake Rasmussen and depressional wetlands in the upper portion of subbasin. Lake storage processes are minimally degraded despite the existing intensity of development within the City, due to retention of existing wetlands and the lake.

Groundwater and Base Flow Maintenance: There are relatively few areas of permeable soils, and higher levels of impervious surface except in the North UGA area that further limit groundwater recharge. Slope wetlands occur around Cherry Creek Tributaries A-1 and A-2 on the forested slopes in the northern portions of the subbasin; however overall there are relatively few features that maintain stream base flows.

Water Quality: Steep slope areas in the northern portion of the subbasin have high export potential for phosphorus and sediment. Runoff from developed areas has likely increased pollutant inputs to subbasin and downstream areas, as well as channel erosion along Cherry Creek Tributary A. Lake Rasmussen and depressional wetlands within the upper subbasin do provide some filtration and sediment deposition for runoff.

Cherry Creek B

Subbasin Characterization	
Acres	158
Within City	46%
Within UGA	15%
Predominant uses within Duvall	Single-family residential, rural residential in North UGA, and vacant lots
Streams	Cherry Creek Tributary B
Soils and Geology	Some steep slopes and moderately well drained soils characterized in HSG B.
Erosion and Landslide Hazard Areas (within City and UGA)	No mapped erosion hazards. 6% mapped as landslide hazard, occurring on forested slopes in the northern portion of the subbasin.

Subbasin Cherry Creek B is located on the northern edge of the City, extending through a residential subdivision at Manion Way NE and 277th Place NE construction in 1995-1996, and north into forested, steep slope open space areas that extend to City limits. The subbasin also includes the eastern portion of the North UGA, including rural residential and forested properties.

Basin topography slopes generally northeast down to the Cherry Creek Valley, with grade increasing through forested open space areas.

The following summarizes existing conditions and importance for key processes relevant to surface and stormwater management as summarized from the City of Duvall Watershed Plan (City of Duvall, 2015):

Surface Storage – This subbasin is of lower importance for surface storage processes and has limited storage opportunity due to steep slopes and lack of wetlands. What surface storage is available is provided by a depressional wetland at the southern edge of the subbasin and is minimally degraded.

Groundwater and Base Flow Maintenance – This subbasin has features that are very important for groundwater recharge and base flow maintenance processes. Permeable soils account for 7% of the subbasin; however, groundwater infiltration is moderately degraded due to higher impervious surface cover within the residential areas. Base flow maintenance processes are likely to be more intact, occurring primarily in forested open space areas.

Water Quality – Potential water quality issues relate to extensive steep slope areas below developed areas with high sediment and phosphorus export potential. The large depressional wetland at the southern edge of the subbasin provides filtration and retains sediment, as do existing stormwater facilities.

Existing stormwater infrastructure (developed in 1995 consistent with 1990 KCSWDM standards) likely provide minimal water quality treatment; but may not fully address water quantity and flow control. Stormwater retrofits and future residential development in the North UGA could provide opportunity to improve water quality and flow control, including potential infiltration approaches.

Cherry Creek C

Subbasin Characterization	
Acres	457
Within City	59%
Within UGA	4%
Predominant uses within Duvall	Single-family residential, Cedarcrest High School, protected open space
Streams	Multiple Cherry Creek Tributary C channels
Soils and Geology	Areas of very steep slopes. Soils can be slowly drained (HSG C) or moderately well drained (HSG B).
Erosion and Landslide Hazard Areas (within City and UGA)	20% mapped as erosion hazard and 32% mapped as landslide hazard, occurring on forested slopes in the northern and eastern portions of the subbasin

Subbasin Cherry Creek C covers the northeastern arm of the City, including residential subdivisions on286th Ave NE and Cedarcrest High School, and extends north into steeply sloped vacant forested areas to City limits, and beyond into forested and rural county residential areas.

Basin topography slopes generally northeast down to the Cherry Creek Valley, with slopes increasing through forested areas.

The following summarizes existing conditions and importance for key processes relevant to surface and stormwater management as summarized from the City of Duvall Watershed Plan (City of Duvall, 2015).

Surface Storage – This subbasin is of low importance for surface storage processes due to a predominance of steep slopes and only one percent of the subbasin surface area being occupied by wetlands. Surface storage was historically provided by a depressional wetland at the northern end of the Subbasin, which has been largely degraded by surrounding development.

Groundwater and Base Flow Maintenance – This subbasin is highly important for groundwater recharge processes, with 36% permeable soils that support recharge. Slope wetlands are present in forested areas. Infiltration to groundwater is moderately degraded within the southern portion of the subbasin due to high impervious surface cover; this process remains intact throughout undeveloped areas. Base flow maintenance processes are of lower importance due to the subbasins position in the watershed.

Water Quality – This subbasin has relatively high sediment export potential due to the erodibility of slopes and tributary channels. Extensive steep slopes in the northern subbasin have high export potential for phosphorus and sediment. Recently developed areas (large subdivisions and Cedarcrest High School) likely provide adequate water quality treatment but impact flow quantity and timing.

3.4.3 DUVALL TRIBUTARIES BASIN

The Duvall Tributaries basin covers approximately 2,500 acres within the study area and discharges into the Snoqualmie River. The majority of the associated subbasins are highly developed and watershed processes are heavily degraded. The importance of these subbasins for surface storage, groundwater and base flow, and water quality tends to be low to moderate. Fish and wildlife habitat is moderate to high, which is primarily due to salmonid use of tributaries that feed into the Snoqualmie River. Only the largely undeveloped Coe Clemons/Thayer Floodplain subbasin retains the most watershed processes.

The majority of the subbasins within the Duvall Tributaries Basin are developed, and watershed processes are heavily degraded. Surface storage, groundwater and base flow, and water quality importance tend to be low to moderate. Fish and wildlife habitat is moderate to high, which is primarily due to salmonid use of tributaries that feed into the Snoqualmie River. Only the Coe Clemons / Thayer Floodplain subbasin, located along the western edge of the city and extending into agricultural lands within King County jurisdiction to the south, retains many watershed processes because it is largely undeveloped as summarized in Table 3-3.

Table 3-3. Duvall Tributaries Subbasin Summary

Subbasin Name	Watershed Plan Management Group	Area (acres)		Impervious Surface within the City (%)			
		City	UGA	non-PGIS	PGIS	Total	Directed to a Stormwater Facility
Old Town	Urban Development (3)	129	10	18%	23%	41%	29%
Coe-Clemons - Lower	Urban Development (3)	98	0	14%	22%	36%	29%
Coe-Clemons - Upper	Urban Development (3)	273	0	19%	16%	36%	92%
Thayer	Urban Development (3)	215	5	9%	16%	25%	64%
Coe-Clemons / Thayer Floodplain	Protect / Restore (1)	84	0	<0.1%	0.15%	0.15%	98%
Unnamed Southern Tributary - Lower	Lowest Conservation (2C)	156	35	13%	13%	26%	87%
Unnamed Southern Tributary - Upper	Lowest Conservation (2C)	117	19	15%	15%	30%	92%

Note: non-PGIS (pollution generation impervious surface) includes walkways/sidewalks, roofs, patios/concrete pads, and decks; PGIS includes roadways, driveways, and parking lots.

Old Town

The Old Town subbasin is located on the northwestern edge of the City, encompassing historic downtown area. The subbasin is primarily commercial and single family residential with some remnant agricultural land at its northern tip.

Subbasin Characterization	
Acres	146
Within City	88%
Within UGA	7%
Predominant uses within Duvall	Commercial
Streams	East bank Snoqualmie River
Soils and Geology	Areas of moderate slopes with moderately well drained soils categorized in HSG B.
Erosion and Landslide Hazard Areas (within City and UGA)	17% mapped as erosion hazard, occurring south of Main St, in the center of the subbasin. No mapped landslide hazards.

Basin topography slopes generally westward to the Snoqualmie River.

The following summarizes existing conditions and importance for key processes relevant to surface and stormwater management as summarized from the City of Duvall Watershed Plan (City of Duvall, 2015).

Surface Storage – This subbasin is of low importance for surface storage processes and has limited storage opportunity due to slopes and existing infrastructure and development patterns. The subbasin contains almost no wetlands (0.1%) and previous development has resulted in piped and ditched stormwater conveyance directly to the river.

Groundwater and Base Flow Maintenance – This subbasin has features that historically were moderately important for groundwater recharge and base flow maintenance processes. However, these processes have been highly degraded. Permeable soils account for 14% of the subbasin; however, groundwater infiltration is highly degraded due to extensive imperious surface cover and altered flow pathways.

Water Quality – This subbasin is important for water quality due its direct discharge of stormwater to the Snoqualmie River. The subbasin has moderate sediment export potential related to surface erodibility and subbasin slopes. Impervious surface cover and conveyance infrastructure has likely reduced sediment export potential; however, this increases water quality issues related to developed areas.

Coe-Clemmons Lower

Subbasin Characterization	
Acres	98
Within City	100%
Within UGA	0%
Predominant uses within Duvall	Single-family residential, City park / open space, commercial development along Main Street
Streams	Coe-Clemmons Creek
Soils and Geology	Areas of moderate slopes with moderately well drained soils categorized in HSG B.
Erosion and Landslide Hazard Areas (within City and UGA)	38% mapped as erosion hazard, occurring along steeper slopes of local drainages throughout the subbasin. No mapped landslide hazards.

The subbasin is located on the western edge of the City, along the southern edge of the Old Town subbasin and includes Taylor and McCormick Parks. The subbasin is primarily single family residential with some commercial areas.

Basin topography slopes generally westward to the Snoqualmie River.

The following summarizes existing conditions and importance for key processes relevant to surface and stormwater management as summarized from the City of Duvall Watershed Plan (City of Duvall, 2015).

Surface Storage – This subbasin is of low importance for surface storage processes and has limited storage opportunity due to slopes and existing infrastructure and development patterns. The subbasin contains only 2% wetlands and previous development has resulted in piped and ditched stormwater conveyance directly to the river.

Groundwater and Base Flow Maintenance – This subbasin has features that historically were moderately important for groundwater recharge and base flow maintenance processes. However, these processes have been highly degraded. Permeable soils account for 8% of the subbasin; however, groundwater infiltration is highly degraded due to extensive imperious surface cover and altered flow pathways. Base flow maintenance processes are of lower importance due to the subbasins position in the watershed.

Water Quality – This subbasin is important for water quality due its direct discharge of stormwater to the Snoqualmie River. The subbasin has moderate sediment export potential related to surface erodibility and subbasin slopes. Impervious surface cover and conveyance infrastructure has likely reduced sediment export potential; however, this increases water quality issues related to polluted runoff from developed areas.

Coe-Clemmons Upper

Subbasin Characterization	
Acres	273
Within City	100%
Within UGA	0%
Predominant uses within Duvall	Single-family residential
Streams	Coe-Clemmons Creek and tributary channels
Soils and Geology	Areas of moderate slopes with moderately well drained soils categorized in HSG B.
Erosion and Landslide Hazard Areas (within City and UGA)	12% mapped as erosion hazard. No mapped landslide hazards.

The subbasin is located at the center of the City. Land use is predominantly single family residential.

Basin topography slopes generally westward to the Snoqualmie River. The central portion of the basin is relatively flat, while the eastern and western portions have more pronounced slopes.

The following summarizes existing conditions and importance for key processes relevant to surface and stormwater management as summarized from the City of Duvall Watershed Plan (City of Duvall, 2015).

Surface Storage - This subbasin is of moderate importance for surface storage processes and is highly degraded. There is significant opportunity for storage process enhancements through retrofits and other actions. The subbasin contains only 1% wetlands or other surface storage features. Previous development has resulted in piped/ditched stormwater conveyance with inadequate flow control measures.

Groundwater and Base Flow Maintenance – This subbasin has features that historically were moderately important for groundwater recharge and base flow maintenance processes. However, these processes have been highly degraded. There are many small slope wetlands along the tributary channels; however, groundwater infiltration is highly degraded due to extensive imperious surface cover and altered flow pathways. Base flow maintenance processes are of lower importance due to the subbasins position in the watershed.

Water Quality – This subbasin is important for water quality due its direct sediment contribution and known erosion issues on Coe-Clemmons Creek. The subbasin has low sediment export potential related to channel erosion and bank stability. Degradation related to impervious runoff has likely increased channel erosion and peak flows downstream. Additionally, urban runoff is likely polluted with metals and other pollutants.

Thayer

The Thayer subbasin is located at the southwestern portion of the City and includes single family residential development, vacant grassy and forested areas, and the Safeway shopping center complex.

Subbasin Characterization	
Acres	235
Within City	92%
Within UGA	2%
Predominant uses within Duvall	High-density single-family residential, rural residential, and commercial
Streams	Thayer Creek
Soils and Geology	Areas of moderate slopes with moderately well drained soils categorized in HSG B.
Erosion and Landslide Hazard Areas (within City and UGA)	12% mapped as erosion hazard, on the steeper slopes draining to Coe-Clemmons Creek. No mapped landslide hazards.

Basin topography slopes generally westward to the Snoqualmie River, except for the areas immediately adjacent to Thayer Creek, which drain steeply to the creek. The eastern portion of the basin is relatively flat, while the western portion slopes more steeply towards the river.

The following summarizes existing conditions and importance for key processes relevant to surface and stormwater management as summarized from the City of Duvall Watershed Plan (City of Duvall, 2015).

Surface Storage – This subbasin is of low importance for surface storage processes and has limited storage enhancement opportunity due to slopes and existing infrastructure and development patterns. The subbasin contains only 2% wetlands or other surface storage features and previous development has resulted in piped/ditched stormwater conveyance directly to the Snoqualmie river floodplain.

Groundwater and Base Flow Maintenance – The subbasin features are of relatively low importance for groundwater recharge and base flow maintenance processes. The area contains 4% pervious soils and there are small slope wetlands along Big Rock Road. However, groundwater infiltration in the subbasin is degraded due to concentrated imperious surface cover and altered flow pathways.

Water Quality – This subbasin is important for water quality due its direct sediment contribution to lower Thayer Creek and the Snoqualmie River floodplain. The subbasin has moderate sediment export potential related to channel erosion, erodible soils, and channel slopes. Stormwater runoff directed to Thayer Creek affects channel erosion and water quality. Additionally, urban runoff is likely polluted with metals and other pollutants.

Coe-Clemmons / Thayer Floodplain

Subbasin Characterization	
Acres	663
Within City	13%
Within UGA	0%
Predominant uses within Duvall	Public park and open space
Streams	East bank of the Snoqualmie River, Lower Coe-Clemmons and Thayer Creeks, Unnamed southern tributary
Soils and Geology	Flat slopes with areas of moderately well drained soils (HGS B) and areas of slowly drained soils (HSG C).
Erosion and Landslide Hazard Areas (within City and UGA)	3% mapped as erosion hazard, along the eastern edge of the subbasin. No mapped landslide hazards.

The Coe-Clemmons and Thayer Floodplain subbasin is located at and to the southwest of the City, with the majority of the subbasin lying outside City boundaries. The subbasin consists primarily of parks and open space immediately adjacent to the Snoqualmie River in the shared floodplain of Thayer Creek, Coe-Clemmons Creek, and the Snoqualmie River.

Basin topography is generally flat, with a minor slope towards the Snoqualmie River. This slope becomes steeper and more pronounced in the western portion of the subbasin.

The following summarizes existing conditions and importance for key processes relevant to surface and stormwater management as summarized from the City of Duvall Watershed Plan (City of Duvall, 2015).

Surface Storage - The subbasin is of high importance for surface storage processes, particularly during floods. These processes are significantly degrading due to past and ongoing agricultural uses that resulted in stream and wetland loss. These processes have been partially restored within City limits. The entire subbasin lies in the floodplain and 4% is wetland.

Groundwater and Base Flow Maintenance – This subbasin contains important features for maintaining agricultural and domestic water supplies as well as Snoqualmie River temperatures. The floodplain is 90% pervious soils and infiltration to groundwater is largely intact due to low levels of impervious surface cover.

Water Quality – The floodplain and wetland landscape supports sediment deposition, water filtration, and shade processes. Although, changes in land use have depleted forest and increased input of pollutants to the subbasin including metals from upstream roadway runoff. The Snoqualmie River also experiences elevated water temperatures due to riparian forest loss and tributary impoundment.

Unnamed Southern Tributary Lower

Subbasin Characterization	
Acres	373
Within City	42%
Within UGA	9%
Predominant uses within Duvall	Single family residential and rural residential
Streams	Lower southern tributary, including Loutsis Dam Pond
Soils and Geology	Areas of moderate slopes with moderately well drained soils categorized in HSG B.
Erosion and Landslide Hazard Areas (within City and UGA)	11% mapped as erosion hazard, along the steep slopes draining to the tributary. No mapped landslide hazards.

The subbasin is located at the southern portion of the City. The subbasin consists primarily of residential development and undeveloped rural areas to the south of City limits.

The basin topography is a valley, with ridges sloping towards Loutsis Dam Pond from both the east and the west. The topography drains westward towards the Snoqualmie River along the western edge of the subbasin.

The following summarizes existing conditions and importance for key processes relevant to surface and stormwater management as summarized from the City of Duvall Watershed Plan (City of Duvall, 2015).

Surface Storage – Subbasin features provide moderate levels of surface storage during storm events, reducing downstream erosion; 6% of the subbasin is comprised of wetlands and other surface storage features (primarily Loutsis Dam pond). Surface storage processes remain largely intact, suggesting importance of maintaining storage into the future.

Groundwater and Base Flow Maintenance – Subbasin features are of relatively low importance to groundwater and base flow maintenance processes. There are no mapped permeable soils, and few mapped slope wetlands; although small slope wetlands likely do occur along the riparian corridors. Processes are minimally degraded due to low levels of existing development and a wide, forested riparian corridor

Water Quality – The subbasin has low sediment export potential; however potential direct sediment contribution to the lowest stream reaches within the ravine upstream of the Snoqualmie River floodplain indicates possible water quality importance. Sediment sources are related to channel erosion, including soil erodibility and channel bank conditions. Sediment sinks occur at Loutsis Dam and other depressional wetlands. Low levels of existing development have left most water quality processes intact. Large areas of impervious surfaces in contributing subbasins have likely increased channel erosion.

Unnamed Southern Tributary Upper

Subbasin Characterization	
Acres	327
Within City	36%
Within UGA	6%
Predominant uses within Duvall	Single family residential
Streams	Upper southern tributary
Soils and Geology	Areas of moderate slopes with moderately well drained soils categorized in HSG B.
Erosion and Landslide Hazard Areas (within City and UGA)	10% mapped as erosion hazard, along the southwestern edge of the subbasin. No mapped landslide hazards.

The subbasin is located at the southeastern edge of the City, and straddles City limits. Within the City, the subbasin consists predominantly of residential development, with less developed rural-residential areas lying outside of the UGA boundary.

Basin topography slopes generally westward towards the Snoqualmie River.

The following summarizes existing conditions and importance for key processes relevant to surface and stormwater management as summarized from the City of Duvall Watershed Plan (City of Duvall, 2015).

Surface Storage – The subbasin is of low importance for surface storage processes, with only 1% wetlands or other surface storage features. Previous development and filling of wetlands in the northeastern portion of the subbasin (within City limits) has reduced the available storage. The surface storage that is provided is minimally degraded, especially in areas outside of City.

Groundwater and Base Flow Maintenance – Subbasin features are of relatively low importance to groundwater and base flow maintenance processes. There are no mapped permeable soils and few mapped slope wetlands, although small slope wetlands likely do occur along the riparian corridors. Processes are minimally degraded due to low levels of existing development and a wide, forested riparian corridor

Water Quality – The subbasin has low sediment export potential; however potential direct sediment contribution to the lowest stream reaches within the ravine upstream of the Snoqualmie River floodplain indicates possible water quality importance. Sediment sources include erodible soils and steep slopes. Degradation related to runoff from impervious areas has likely increased channel erosion and peak flows downstream. Additionally, urban runoff is likely to contain metals and other pollutants.

3.4.4 WEISS CREEK BASIN

Weiss Creek discharges into the Snoqualmie River upstream of the City. Most of the basin has low to moderate development and watershed processes are moderately intact as summarized in Table 3-4. Of the 2,169 acres in the basin, only the Upper Weiss Creek subbasin is within the City and UGA boundaries.

Table 3-4. Upper Weiss Creek Subbasin Summary

Subbasin Name	Watershed Plan Management Group	Area (acres)		Impervious Surface within the City (%)			
		City	UGA	non-PGIS	PGIS	Total	Directed to a Stormwater Facility
Upper Weiss Creek	Moderate Conservation (2B)	7	156	2%	9%	11%	4%

Weiss Creek - Upper

Subbasin Characterization	
Acres	207
Within City	4%
Within UGA	75%
Predominant uses within Duvall	Rural residential and vacant forest lands
Streams	Headwaters of Weis Creek
Soils and Geology	Areas of moderate slopes with moderately well drained soils categorized in HSG B.
Erosion and Landslide Hazard Areas	No mapped erosion or landslide hazards.

The Upper Weis Creek subbasin is located to the southeast of the City, with the majority of the subbasin lying outside City boundaries. The subbasin is predominantly rural with large areas of forested land. The subbasin is within the existing UGA; any future annexation would increase development pressure, especially along the Big Rock Road and Batten Road corridors.

Basin topography is generally flat, with steeper slopes along the eastern basin boundary.

The following summarizes existing conditions and importance for key processes relevant to surface and stormwater management as summarized from the City of Duvall Watershed Plan (City of Duvall, 2015).

Surface Storage – The subbasin provides a moderate level of surface storage, with 13% of the land area occupied by wetlands or other surface storage features. There is a large, forested, depressional wetland complex within the UGA, to the northeast of Big Rock Ball Fields Park. Surface storage processes are generally intact, as there are low levels of existing development.

Groundwater and Base Flow Maintenance – The subbasin features are moderately important for base flow maintenance processes, but less important for recharge. There are no areas of mapped permeable soils, but large headwater wetlands for Weiss Creek are present. These processes have been minimally degraded, as there are generally low levels of existing development. Low impervious surface cover and high forest cover (especially within wetlands) support groundwater processes.

Water Quality – The headwater landscape of the subbasin supports sediment deposition and water filtration processes. Extensive areas of depressional wetlands suggest that the overall subbasin is a sediment and phosphorus sink. Wetlands provide water quality filtration before discharge to Weiss Creek. Water quality processes are relatively intact due to low levels of development throughout subbasin, especially areas surrounding the large forested wetland complex.

3.5 TARGET RETROFIT SUBBASINS

Potential Target Retrofit Subbasins were evaluated based on information in this Plan and the City's Watershed Plan (City of Duvall, 2015). The Unnamed Southern Tributary subbasin, Old Town, Coe-Clemmons – Lower, and two subbasins draining to Cherry Creek (the Cherry Creek A and C subbasin) have been identified as potential Target Retrofit Subbasin due to water quality sensitivity, the risk of erosion due to their positions in the watershed, and the presence of listed salmon species. In general, most of these subbasins are characterized by steep slopes, ravines, and large areas of mapped erosive soils and have the following specific characteristics:

1. All the project sites are located within areas with relatively high amounts of pollution generating impervious surfaces. Water quality LID solutions such as bioswales and vegetated buffers could have positive effects on water quality and removal of suspended sediment. Improved storage solutions such as ponds and vaults can also reduce peak stormwater runoff volumes and alleviate erosion on steep slopes and ravines.

2. The Cherry Creek A subbasin also contains Lake Rasmussen, which has been identified as a critical area for sediment and nutrient loading. Projects in this subbasin may help to improve water quality in the lake.

3. The Unnamed Southern Tributary subbasins have no mapped permeable soils, and the Cherry Creek A subbasin has very limited permeable soils. These areas are thus poor candidates for infiltration-based LID actions.

4. In the Cherry Creek C subbasin 36% of the soils are mapped as permeable with a high potential for groundwater recharge. Depending on the location of the proposed project within the subbasin, this site could potentially be an excellent opportunity for infiltration-based LID. This should be explored further using a site-specific feasibility analysis.

5. In the Old Town and Coe-Clemmons – Lower subbasins have been identified as requiring additional water quality features. Projects in this subbasin may help to improve water quality in the Snoqualmie River.

CHAPTER 4. SURFACE AND STORMWATER SYSTEM DESCRIPTION

4.1 OVERVIEW OF STORMWATER INFRASTRUCTURE

The City's diverse stormwater infrastructure is characteristic of its transformation from a small, riverfront, logging town into a growing, modern, city. Flow control and water quality facilities are largely nonexistent in the heart of Old Town residential neighborhoods while newer developments are characterized by LID BMPs and other stormwater facilities designed to meet current requirement.

The information presented in this chapter was derived from as-built design drawings for private and public projects along with Geographic Information Systems (GIS) facility analysis and inventory performed by Public Works staff. This analysis represents the best available data on the City's stormwater system.

4.1.1 FACTORS ANALYZED

Facilities

A total of 170 public and privately-owned stormwater facilities were identified within the City as of June 2017. As a NPDES Permit requirement, these facilities are reported on an annual basis to Ecology. Table 4-1 shows the facility distribution by type and ownership.

Table 4-1. Facilities by Type

Type	Ownership	
	Public	Private
Bioswale	38	2
Detention Pipe	32	7
Stormfilter	13	11
Pond	29	4
Vault	20	9
Other (OWS structures, infiltration, etc.)	2	3
Totals	**134**	**36**
	170	

Bioswales, including bioretention areas (typically paired with detention vaults or ponds to provide additional water quality function), and detention pipes are the most common facility types in the City, followed by ponds, vaults, and Stormfilter respectively. As discussed in Chapter 3, the relatively low infiltration capacity of the glacially consolidated fin-grained soils within the City limits locations where full infiltration techniques will operate effectively.

City staff determined that important factors for assessing the effectiveness of stormwater infrastructure are the water quality and detention requirements that correlate to the edition of the KCSWDM used to design the facility. As the science has improved, the effectiveness of stormwater facilities has also improved. Stormwater facilities designed to more recent standards will provide more effective flow control and water quality treatment along with increasing protection of sensitive areas and downstream systems. For example, the 1998 KCSWDM provides a higher standard of flow detention and treatment than previous manuals, whereas the most recent (2005, 2009, and 2016) manuals are even better still. Table 4-2 shows the facility distribution by design basis.

Table 4-2. Facilities by Design Basis

Design Manual	Percent (%)
Pre-1998 KCSWDM	44%
1998 KCSWDM	31%
2005 KCSWDM	9%
2009 KCSWDM	15%
2016 KCSWDM	No constructed facilities as of November 2017

The largest percentage by category is for facilities based on the pre-1998 KCSWDMs, however, this percentage is shifting as newer facilities come online, and older facilities are retrofitted. These facility design dates strongly reflect trends in the robust development and housing market with spikes in the early 1990’s and the early to mid-2000’s.

Detention and Water Quality

Actual detention and water quality volumes for existing stormwater facilities was not readily available for approximately 40% of the inventoried facilities. Consequently, while the data presented is the best available based on actual volumes and approximate measurements and is believed to be representative, it should be regarded as an estimate. For these calculations, Total Volume refers to the total amount of stormwater that a facility can store, while Water Quality Volume is the amount of that storage that provides water quality benefits. For example, in a bioswale, 100% of the available storage would be expected to provide water quality benefits, while in a detention pond or a vault, the percentage would be much lower and would depend on the design of the individual facility. Currently, there is over two million cubic feet of known detention volume in the study area, 20% of which also provides water quality benefits by design. Some facility types (such as ponds) may provide incidental water quality benefits associated with vegetated slopes even if they are not specifically designed to do so.

Catch Basins

There are over 2,600 mapped public and privately-owned catch basin stormwater structures in the City, for an average density of 2.8 catch basins per developed acre. Catch basin density can be an important metric because it serves as an indication of how far runoff will have to travel before finding its way into the stormwater system. The longer runoff travels before entering the stormwater system, the more opportunities there are to cause erosion or collect pollutants. Table 4-3 details the types of catch basins in the City.

Table 4-3. Catch Basins by Type

Type	Count	Percent (%)
Type 1 Catch Basin	1,979	76
Type 1-L Catch Basin	68	3
Type 2 Catch Basin	553	21
Total	**2,600**	**100**

A Type 1 catch basin has a metal lid (solid or grated) set flush with the ground surface and covering a rectangular concrete box up to five feet deep. These are used to convey water into pipes less than 12-inches in diameter (Type 1) and up to 18-inches in diameter (Type 1L) within five feet of the surface. These structures commonly include a sediment sump are the most common type of stormwater catch basin in the City and widely used nationwide.

A Type 2 catch basin has either a solid or a grated cover. These are used to connect to larger pipes or when the depth from the ground surface to the pipe is greater than five feet. These structures are also used as control structures or flow splitters to manage discharge flow rates from facilities. These structures include a sediment sump and are the second most common type of catch basin in the City and widely used nationwide.

There are more than 60 miles of mapped stormwater conveyance in the study area, including approximately 172 mapped culverts (includes driveway crossings) and 2.5 miles of natural stream mapped as part of the stormwater conveyance system.

Pipes are by far the most common type of conveyance in the City, as in most cities, as seen in Table 4-4. Pipes are effective, safe, out of sight, have a long service life, and are the right design choice for many situations. However, most conveyance pipes are not designed to provide water quality or ecological benefits in contrast to grass-lined swales or other naturalized conveyance systems. Consequently, it is important to pair pipes with stormwater facilities that provide these benefits.

Table 4-4. Conveyance by Type

Type	Count (Segment)	Total Length (Ft)	Percent (%) by Length	Percent (%) by Count
Artificial Stream	2	336	0.1	0.05
Culvert	172	7,902	2	4
Detention Pipe	51	4,738	1	1
Ditch	264	39,910	12	6
French Drain	34	4,115	1	1
Infiltration Trench	27	1,644	0.5	1
Pipe	2,953	220,240	66	67
Natural Stream	52	13,548	4	1
Yard Drain	879	38,860	12	20
Total	**4,434**	**331,295**	**100**	**100**

4.2 ASSET MANAGEMENT

In addition to planning for regular operations and maintenance of the system (described in more detail in Chapter 8) the City must also budget and plan for regular replacement cycles as stormwater system components reach the end of their functional lives. Different components of the system have different service lives, and may last longer or shorter depending on how they were constructed and how they are being used. Table 4-5 shows the minimum design service life for different system components (WSDOT, 2017). This the minimum amount of time that a well-designed and properly installed and maintained component should be expected to last.

Table 4-5. Recommended Component Service Life (WSDOT, 2017)

Component	Service Life (years)
Conveyance Pipe	50 - 80
Drain Pipe	25
Manhole	50
Catch Basin	30
Roadside Ditch	15
Culvert	50 - 75

The City is fortunate to have a relatively new stormwater systems in most parts of the City. As part of the planning process, the Public Works Department has been compiling information on the age and types of different components of the system, as seen in Table 4-6, and Table 4-7. This process is still ongoing, and it is likely that some of the components with unknown installation dates listed will still be identified. Facilities in parts of Old Town are likely to be older and designed to less stringent requirements.

Table 4-6. Public Conveyance by Age in linear feet (as of March 2018)

	Total Length	Age (Years)					Average Cost*
		Unknown	≤ 10	11 - 20	21-30	31 - 40	
Pipe (12" PVC only)	109,151	74,522	2,585	690	25,917	5,437	$76 per linear foot
Ditch (Grass lined swale)	36,024	3,366	200	3,484	14,498	14,476	$5 per square foot

*Average costs derived from recent City projects

Table 4-7. Count of Public Catchments by Age (as of March 2018, *does not include private structures*)

	Total Number	Age (Years)					Average Unit Cost*
		Unknown	≤ 10	11 - 20	21-30	31 - 40	
Type 1	1,709	621	174	442	369	103	$1,500
Type 1-L	64	20	5	30	8	1	$1,630
Type 2	470	159	54	133	102	22	$4,000 - $4,800

*Average costs derived from recent City projects

4.3 Stormwater Flow Control and Water Quality Treatment Facilities

This section discusses existing stormwater infrastructure by subbasin. The stormwater flow control and water quality facility distribution shown in Table 4-8 reflects the broader pattern of development within the City. Older areas are less likely to be served by a stormwater facility, shown in red in Figure 4-1.

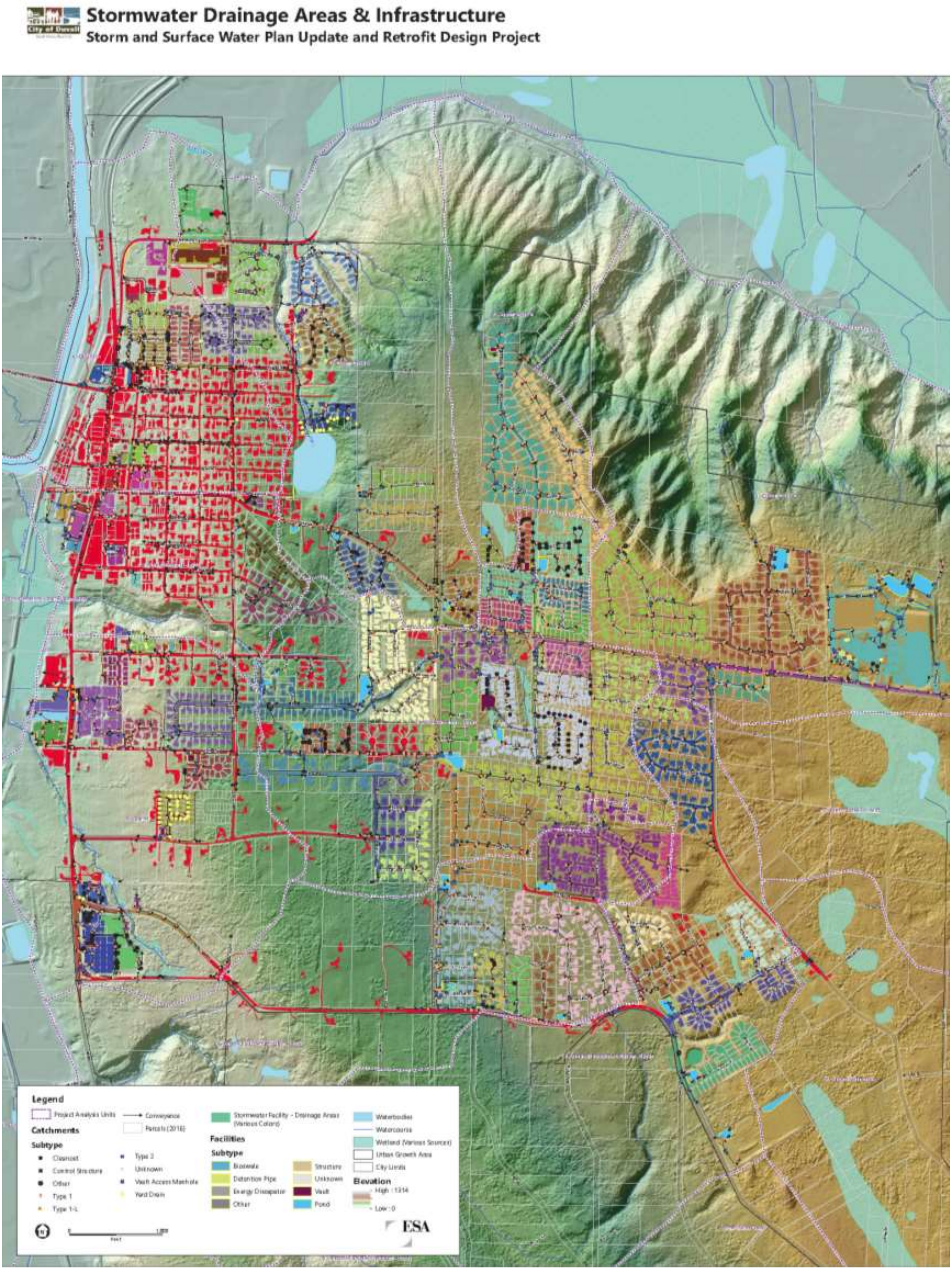

Figure 4-1. Stormwater drainage areas and infrastructure

Table 4-8. Stormwater facility distribution by subbasin.

Subbasin	Developed Area* (Acres)	Total Area in City & UGA (Acres)	Developed Area* Served by a Facility (%)	Facility Count	Average Development Year
Cherry Creek A	100	215	81%	19	2000
Cherry Creek B	50	76	96%	7	2000
Cherry Creek C	143	268	100%	16	2001
Coe-Clemmons - Lower	74	99	31%	12	1990
Coe-Clemmons - Upper	196	212	94%	36	1998
Coe-Clemmons / Thayer Floodplain	9	94	79%	6	1998
Old-Town	104	136	26%	25	2003
Thayer	71	315	77%	22	2002
Unnamed Southern Tributary - Lower	126	166	100%	11	1997
Unnamed Southern Tributary - Upper	99	108	78%	13	1995
Upper Weiss Creek	5	123	94%	3	Unknown

* Developed area was approximated as any area within a subdivision that does not include: wetlands, stream buffers, landslide hazard areas, or designated open space.

4.3.1 Cherry Creek Basin

The Cherry Creek tributaries drain the northern edge of the City and the North UGA. The large-scale transition of this area from primarily rural-residential development and forest land to residential subdivision started in the early 1990's and continues to the present. The three subbasins are very similar in percent coverage and age of development.

Cherry Creek A

Facilities – There are 19 stormwater facilities in the Cherry Creek A subbasin, which were constructed between 1989 and 2016, with an average construction year of 2000. Approximately 81% of the developed area is classified as both developed and served by a stormwater facility. Facility types are primarily bioswales, detention pipes, ponds, and vaults, with Stormfilters being less common. The majority were designed using the 1998 KCSWDM with the remainder based on the pre-1998 KCSWDM, 2005 KCSWDM, and 2009 KCSWDM.

Detention and Water Quality – Approximately 32% of the known storage volume in the watershed provides water quality benefits.

Catch basins – There are approximately 308 mapped catch basins in the Cherry Creek A subbasin for a density of 3.1 catch basins per developed acre. Most of these catch basins are Type 1 and Type 2.

Conveyance – There are 34 mapped culverts and approximately eight miles of conveyance in the Cherry Creek A subbasin. Most of this conveyance is pipes and ditches. The subbasin also contains 3,470 feet of natural stream and 342 feet of infiltration/dispersion trench.

Cherry Creek B

Facilities – There are 7 stormwater facilities in the Cherry Creek B subbasin that were constructed in 1994 or 2005, with an average construction year of 2000. Approximately 96% of the developed area is served by a stormwater facility. Facility types are primarily bioswales, detention pipes, and vaults with Stormfilters and ponds being less common. Over half were designed using the 1998 KCSWDM and the rest using the pre-1998 KCSWDM.

Detention and Water Quality – Only 7% of the known storage volume in the watershed provides water quality benefits.

Catch basins – There are approximately 84 mapped catch basins in the Cherry Creek B subbasin for a density of 1.7 catch basins per developed acre. Most of the catch basins are Type 1 or Type 2.

Conveyance – There are no mapped culverts and approximately two miles of conveyance pipe in the Cherry Creek B subbasin. There are no natural or artificial streams mapped as part of the stormwater conveyance.

Cherry Creek C

Facilities – There are 16 stormwater facilities in the Cherry Creek C subbasin that were constructed between 1992 and 2016, with an average construction year of 2001. Approximately 100% of the developed area is served by a stormwater facility. Facility types are primarily bioswales, detention pipes, and vaults with Stormfilters, infiltration or dispersion trenches, and ponds being less common options. The majority were designed using a pre-1998 KCSWDM and the remainder using the 2005 and 2009 KCSWDM.

Detention and Water Quality – Approximately 16% of the known storage volume in the watershed provides water quality benefits.

Catch basins – There are approximately 405 mapped catch basins in the Cherry Creek C subbasin for a density of 2.8 catch basins per developed acre. Most catch basins are Type 1 or Type 2.

Conveyance – There are 13 mapped culverts and approximately nine miles of conveyance pipe in the Cherry Creek C subbasin. The subbasin also contains 415 feet of infiltration or dispersion trench. There are no natural stream channels mapped as part of the stormwater conveyance.

4.3.2 DUVALL TRIBUTARIES BASIN

The Tributaries Basin covers the oldest and most developed portions of the City including the lowland areas and floodplain of the Snoqualmie River. Since much of this area was developed before stormwater collection and treatment was common, there tend to be no stormwater facilities.

Old Town

Facilities – There are 25 stormwater facilities in the Old Town subbasin that were constructed between 1989 and 2014, with an average construction year of 2003. These facilities are largely clustered in Old Town and are privately-owned facilities serving commercial properties. Only 26% of the developed area is served by a stormwater facility, reflecting the area's age and history. Facility types are primarily Stormfilters and detention pipes, with bioswales, ponds, vaults, and infiltration/dispersion trenches being less common options. Design basis is evenly split among all the KCSWDMs with no period having prevalence.

Detention and Water Quality – Approximately 54% of the known storage volume in the watershed provides water quality benefits, the highest of any subbasin in the City.

Catch basins – There are approximately 322 mapped catch basins in the subbasin for a density of 3.1 catch basins per developed acre. Most of these catch basins are Type 1.

Conveyance – There are 32 mapped culverts and approximately six miles of conveyance in the subbasin, most of which conveys flows from other parts of the City. Most of this conveyance is piped with the remainder being open ditch. This subbasin also contains 39 feet of infiltration or dispersion trench.

Coe-Clemmons Lower

Facilities – There are 12 stormwater facilities in the relatively small Coe-Clemmons Lower subbasin that were constructed between 1987 and 2002, with an average construction year of 1990. Only 31% of the developed area is served by a stormwater facility, reflecting the area's age and history. Facility types are primarily detention pipes with bioswales, ponds, and vaults being less common options. All but one of the facilities were designed based on a pre-1998 KCSWDM.

Detention and Water Quality – None of the known storage in this subbasin is designed to provide water quality benefits.

Catch basins – There are approximately 112 mapped catch basins in the subbasin for a density of 1.5 catch basins per developed acre. Most of these catch basins are Type 1.

Conveyance – There are 31 mapped culverts and approximately five miles of conveyance in the subbasin. Most of this conveyance is pipes and ditches. The subbasin contains 3,900 feet of natural stream.

Coe-Clemmons Upper

Facilities – There are 36 stormwater facilities in the Coe-Clemmons Upper subbasin that were constructed between 1988 and 2012, with an average construction year of 1998. Approximately 94% of the developed area is served by a stormwater facility. Facility types are primarily bioswales, detention pipes, and ponds with vaults being a less common option. Most of the facilities were designed based on the 1998 or a pre-1998 KCSWDM. The remainder are split between the 2005 or 2009 KCSWDM.

Detention and Water Quality – Approximately 21% of the known storage volume in the watershed provides water quality benefits.

Catch basins – There are approximately 566 mapped catch basins in the subbasin for a density of 2.9 catch basins per developed acre. Most of these catch basins are Type 1 or Type 2.

Conveyance – There are 21 mapped culverts and approximately 12 miles of conveyance in the subbasin. Most of this conveyance is pipes and ditches. The subbasin contains 4,360 feet of natural stream.

Thayer

Facilities – There are 22 stormwater facilities in the Thayer subbasin that were constructed between 1998 and 2009, with an average construction year of 2002. Approximately 77% of the developed area is served by a stormwater facility. Facility types are primarily bioswales and vaults with detention pipes, Stormfilters, infiltration or dispersion trenches, and ponds being less common options. The design basis for these facilities is evenly split between the pre-1998, 1998, and 2009 KCSWDMs, plus a few facilities based on the 2005 KCSWDM.

Detention and Water Quality – Approximately 24% of the known storage volume in the watershed provides water quality benefits.

Catch basins – There are approximately 334 mapped catch basins in the subbasin for a density of 4.7 catch basins per developed acre – some of the densest coverage in the City, largely due to newer shopping complexes. Most of these catch basins are Type 1 or Type 2.

Conveyance – There are 29 mapped culverts and approximately seven miles of conveyance in the subbasin. Most of this conveyance is pipes and ditches. The subbasin contains 3,550 feet of natural stream and 650 feet of infiltration/dispersion trench.

Coe-Clemmons / Thayer Floodplain

Facilities – There are 6 stormwater facilities in the very small and largely undeveloped (and undevelopable) Coe-Clemmons/Thayer Floodplain subbasin. These facilities were constructed between 1991 and 2003, with an average construction year of 1998. Approximately 79% of the developed area is served by a stormwater facility. Facility types are primarily detention pipes with bioswales and

Stormfilters being less common options. Most of the facilities were designed based the 1998 KCSWDM, with a couple using an earlier guidance manual or method.

Detention and Water Quality – None of the known storage in this subbasin is designed to provide water quality benefits.

Catch basins – There are approximately 43 mapped catch basins in the subbasin for a density of 4.9 catch basins per developed acre. Most of these catch basins are Type 1 or Type 2.

Conveyance – There are 4 mapped culverts and approximately one mile of conveyance in the subbasin. Most of this conveyance is pipes and natural stream. The subbasin contains 1,800 feet of natural stream.

Unnamed Southern Tributary Lower

Facilities – There are 11 stormwater facilities in the Unnamed Southern Tributary Lower subbasin. These facilities were constructed between 1985 and 2011, with an average construction year of 1997. Approximately 100% of the developed area is served by a stormwater facility. Facility types are evenly split between bioswales, detention pipes, ponds, and vaults with Stormfilters being a less common options. Most of the facilities were designed based on a pre-1998 KCSWDM with all but one of the rest using the 1998 KCSWDM.

Detention and Water Quality – Approximately 18% of the known storage volume in the watershed provides water quality benefits.

Catch basins – There are approximately 299 mapped catch basins in the subbasin for a density of 2.4 catch basins per developed acre. Most of these catch basins are Type 1 or Type 2.

Conveyance – There are three mapped culverts and approximately six miles of conveyance in the subbasin. Most of this conveyance is pipes. The subbasin contains no infiltration/dispersion trenches or natural streams mapped as stormwater conveyance.

Unnamed Southern Tributary Upper

Facilities – There are 13 stormwater facilities in the Unnamed Southern Tributary Upper subbasin. These facilities were constructed between 1989 and 2005, with an average construction year of 1995. Approximately 78% of the developed area is served by a stormwater facility. Facility types are primarily detention pipes with bioswales and ponds being less common options. Most of the facilities were designed based on a pre-1998 KCSWDM with the rest using the 1998 KCSWDM.

Detention and Water Quality – Only 2% of the known storage volume in the watershed provides water quality benefits.

Catch basins – There are approximately 214 mapped catch basins in the subbasin for a density of 2.2 catch basins per developed acre. Most of these catch basins are Type 1 or Type 2.

Conveyance – There are five mapped culverts and approximately four miles of conveyance in the subbasin. Most of this conveyance is pipes or ditches. The subbasin contains 198 feet of infiltration/dispersion trench.

4.3.3 Weiss Creek Basin

The Weiss Creek basin is located to the southeast of the City, with most of the basin lying outside of City boundaries. Only a very small area of developed land lies within this basin – a portion of Big Rock Ball Fields Park.

Weiss Creek - Upper

Facilities – There are three inventoried stormwater facility in the Upper Weiss Creek subbasin, covering 94% of the area classified as developed. These are pond facilities, but the date of construction and design basis are not known.

Detention and Water Quality – The attributes of these facilities are not known.

Catch basins – There are four catch basins in the subbasin for a density of 0.7 catch basins per developed acre – the lowest in the city. Three catch basins are Type 2 and one Type 1.

Conveyance – There are no mapped culverts and approximately 782 linear feet of conveyance in the subbasin. Most of this conveyance is ditches and pipes.

4.4 Drainage, Erosion and Water Quality Concerns

The following section provides areas of known drainage, erosion and/or water quality concerns within the City's surface and stormwater drainage network. For the most part, these areas have been identified through maintenance activities, citizen complaints, and storm incident response documentation.

- Duvall Mobile Home Park
- Big Rock Road NE
- Cherry Valley Vista (NE Rupard Road)
- 3rd Avenue NE Corridor
- Legacy Ridge (NE 286th Avenue culvert)
- Juniper Glen (neighborhood ditch conveyance)
- 4th Avenue Apartments (a.k.a. The Park Apartments – outfall)
- NE Kennedy Drive Corridor

Public Works has also implemented several capital projects in the last decade to address concerns within other subbasins at specific storm drainage catchments. These projects and the underlying concerns addressed are documented in Chapter 2 and include several stormwater pond retrofit activities in the Coe-Clemmons Upper subbasin and the Unnamed Southern Tributary Upper subbasin.

CHAPTER 5. SYSTEM ANALYSIS

5.1 Systems Analysis and Priority Project Identification Methods

There are approximately 170 mapped stormwater facilities within the City, including many multi-structure facilities. As such, it was not feasible to visit each one to conduct a field analysis as a part of this planning effort. Instead, Public Works developed and implemented an innovative approach to assess and prioritize drainage areas (organized as drainage plats) across the City and urban growth areas (UGAs). For this Plan, all assessment relies on the City's geodatabase of existing stormwater conveyance infrastructure, including: type, size, outfall location, and design parameters at the time of development (as well as identification of areas without water quality or detention facilities).

Geodatabase characteristics were considered at the drainage plat level along with detailed mapping of tree canopy cover and impervious surface coverage. City staff used these parameters to establish an assessment and ranking tool to identify stormwater retrofit opportunities across the City. Each facility and associated drainage plat area was assigned a score based on:

- Facility features:
    - Facility type;
    - Design basis (adopted design manual used);
    - Outfall location.
- Drainage area features:
    - Tree cover;
    - Impervious surface coverage;
- Watershed features:
    - Susceptibility to erosion;
    - Sensitivity of downstream waters - *with respect to water quality.*

Assigning scores to each of the factors resulted in a facility rank in each of three categories: Opportunity, Performance, and Downstream Water. Figure 5-1 conceptually highlights the overall assessment and ranking structure (see Appendix A of this Plan for details on assessment and ranking methodology).

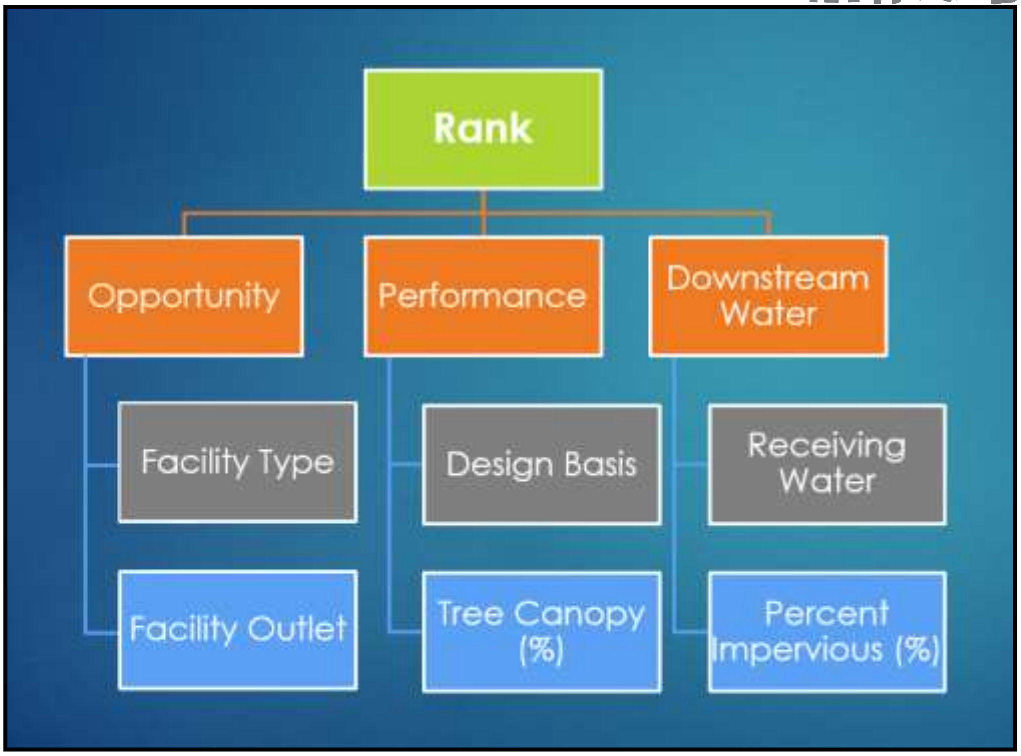

Figure 5-1. A diagram outlining the facility assessment and ranking process including the factors in each scoring category.

The higher the aggregate score, the higher the facility (and associated drainage plat) ranked for retrofit. Drainage plat areas within the City that are not currently served by a facility were also ranked, but in a separate list that does not include the Opportunity scoring component. Separate scoring and ranking of drainage plats with no facility recognize the additional cost and complexity of installing new facilities in an area where one does not exist.

For all drainage plats with existing facilities, the top-ranked projects were then reviewed by the project team and assessed on more site-specific factors. These factors include additional considerations for:

- Private/Public partnership potential;
- Ownership;
- Known facility deficiencies – “hot spots”;
- Site specific information regarding retrofit ease/difficulty (available area, existing grade, etc.);
- Potential to implement Low Impact Development (green stormwater) solutions; and
- Upstream or downstream retrofit opportunity.

The final list of projects recommended for retrofit reflects both the ranking process, additional filters for feasibility, and the professional judgement of City staff.

5.2 RETROFIT OPTIONS

The goal of any retrofit project is to improve the performance of the existing facility. In this context, improvement is measured in reductions in peak flows (improved detention) and reductions in pollutants (improved water quality). The specific pollutants that need to be addressed vary by location. Water quality testing should be conducted at each proposed retrofit site so that the system can be designed to best address the prevailing water quality issues. Common water quality issues include total suspended solids (TSS), heavy metals, oil and grease, and biological matter.

This section provides general identification of the suite of retrofit approaches that could be used to address identified surface and stormwater impairments. Each of the specific actions that have been considered for stormwater retrofit projects rely on these general retrofit approaches. Along with traditional stormwater facility retrofit actions, green-stormwater infrastructure (GSI) and LID actions will be identified, as well as discussion of actions that could combine traditional and GSI/LID approaches

5.2.1 REDUCING PEAK FLOWS

Reducing peak flows to downstream receiving waters generally involves use of BMPs to either reduce runoff from a drainage area, or delay the arriving inflows. Reduction in flow is generally accomplished by increasing infiltration to the groundwater table, while delay of flow is generally accomplished by providing additional storage or reconfiguring the facility's outfall to release storage more slowly.

Maximizing Infiltration

As discussed in Chapter 3, infiltration is not a widely applicable solution in the till soils of the City. However, permeable soils are present in some areas, and depending on results of site-specific investigation, it may be feasible to design infiltration facilities at these locations. For sites located within mapped areas of permeable soils, it is recommended to conduct infiltration tests to verify that the soils have the appropriate characteristics for infiltration as well as any available groundwater mapping. This will assess if the infiltrated stormwater will just reappear as a spring further downslope, resulting in adverse drainage problems for adjacent properties (whether developed or natural).

Another alternative to a traditional infiltration system is to change the characteristics of the contributing drainage area from impervious to pervious surface coverage. Impervious surfaces such as roofs, driveways, and roadways increase runoff concentrations as opposed to soaking into vegetated areas. For example, replacing a paved pathway with woodchips, gravel, pavers, grasscrete, or some other pervious material would allow more runoff to soak in rather than flow into a conveyance system. For many areas of the City, implementing retrofits that separate 'clean' runoff from pollution generating impervious surfaces would allow for a more beneficial focus of resources.

Amending soils to increase infiltrative capacity, and increasing vegetative cover across a site, are additional strategies to maximize pervious surfaces. Planting trees or retaining and shrubs can help reduce total runoff, especially if providing canopy and root structures in areas of restored soils converted from hardscapes. Additionally, for single family residential homes, LID solutions like rain barrels and cisterns can have dual benefits of reducing both winter runoff and summer domestic water demand by allowing homeowners to store runoff on their properties for use on their lawns and gardens.

New or Expanded Detention

The concept of stormwater detention has been around for a long time and is generally well understood. By capturing runoff during a storm's peak rainfall intensity, and releasing it over a longer period to mimic pre-developed conditions, you can reduce downstream flow impacts including flooding and erosion. This approach also leads to a more natural stream hydrograph, maintaining aquatic habitat conditions beneficial to native fish species, including salmonids. Increasing detention time generally involves enlarging a facility to add additional storage capacity, but can sometimes be accomplished more economically by reconfiguring an outlet control structure.

There are several stormwater models to determine detention requirements in a basin, including the Washington Department of Ecology's Western Washington Hydrologic Model (WWHM). These models are frequently required for new construction but can also be applied to retrofit studies. Other ways to assess if more detention is required in a basin is to monitor existing facilities and look for downstream impacts. If an existing facility reaches its storage capacity and overflows frequently during rainfall events, it is a candidate for expansion. Evidence of bank erosion in an otherwise healthy channel or reports of downstream flooding during storms are also indicators of a need for additional storage upstream.

After determining that there is a need for additional detention in the subbasin, sites should be assessed for feasibility such as site layout and facility type. The site layout determines if there is space available to make the proposed modifications, and how it should be designed. For example, at a wide-open site it may be possible to add a new pond or expand an existing one, while in a more constrained location an underground facility might be a better option. Facility type affects the ease of construction. It is much easier to add capacity to a pond rather than modify a buried concrete vault.

5.2.2 Improving Water Quality

The 2009 and 2016 KCSWDMs place nearly equal emphasis on controlling peak discharge and protecting water quality. The goal in protecting water quality is to prevent TSS, oils, heavy metals, and a host of other pollutants from reaching rivers and streams. This is best achieved by some form of filtration. Settling, which may be achieved in a traditional pond or vault, is an effective treatment for TSS but does very little to remove fine particles, oils, or dissolved contaminants.

There are already a significant number of facilities within the City that are classified as bioswales or Stormfilters, highlighting the higher water quality treatment standards that have been implemented since adoption and enforcement of the 2005 KCSWDM. Filtration has two fundamental approaches: mechanical and biological.

- **Mechanical filtration** includes Stormfilters and oil-water separators that use some form of natural or artificial media to strain pollutants from the flow. This media usually needs to be maintained and replaced at some defined interval for the facility to continue the designed function.
- **Natural filtration** includes bioswales, treatment wetlands, and grass filter strips, which use the inherent ability of vegetation to absorb pollutants and trap sediment to achieve water quality improvements. Natural filtration methods take more work to establish and require regular maintenance to prevent sediment accumulation or colonization by invasive weeds.

5.3 STORMWATER RETROFIT PROJECT EVALUATION

5.3.1 RETROFIT RANKING RESULTS

This section presents the results of the City's retrofit ranking results for drainage plats with existing stormwater facilities. Table 5-1 shows the top 25 ranked existing stormwater facilities that were identified as needing retrofit actions. A detailed methodology for facility assessment and ranking can be found in Appendix A of this Plan. After these facilities were identified, City staff applied additional feasibility criteria and known system deficiencies to come up with five retrofit projects to be added to the CIP project list. With the update of this Plan, conceptual pre-design reports for these five facilities are provided in Appendix B of this Plan.

Table 5-1. Top 25 Retrofit ranking for drainage plats with existing stormwater facilities

Rank	Facility / Drainage Plat Name	Facility Description
1	Taylors Ridge I (No. 1)	Detention Pipe in ROW (150th St) (public facility)
2	Taylors Ridge I (No. 2)	Detention Pipe in ROW (150th St) (public facility)
3	**Duvall Highlands Mobile Home Park**	**Pond (privately owned)**
4	Big Rock Ridge Div. 1-3 (South Pond)	Pond (public facility)
5	**Big Rock Ridge Div. 1-3 (North Pond)**	**Pond (public facility)**
6	Houston Barclay Building	Detention Pipe (privately owned)
7	US Post Office	Oil/Water Separator (privately owned)
8	**Kasper Heights Div. 1**	**Pond (public facility)**
9	**Cedarcrest High School (1992)**	**Pond (privately owned)**
10	278th Street Improvements	Detention Pipe in ROW (278th St) (public facility)
11	Chapman Div. 1	Bioswale (public facility)
12	Bruett Road Phase II (a.k.a. 152nd St)	Pond (public facility)
13	Cedar Grove	Pond (public facility)
14	Cedarbrooke	Pond (public facility)
15	Duvall Town Center (a.k.a. Chevron)	Detention Pipe (privately owned)
16	NE 150th Road Improvements (1996)	Detention Pipe in ROW (150th St) (public facility)
17	Taylors Ridge Div. 1 & 2	Bioswales to Vault (public facility)
18	Legacy Ridge	Pond (public facility)
19	Braithburn Academy	Infiltration pipe (privately owned)
20	Big Rock Road	Bioswale (public facility)
21	**Cherry Valley Vista**	**Detention Pipe (public facility)**
22	Cherrybrooke	Detention Pipe (public facility)
23	150th Vault (CHS off-site)	Vault (public facility)
24	Ritas Homestead	Bioswale (public facility)
25	The Ridge	Pond (public facility)

The five highlighted facilities have been identified as the City's top priorities and are included on the CIP project list

5.3.2 Top Five Retrofit Projects

Duvall Highland Mobile Home Park - Pond (Ranked #3)

This is a shallow asphalt lined, privately owned and maintained ‘flow-through’ pond constructed in 1986, Figure 5-2. The City is proposing to either create a partnership with the property owners, or take over ownership and maintenance of the facility. Currently the pond has little to no storage or water quality attributes. Design could include accommodation of stormwater from future ROW improvements along NE 142nd Place and expansion into the ROW.

The facility is located in the southwest corner of King County parcel, 1926079005 at address 28000 NE 142nd Place, Duvall, WA 98019.

Figure 5-2. Duvall Highlands Mobile Home Park Pond

Facility Opportunities and Efficiencies

This stormwater facility ranked third in the City’s watershed based approach to improve stormwater management. Based on the age of the facility and 2016/2017 stormwater management standards, the opportunity to add water quality and increase detention volumes will protect and improve downstream systems. This project will incorporate a larger, deeper stormwater pond to comply with 2016 KCSWDM flow control and water quality standards as well as incorporating low impact development (LID) techniques. These LID approaches include but are not limited to increased tree canopy coverage, water quality components, and right-of-way (NE 142nd Place) bioretention options.

This project also provides unique opportunities including:

- Reduced peak flow and improved water quality to the Unnamed South Tributary - Lower watersheds and sensitive downstream conditions associated with the NE Big Rock Road drainage.
- A public/private partnership between the City and MHP
- Treatment and detention for offsite properties located north of the MHP that currently drain to the MHP facility.
- Treatment, detention, and possible coordinated construction for the NE 142nd Non-motorized improvement project (TIP# C-1 and C-2)
- Incorporation of BMP T7.30: Bioretention Cells
- Incorporation of BMP T5.16: Tree Retention
- Incorporation of BMP T5.13: Post Construction Soil Quality and Depth
- Incorporation of BMP T10.40: Combined Detention and Wetpool Facilities

Big Rock Ridge Div. 1-3 – North Pond (ranked #5)

This is a large pond constructed in 1998 that discharges south of NE Big Rock Road out of City limits into a sensitive drainage (unnamed stream) area. There is room in the northwest of this facility to incorporate the Laura Vera Estates detention pipe (ranked #57) which is occupying a City owned parcel, and possibly Big Rock Road bioswale (ranked #20). All three facilities are shown in Figure 5-3. The intent is to add storage and water quality and possibly eliminate the Laura Vera Estates detention pipe. Monumentation, informational signage (LID), and park equipment could also be incorporated for this project.

This facility is located on the King County parcel, 0808300250 in the northeast corner of the intersection at NE Big Rock Road and NE Roney Road. The facility is owned and maintained by the City of Duvall. The Laura Vera Estates detention pipe is located to the northwest on the vacant, City owned King County parcel, 4213500170. The Big Rock Road bioswale is location on City owned, King County parcel, 6672930380 in the NE corner of the intersection at NE Big Rock Road and 282nd Place NE.

Figure 5-3. Big Rock Ridge Pond, Laura Vera Detention Pipe, and Big Rock Road Bioswale.

Facility Opportunities and Efficiencies

This stormwater facility ranked fifth in the City's watershed based approach to improve stormwater management. There is a possibility to regionalize this facility to add water quality and increase detention volumes to protect and improve downstream systems. This project will incorporate a larger, deeper stormwater pond to comply with 2016 KCSWDM flow control and water quality standards as well as incorporating LID techniques. These LID approaches include but are not limited to increased tree canopy coverage, large bioretention components, and right-of-way (282nd Place NE and NE Big Rock Road) water quality options.

This project also provides unique opportunities including:

- Reduced peak flow and improved water quality to the Unnamed South Tributary - Upper watersheds and sensitive downstream conditions associated with the NE Big Rock Road drainage.
- Possible consolidated drainage with the Laura Vera Facility (located upstream and to the north) and 282nd Ave NE intersection bioswale.
- Incorporation of BMP T7.30: Bioretention Cells
- Incorporation of BMP T5.16: Tree Retention
- Incorporation of BMP T5.13: Post Construction Soil Quality and Depth
- Incorporation of BMP T10.40: Combined Detention and Wetpool Facilities

Kasper Heights Div. 1 (ranked #8)

This is a pond/bioswale/detention pipe facility constructed in 1997, Figure 5-4, which discharges within City limits to downstream ditches and ultimately south of NE Big Rock Road out of City limits into a sensitive drainage area with previous drainage complaints. There is opportunity to add storage volume to the facility and possibly reconfigure the water quality portion to reduce burdens on downstream conveyance.

This facility is located on the King County parcel, 3793400420 in the northeast corner of the intersection at 275th Avenue NE and NE 140th Place.

Figure 5-4. Kasper Heights Pond and Bioswale

Facility Opportunities and Efficiencies

This stormwater facility ranked eighth in the City's watershed based approach to improve stormwater management. Based on the age of the facility and 2016/2017 stormwater management standards, the opportunity to add water quality and increase detention volumes will protect and improve downstream systems. This project will incorporate a larger, deeper stormwater pond to comply with 2016 KCSWDM flow control and water quality standards as well as incorporating LID techniques. These LID approaches include but are not limited to increased tree canopy coverage, and improving water quality components.

This project also provides unique opportunities including:

- Reduced peak flow and improved water quality to the Unnamed South Tributary - Lower watersheds and sensitive downstream conditions associated with the NE Big Rock Road drainage and drainage complaints within unincorporated King County south of City Limits.
- Incorporation of BMP T5.16: Tree Retention
- Incorporation of BMP T5.13: Post Construction Soil Quality and Depth
- Incorporation of BMP T10.40: Combined Detention and Wetpool Facilities

Cedarcrest High School – 1992 Pond (ranked #9)

This facility was designed and built in 1992 during construction of Cedarcrest High School and originally discharged from the east pond, Figure 5-5, through a 200-foot grass-lined swale onto undeveloped property to the north. Since the construction of Cedarcrest High School, athletic field improvements have updated aspects of the stormwater system and incorporated new components. A swale was added to the inlet of the pond in 2002 when the synthetic football field was constructed. In 2013, the bioswale was improved and relocated. The design intent is to increase storage volume of the 1992 pond and possibly relocate the outlet to discharge to the northeast onto School District owned property, minimizing downstream impacts.

This facility is located in the northeast corner of King County parcel: 1826079013 at address: 29000 NE 150th Street, Duvall, WA 98019.

Figure 5-5. Cedarcrest High School East Pond

Facility Opportunities and Efficiencies

This stormwater facility ranked ninth in the City's watershed based approach to improve stormwater management. Based on the age of the facility and 2016/2017 stormwater management standards, the opportunity to add water quality and increase detention volumes will protect and improve downstream systems. This project may incorporate a deeper stormwater pond to comply with 2016 KCSWDM flow control and water quality standards as well as incorporating low impact development (LID) techniques. These LID approaches include but are not limited to water quality and detention components with steep slopes, and improving existing dispersion/infiltration trench. This project will also include a public/public cooperation between the City and the Riverview School District.

This project also provides unique opportunities including:

- Reduced peak flow and improved water quality to steep slopes associated with the Cherry Creek C watersheds and sensitive downstream conditions associated with the Cherry Creek Tributary drainage.
- A partnership between the City and Riverview School District.
- Possible coordinated construction of a new outfall facility to improve dispersion and infiltration.
- Incorporation of BMP T7.20: Infiltration Trenches (depending on soil conditions).
- Incorporation of BMP T5.16: Tree Retention.
- Incorporation of BMP T5.13: Post Construction Soil Quality and Depth.
- Incorporation of BMP T10.40: Combined Detention and Wetpool Facilities

Cherry Valley Vista (ranked #21)

This facility includes detention pipes, bioswale, and culverts, constructing in 1994 as seen in Figure 5-6. Currently there is a significant impact downstream during the wet season as the bioswale is no longer established or functioning. Water tops the ditch and culvert system and flows over NE Cherry Valley Road. The existing culverts are nearing failure with piping observed along the culverts. There is a large area where a storage or water quality cell could be added, or the bioswale could be re-established. Additional improvements could include mitigation or replacement of the cross-culvert beneath NE Rupard Road.

The detention pipes are located within the right-of-way, parallel to the curb-line in NE Rupard Road, and culverts cross under NE Rupard Road conveying a tributary creek. The bioswale area is on the King County parcel: 1558500320 at the northeast corner of the intersection of 270th Place and Rupard Road.

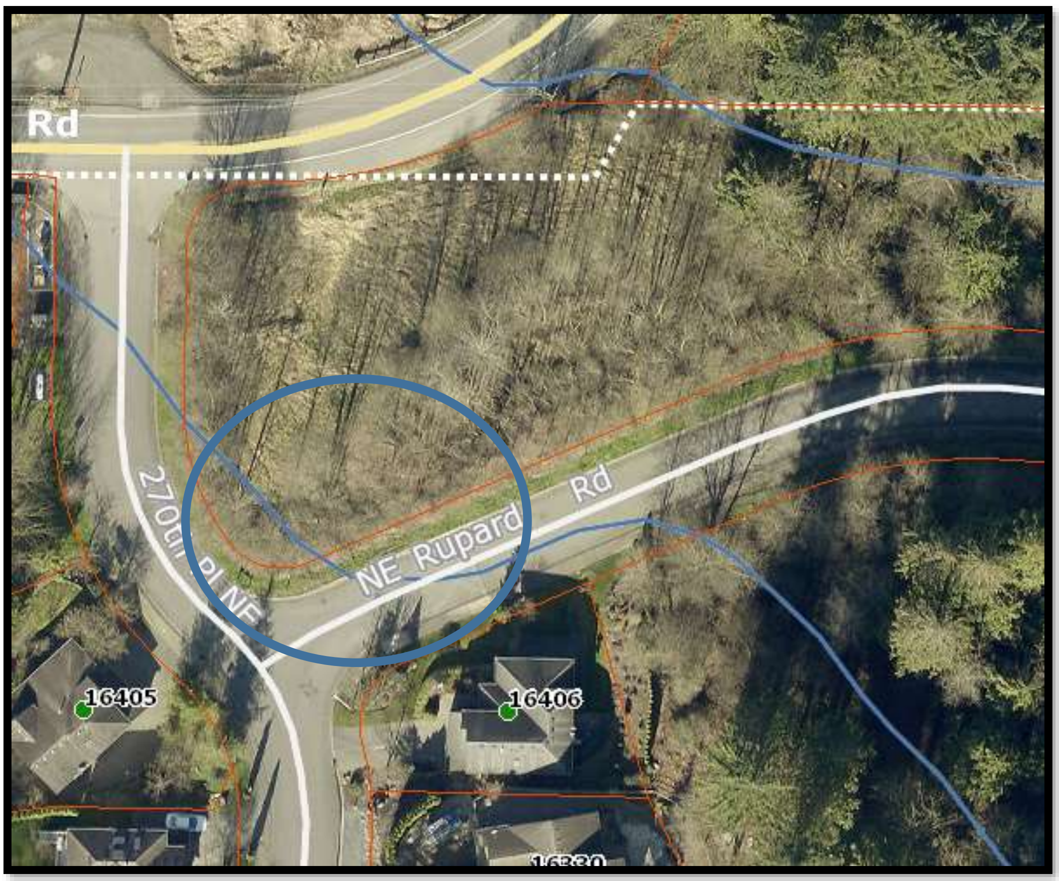

Figure 5-6. Cherry Valley Vista Detention Pipes

Facility Opportunities and Efficiencies

This stormwater facility ranked twenty-one in the City's watershed based approach to improve stormwater management. Based on the age of the facility and 2016/2017 stormwater management standards, the opportunity to add flow control and water quality features will protect and improve downstream systems. This project will incorporate a new stormwater pond to comply with 2016 KCSWDM flow control and water quality standards as well as incorporating low impact development (LID) techniques. These LID approaches include but are not limited to water quality and detention components, while possibly improving fish passage elements (for the culvert segment).

This project also provides unique opportunities including:

- Improved water quality to the Cherry Creek A watersheds and sensitive downstream conditions associated with the tributary of the Cherry Valley Creek drainage.
- Possible coordinated construction and mitigation with the Rupert Road culvert fish passage barrier.
- Possibly improve on-site wetlands/re-establish bioswale.
- Incorporation of BMP T7.30: Bioretention Cells.
- Incorporation of BMP T5.16: Tree Retention.
- Incorporation of BMP T5.13: Post Construction Soil Quality and Depth.

CHAPTER 6. FUNDING AND FINANCING PROGRAM

6.1 FISCAL POLICIES AND FINANCIAL STATUS

Funding and Financing of stormwater infrastructure operations, maintenance, and improvements are a vital component of a successful Stormwater Utility and associated environmental stewardship. Storm Drainage Utility rates and City allotted funds for professional services allow the City to maintain its existing infrastructure and plan for replacement of infrastructure that is nearing the end of its functional lifecycle.

Operations and Maintenance activities are typically funded through rate-payer monthly fees paid into the **404 Storm Drainage Utility Fund**. These utility billing fees pay for personnel, equipment, and other resources required for regular operations. Storm Drainage Utility rates and annual budget are determined through processes separate from adoption of this Plan and documented by Duvall Municipal Code Chapter 9.06 (Storm Drainage Utility) and associated Fee Ordinances. Storm Drainage Utility revenue in the 404 Storm Drainage Utility Fund was approximately $724,939 in 2017, and has seen an average 4% annual growth from 2014 to 2017, largely due to annual inflation adjustments and increases in the number of dwelling units across the City.

Capital system improvements, such as retrofits and conveyance improvements, are typically funded through development-related fees paid into the City's **409 Storm Drainage Capital Improvement Fund**, and supplemented by grants and other resources. Development-related stormwater acreage revenues have varied based on the amount of development occurring each year. The development-related stormwater revenue for 2017 was approximately $83,937. Table 6-1 lists recent revenues for stormwater improvements.

Table 6-1. Summary of Existing Revenue for Operations, Maintenance and Capital Improvements of the City's Storm Drainage Utility.

	404 Storm Drainage Utility revenue	409 Storm Drainage Capital Improvement Fund	One-Time Grants
2014	$656,580	$7,684	$41,820
2015	$679,063	$1,890	$80,018
2016	$701,536	$2,286	$11,213
2017 (Year End Estimate)	$724,939	$83,937	$440,816
Annual Average	$690,529	$23,949	$143,466

In addition to these revenue sources, the City's budget for stormwater operations, maintenance, and capital improvements has been supplemented by one-time, variable funding sources. From 2012-2017, these sources have included:

- King Conservation District grants;
- King County Flood Control District Sub-Regional Opportunity Fund grants;
- Washington State Department of Ecology NPDES Municipal Capacity Grants for NPDES Permit implementation and water quality retrofit planning (future allocations are likely); and
- One-time grants for both capital construction and studies. To provide just a few examples, the City was awarded $155,020 for the Carrie-Rae Pond Retrofit Project in 2013, $203,468 for the Parkwood Pond retrofit project in 2017, and was awarded approximately $200,000 for this Surface and Stormwater Planning and Retrofit Pre-Design project in 2015/2016.

6.1.1 FUTURE REVENUE

Potential rate and fee impacts associated with this Plan's recommendations were a primary consideration in identifying required surface and stormwater services, with the goal of minimizing the need for additional revenue over the life of the Plan. The City recognizes that the Storm Drainage Utility rates and development impact fees collected over the last twenty years have been less than the annual costs of appropriate operations and maintenance of existing publicly owned facilities and capital improvements. Completion of these activities and associated system capital improvements have been heavily dependent on grant revenues, which have accounted for approximately 20% of all available stormwater funding in the 2012-2017 timeframe.

The City owned and operated Storm Drainage Utility served approximately 2,548 accounts in 2017. Commercial, multi-family, and other non-residential Storm Drainage Utility customers within the City pay a monthly storm drainage utility fee that is directed to the City's **404 Storm Drainage Utility Fund**. These charges are based on the number of "equivalent residential units" (ERUs) of impervious surface on the property, where one ERU equals 3,000 square feet of impervious surface. Single-family residences pay a flat fee of one ERU and commercial properties pay a fee based on impervious area measurements completed by the City from recent air-photos. The monthly rate for each ERU is adjusted annually every January based on the 12-month average (July—June) percent change in Consumer Price Index for All Urban Consumers (CPI-U) for the preceding two years within the Seattle-Tacoma-Bremerton area. The 2017 Storm Drainage Utility rate for a single-family residence was $19.56 per month ($234.72 annually).

Developers pay a one-time Storm Drainage Acreage Charge which accounts for the developer portion of cost associated with the CIP. The Storm Drainage Acreage Charge is collected at Final Plat or Commercial Building Permit Approval and is used to help fund system capital improvements that are needed to serve, or mitigate impacts from future growth. All revenue collected from these fees are directed to the City's **409 Storm Drainage Capital Improvement Fund**. According to DMC 9.06.120, the fund is to be "used to pay the cost and expense of constructing and installing general facilities for storm drainage and flood control". Monies within this fund can be supplemented by contributions from other sources such as grants. This fund has been the primary source for implementing facility retrofits. The 2017 acreage charge was $1,972 per acre or fraction thereof; the acreage charge had not been increased or otherwise adjusted since 2001 except for annual inflationary increases. Funds collected between 2001-2017 were insufficient for completion of capital projects. In order to address this funding discontinuity, a recommendation of this Plan is to create a new Stormwater General Facility Charge (GFC) at Residential and Commercial Building permit issuance to further mitigate impacts from new development and provide funding for capital projects.

6.2 DEVELOPER IMPROVEMENTS

The City has adopted specific requirements for new development and redevelopment which include installation of on-site stormwater facilities along with roadway frontage stormwater improvements. Mitigation of identified downstream drainage deficiencies is also required in accordance with King County Surface Water Design Core Requirement 2 (Section 1.2.2.2). Other City requirements, LID best management practices, retrofit of existing facilities, and measures to reduce the burden on stormwater infrastructure is promoted by City staff for all project within the City from preliminary design to construction.

The City also evaluates development impacts under the State Environmental Policy Act (SEPA) guidelines. A SEPA review process may identify adverse stormwater impacts that require additional mitigation beyond installation of improvements to manage water quality and quantity. These impacts and mitigation measures could be related to downstream private water supplies, sensitive areas, erosion hazards, habitat and endangered species, or other stormwater issues. The needed improvements may or may not be identified as specific projects in this Plan.

6.3 COST SUMMARY

The City has prepared an updated Capital Improvements Plan (CIP) which details the anticipated project costs, including total Capital Improvements and on-going Citywide Programs, from 2018 to the 2035 horizon year. These costs are summarized in Table 6-2. The improvement projects and programs are estimated to cost approximately $8.87 million in 2017 dollars, project list and project cost breakdown can be found in Chapter 7. Approximately $3.33 million of the total project costs are associated with future development and are considered as the basis for calculation of the Storm Drainage Acreage Charge and proposed Stormwater GFC. The remaining $5.54 million of total project costs represents the City and grant portion of these costs. This requires approximately $326,000 per year of City and/or grant funds over the life of this Plan.

However, if no changes are made to the Storm Drainage Acreage Charge or GFC, the City and/or grant portion would increase to $7.21 million, requiring approximately $424,000 per year over the life of this Plan. The GFC is a recommended funding mechanism of this Plan (that may be completed as a separate action) that will provide capital improvement funds due to growth from development.

Table 6-2. 2018 to 2035 Project Cost Summary

Capital Improvements		Citywide Programs		Total Costs ($1,000's)
Description	Costs ($1,000's)	Description	Costs ($1,000's)	
Retrofit Projects (Projects R1-R12)	$3,853	**Conveyance and other facility or Citywide improvements (Projects O-1 to O-9)**	$1,147	
Culvert/Outfall Repair or Replacement (C-1 to C-6)	$1,852	**Education and Outreach (Project O-10)**	$ 85	
Minor Conveyance and/or Water Quality Improvements (I-1 to I-8)	$1,833	**Stormwater Management Plan, Standards, and Code Updates (Project O-11)**	$100	
Subtotal	**$7,538**		**$1,332**	**$8,870**

6.4 DEVELOPMENT FORECAST (2018 TO 2035)

The City's Public Works and Planning Departments completed a buildable lands study to support development of the 2015 Comprehensive Plan amendment. The study includes parcel-specific baseline measurements for residential and commercial uses within the City as of January 1, 2015 and forecasts future growth for a period of 20 years, to the horizon year of 2035. This is summarized in the memorandum titled *City of Duvall 2015 Capacity and Transportation Analysis Study/EIS Alternatives* (City of Duvall, 2017) and summarized in Table 6-3.

Table 6-3. 2018 to 2035 Development Forecast

	Parcel Area (Acres)	Dwelling Units (Units)	Commercial *Floor Area* (SF)	Light Industrial *Floor Area* (SF)	Commercial *Impervious Area* (SF)	Light Industrial *Impervious Area* (SF)
2015 Existing Total Development	963	2,657[2]	370,021[2]	56,200[2]	2,602,330	233,988
2035 Anticipated Total Development	1,412[1]	3,844[2]	789,767[2]	89,685[2]	5,554,372	373,402
2015-2035 Anticipated Change in Development	449[1]	1,227[3]	419,746[3]	33,485[3]	2,952,042	139,414
2015 – 2017 Actual Development	20[4]	145[4]	0[4]	0[4]	0	0
2018 – 2035 Anticipated Change in Development	429[5]	1,082[5]	419,746[5]	33,485[5]	2,952,042	139,414

[1]Table 5b, *City of Duvall 2015 Capacity and Transportation Analysis Study/EIS Alternatives* (City of Duvall, 2017).
[2]Table 7, *City of Duvall 2015 Capacity and Transportation Analysis Study/EIS Alternatives* (City of Duvall, 2017).
[3]Difference between 2035 Anticipated Development and 2015 Existing Development.
[4]Based on City of Duvall Building Department Data for new homes in 2015-2017 (Year End Estimate), Parcel Area estimated at an average 6,000 SF.
[5]Difference between 2015-2035 Anticipated Development and 2015-2017 Actual Development.

6.5 REVENUE REQUIREMENTS

The financial analysis of the Storm Utility is intended to provide a focused review of the overall financial health of the utility and the revenue needed to implement the recommendations of this Plan. The following sections summarize recommended revenue approaches to fund the proposed Plan.

6.5.1 404 STORM DRAINAGE OPERATIONS UTILITY FUND

404 Storm Drainage Operations Utility Fund charges are billed as monthly rates to customers and contribute to operations and maintenance activities along with minor system improvements. These funds pay for:

- Staff;
- Equipment;
- Services;
- and Other resources required for day-to-day operation of the Storm Utility.

A City of Snoqualmie report documented that the Storm Utility rate at seven eastern Puget Sound Cities, ranged from $12.36 (North Bend) to $28.36 (Bellevue) in 2017 (FCS Group; City of Snoqualmie, 2017). The City of Duvall 2017 rate was slightly above the average of seven cities studied at $19.56 per month ($234.72 annually) as illustrated in Figure 6-1.

Figure 6-1. Summary of 2017 Monthly Storm Utility Rates at Seven Cities

Annual **404 Storm Drainage Operations Utility Fund** rate revenue and expenses associated with operations and maintenance were relatively balanced from 2014 to 2017 suggesting appropriate rate amounts during that timeframe. However, approximately $146,000 in Ecology's NPDES Municipal Capacity Grant revenue directly offset operation and maintenance costs during this time as well. Therefore, lack of future grant revenue could result in a revenue shortfall for the **404 Storm Drainage Operations Utility Fund**. However, changes to the 2017 Storm Drainage Utility rate and structure are not recommended as part of this Plan based on rate comparison with nearby cities.

6.5.2 409 Capital Improvement Fund

409 Storm Drainage Capital Improvement Fund revenues are reserved for completion of retrofits, conveyance capacity improvements, water quality improvements, and other general system improvements. Prior to 2018, revenue to the **409 Storm Drainage Capital Improvement Fund** was limited to a one-time Storm Drainage Acreage Charge charged at final plat or Commercial Building Permit Approval of $1,972 per acre or fraction thereof (2017 rate). Revenue in the 2014 to 2017 timeframe totaled $95,797 which did not provide sufficient funds for Capital Project completion.

The City's Storm Drainage Acreage Charge is a bulk acreage charge independent of actual use, development density, or burden on the stormwater system and environment. Stormwater capital improvement charges vary among neighboring cities in eastern Puget Sound. However, most cities (except Duvall) charge GFCs as opposed to an acreage charge. These GFCs are generally based on square feet (SF) of impervious surface coverage or an ERU for each single-family residence (SFR). Conversion of the City's 2017 Storm Drainage Acreage Charge to an equivalent GFC ERU would vary from $99/ERU for R-20 (20 units per acre) to $493/ERU for R4 (four residential units per acre) with an ERU equal to a Single Family

Residential (SFR) lot or 3,000 SF of impervious (DMC 9.06.125.C). Table 6-4 summarizes 2017 Stormwater Capital Improvement charges from nearby cities.

Table 6-4. Summary of 2017 One-Time Storm Capital Charges at Seven Cities.

City	General Facility Charge (SFR)	Notes
Bellevue	$999	Capital Recovery Charge for each SFR (based on $5.55/2,000 SF per month for 10 years, normalized to 3,000 SF for consistency with Duvall rate structure).
Snoqualmie	$328	General Facility Charge for each SFR
Duvall*	$99 to $493	Conversion from Storm Drainage Acreage Charge to ERU basis for each SFR (R-20 to R4)
Sammamish	$1,491	System Development Charge ($1,491 for $2,500 SF, an additional $298 for 500 SF to normalize to 3,000 SF for comparison)
Redmond	$1,437	Stormwater Capital Facility Charge (based on $958/2,000 SF, normalized to 3,000 SF for comparison)
Issaquah	$1,256	General Facility Charge per SFR
North Bend	$800	Per SFR (based on $800/2,920 SF)
Average	$916 to $972	

*The City of Duvall is proposing a ***new*** General Facility Charge based on SFR

The 2017 Storm Drainage Acreage Charge was found to be less than capital charges for nearby cities. This charge did not provide sufficient funds for Capital Project completion prior to 2017, and was found to provide insufficient funds for the 2018-2035 CIP within this Plan. The recommendation of this Plan is that revenue from the Storm Drainage Acreage Charge would pay half of the Development-related Capital Improvements summarized in Table 6-2 and revenue from a new GFC would pay for the remaining half of Development-related Capital Charges. Alternatively, if no GFC is adopted the City would absorb half of the Development related capital improvements or the Strom Drainage Acreage Charge would need to double.

To increase revenue into the City's *409 Storm Drainage Capital Improvement Utility Fund* and encourage additional use of LID BMPs as new development occurs, the following is recommended as part of this Plan:

The Storm Drainage Acreage Charge, paid based on site acreage at the time of final plat, stand-alone new residential, or commercial building permit, should be adjusted upward from $1,972 per acre or fraction thereof, to $3,878 per acre, is outlined in Table 6-5.

- The Storm Drainage Acreage Charge includes allowed reductions where applicants agree to implement additional LID BMPs beyond minimum requirements as summarized in section 6.5.3.

Also shown in Table 6-5 is the amount of the Storm Drainage Acreage charge if no GFC is adopted.

Table 6-5. Storm Drainage Acreage Charge for 2018-2035 Anticipated Change in Development.

Total Development-Related Costs	Half of Development-Related Costs	Parcel Area (Acres)	Acreage Cost with GFC (2017 Dollars)[1]	Acreage Cost with no GFC (2017 Dollars)[2]
$3,327,042	$1,663,521	429	$3,878	$7,755

[1]Half of Development-Related Costs/Parcel Area (Acres) with a GFC

[2]Half of Development-Related Costs/Parcel Area (Acres) without a GFC

6.5.3 STORM DRAINAGE ACREAGE CHARGE INCENTIVES

This Plan includes proposed Storm Drainage Area Charge reductions where applicants agree to implement additional LID BMPs beyond minimum requirements:

Residential:

- 100% Storm Drainage Area Charge with standard infrastructure and minimal LID BMP implementation because of site limitations.
- Reduction of the Storm Drainage Area Charge to 75% where LID BMPs are used as part of residential development to eliminate the need for traditional detention facilities (vaults, ponds, and detention pipes) and other gray infrastructure approaches.
- Reduction of the Storm Drainage Area Charge by a maximum of 50% as part of residential development if storm runoff is kept on-site through use of LID BMPs and traditional facilities are significantly reduced.

Commercial:

- Reduction of the Storm Drainage Area Charge to 75% where LID BMPs are used as part of commercial development to eliminate the need for traditional detention facilities (vaults, ponds, and detention pipes) and other gray infrastructure approaches.

The intent of the proposed residential Storm Drainage Area Charge reduction is to encourage installation of new and emerging technologies focused around LID and preservation of natural systems to manage surface and stormwater. Reduced capital fee revenues will be offset by the long-term system-wide savings for reduced LID repair/replacement costs, as well as reducing required operations and maintenance activities. Proposed commercial Storm Drainage Area Charge reduction intent is similar. Additional Commercial Rate reductions to further encourage management of all privately owned and maintained commercial facilities is allowed in accordance with DMC 9.06.125.E.4.

CHAPTER 7. SYSTEM IMPROVEMENTS

7.1 STORMWATER SYSTEM IMPROVEMENTS

7.1.1 CAPITAL IMPROVEMENT PLAN (CIP) DEVELOPMENT

The Capital Improvement Plan (CIP) is a priority list of stormwater system improvement projects and programs that the City hopes to undertake by 2035. Each project in the CIP includes a project description, an estimate of total project cost, the funding approach (proportions of City Storm Fund allocations), and an identified timeframe for implementation. This list was developed by Public Works staff based on the systemwide evaluation and analysis summarized in Chapter 5, and additional consideration of current maintenance practices and anticipated maintenance and system improvement needs. The identified improvement projects and programs will help the City to implement the overall Comprehensive Plan goals and policies.

The CIP includes the following categories of water quality, detention, and conveyance improvements and strategies:

1. Retrofit Projects;
2. Culvert/Outfall Repair or Replacement Projects;
3. Minor Conveyance and/or Water Quality Improvement Projects; and
4. Other Citywide Stormwater Programs.

Table 7-1 summarize the Stormwater System CIP and specific project locations are depicted in Figure 7-1.

Table 7-1. Stormwater System Capital Improvement Program Project List (2018-2035).

Project Group	Map ID	Project Name	Project Limits	Project Description	Total Project Cost Estimated	City Funds		Development Charges		Grants		Time Frame
						Share (%)	Cost ($)	Share (%)	Cost ($)	Share (%)	Costs ($)	
RETROFIT PROJECTS	R-1	Duvall Highland Mobile Park Homes Pond Retrofit - Public/Private Partnership	Duvall Highlands MHP Stormwater Pond	Expand stormwater pond and increase detention volume to mitigate downstream issues, possibly expanding the facility into existing ROW to accommodate frontage improvement stormwater (requires dedication or easement)	$267,084	0%	$0	40%	$106,834	60%	$160,250	Short
	R-2	Big Rock Ridge Div. 1-3 (North Pond) Retrofit	NE Big Rock Road and NE Roney Road	Retrofit pond and bioswale to increase detention and water quality while possibly incorporating an older detention pipe to the north (Laura Vera Estates), which could regionalize the facility.	$536,169	0%	$0	40%	$214,468	60%	$321,701	Short
	R-3	Kasper Heights Div. 1 Retrofit	275th Avenue NE and NE 140th Place	Retrofit stormwater facility to increase storage volumes and mitigate downstream flooding issues	$454,011	0%	$0	40%	$181,604	60%	$272,407	Short
	R-4	Cedarcrest High School East Pond Retrofit - Public/Public Coop	Cedarcrest High School	Retrofit stormwater facility to increase storage volumes and improve pond outfall.	$281,757	0%	$0	40%	$112,703	60%	$169,054	Short
	R-5	Cherry Valley Vista Retrofit	270th Place NE and NE Rupard Road	Retrofit stormwater facility to accommodate higher flows while incorporating water quality. May include repair or replace existing hanging/undersized culverts to the east.	$235,537	0%	$0	40%	$94,215	60%	$141,322	Short
	R-6	Big Rock Ridge Div. 1-3 (South Pond) Retrofit	NE Big Rock Road and NE 138th Place	Retrofit stormwater pond to increase storage volumes to protect sensitive outfall area south of Big Rock Road (Possibly incorporate PGIS from NE Big Rock Road for additional water quality).	$460,152	0%	$0	40%	$184,061	60%	$276,091	Mid - Long
	R-7	Legacy Ridge Pond & Bioswale Retrofit	near 15413 286th Avenue NE	Reestablish bioswale and increase storage volume in existing stormwater pond to protect Cherry Creek tributary outfall. Possibly look at bypassing or incorporating high flows from adjacent natural flow path to the west to protect from downstream erosion and sediment transport.	$849,560	0%	$0	40%	$339,824	60%	$509,736	Mid - Long
	R-8	Cherrybrooke Bioswale Retrofit	3rd Avenue NE and NE Cherry Valley Road	Retrofit bioswale and incorporate additional water quality features.	$44,066	0%	$0	40%	$17,626	60%	$26,440	Mid - Long
	R-9	Rita's Homestead Bioswale Retrofit	278th Avenue NE and NE 152nd Street	Retrofit stormwater facility to accommodate higher flows while incorporating water quality. Increase volume/storage of bioswale.	$115,983	0%	$0	40%	$46,393	60%	$69,590	Mid - Long
	R-10	Cedarbrooke Pond and Bioswale Retrofit	near 26923 NE Kennedy Drive	Retrofit Pond for additional volume/water quality to incorporate neighborhood to the east (PGIS and nine existing homes) and add outfall energy dissipater.	$179,340	0%	$0	40%	$71,736	60%	$107,604	Mid - Long
	R-V1	Pond Retrofit (various)	Various	Pond Retrofit from included within Table 5-1 of 2018 Surface and Stormwater Management Plan	$350,000	0%	$0	50%	$175,000	50%	$175,000	Mid – Long
	R-V2	Bioswale Retrofit (various)	Various	Bioswale Retrofit from included within Table 5-1 of 2018 Surface and Stormwater Management Plan	$80,000	0%	$0	50%	$40,000	50%	$40,000	Mid - Long
CULVERT/OUTFALL REPAIR OR REPLACEMENT	C-1	Coe Clemons Creek Culvert 1	NE Kennedy Drive	Repair/Replace hanging NE Kennedy Drive Culvert immediately east of 3rd Avenue NE	$367,217	25%	$91,804	40%	$146,887	35%	$128,526	Mid - Long
	C-2	Coe Clemons Creek Culvert 2	NE 144th Place	Repair/Replace undersized roadway culvert, near 26932 NE 144th Place	$363,578	25%	$90,895	40%	$145,431	35%	$127,252	Mid - Long
	C-3	Coe Clemons Creek Culvert 3	3rd Avenue NE	Repair/Replace hanging 3rd Avenue NE Culvert immediately east of 3rd Avenue NE and north of NE Kennedy Drive	$366,307	25%	$91,577	40%	$146,523	35%	$128,208	Mid
	C-4	Cherry Creek Tributary Culvert	NE Rupard Road	Repair/Replace culvert beneath NE Rupard Road and associated downstream ditch/swale conveyance (Possible Coordination with Project R-2).	$368,127	25%	$92,032	40%	$147,251	35%	$128,844	Short
	C-5	Thayer Creek Outfall	NE 145th Street	Repair/Replace hanging culverts in the southwest corner of Duvall's Wastewater Treatment Plant property.	$23,851	10%	$2,385	90%	$21,466	0%	$0	Short
	C-6	Unnamed Tributary Culvert	NE Big Rock Road	Repair/replace culvert to address associated flooding issues near 26801 NE Big Rock Road. Add catch basin and piped conveyance upstream if necessary.	$363,578	25%	$90,895	40%	$145,431	35%	$127,252	Mid

Project Group	Map ID	Project Name	Project Limits	Project Description	Total Project Cost Estimated	City Funds		Development Charges		Grants		Time Frame
						Share (%)	Cost ($)	Share (%)	Cost ($)	Share (%)	Costs ($)	
MINOR CONVEYANCE AND/OR WATER QUALITY IMPROVEMENTS	I-1	Kennedy 1 Development outfall swale revision	NE Kennedy Place and 1st Ave NE	Re-establish bioswale to accommodate increased flows and improve bioswale outfall system to reduce bypass flow to the west.	$55,993	25%	$13,998	40%	$22,397	35%	$19,598	Short
	I-2	NE 150th Street Pavement Removal/LID Improvements	275th Avenue NE to 286th Avenue NE	Remove pollution generating impervious surface (pavement) width and incorporate bioretention/other LID to improve water quality.	$755,002	25%	$188,751	40%	$302,001	35%	$264,251	Short
	I-3	Improve conveyance along Big Rock Road (ditch, catch basins, pipe)	275th Avenue NE to 3rd Avenue NE Extension	Improve conveyance system along the north side of NE Big Rock Road to accommodate increased volumes (tightline or improved ditch section).	$419,321	10%	$41,932	90%	$377,389	0%	$0	Developer-Driven
	I-4	Improve conveyance/outfall from Glen Cairn	272nd Place NE	Improve outfall in the SW corner of Glencairn development by incorporating level spreader or dispersion trench.	$13,440	10%	$1,344	90%	$12,096	0%	$0	Developer-Driven
	I-5	Improve catch basin/conveyance - 1st Avenue NE	NE Valley Street to NE Stephens Street	Improve stormwater conveyance along 1st Avenue NE to accommodate increased volumes. Includes new pipe and structures along with water quality measures.	$161,028	25%	$40,257	40%	$64,411	35%	$56,360	Mid
	I-6	NE Miller Street Conveyance Improvements (ditch, culverts, catch basins)	NE 3rd Place to Miller Homestead	Improve conveyance system for Coe Clemons Creek tributary along NE Miller Street. Includes re-alignment of conveyance pipe along the north side of the road and new catch basins.	$116,480	25%	$29,120	40%	$46,592	35%	$40,768	Mid - Long
	I-7	Improve conveyance (ditch and pipe) in Juniper Glen Plat	2nd Place NE and NE Comegys Street	Improve conveyance with in Juniper Glen subdivision to minimize downstream impacts and improve flooding issues.	$311,760	25%	$77,940	40%	$124,704	35%	$109,116	Mid
CITYWIDE PROGRAMS	O-1	Annual Pipe Replacement/CIPP Program/Root Removal Program	Citywide	Citywide program to replace broken/deteriorated/missing storm conveyance pipe or utilize Cured-In-Place-Pipe (CIPP) alternatives as well as addressing root intrusion issues that create flooding problems annually or as necessary.	$85,000	95%	$80,750	0%	$0	5%	$4,250	On-going
	O-2	Facility Tree Planting Program	Citywide	Citywide program to plant new trees or shrubs for facility screening, shading, and maintenance.	$17,000	25%	$4,250	0%	$0	75%	$12,750	On-going
	O-3	Disconnect Downspout	Citywide	Public education and outreach program to highlight the importance of finding ways to manage stormwater from your home on site and reduce the burden on existing infrastructure.	$85,000	25%	$21,250	0%	$0	75%	$63,750	On-going
	O-4	Rain Garden Program	Citywide	Public education and outreach program to highlight the importance of incorporating rain gardens to manage stormwater from individual lots and reduce the burden on existing infrastructure.	$25,500	25%	$6,375	0%	$0	75%	$19,125	On-going
	O-5	Chain Link Fence Upgrades	Citywide	This is an on-going, Citywide effort to remove and replace failing perimeter fencing around City owned and maintained stormwater facilities.	$340,000	95%	$323,000	0%	$0	5%	$17,000	On-going
	O-6	Stormwater Facility Baseline Mapping and Asset Management	Citywide	Implementation of an asset management system to compliment and improve operations and maintenance of City owned infrastructure.	$85,000	95%	$80,750	0%	$0	5%	$4,250	On-going
	O-7	Catch Basin Cleaning	Citywide	On-going Citywide program (NPDES requirement)	$170,000	25%	$42,500	0%	$0	75%	$127,500	On-going
	O-8	Maintenance and Operations	Citywide	On-going Citywide program to maintain vegetation and infrastructure.	$255,000	25%	$63,750	0%	$0	75%	$191,250	On-going
	O-9	General Old Town Water Quality Improvements Program	Old Town	Incorporate low impact development (LID) techniques into Old Town to maximize basic treatment of pollution generating impervious surfaces (PGIS).	$85,000	25%	$21,250	0%	$0	75%	$63,750	On-going
	O-10	Education and Outreach Program	Citywide	On-going Citywide program (NPDES requirement)	$85,000	25%	$21,250	0%	$0	75%	$63,750	On-going
	O-11	Stormwater Comprehensive Plan Update	Citywide	On-going effort to keep goals, policies, and design standards current with Federal regulations.	$100,000	25%	$25,000	40%	$40,000	35%	$35,000	On-going
				Totals	**$8,871,841**	-	**$1,543,054**	-	**$3,327,042**	-	**$4,001,745**	-

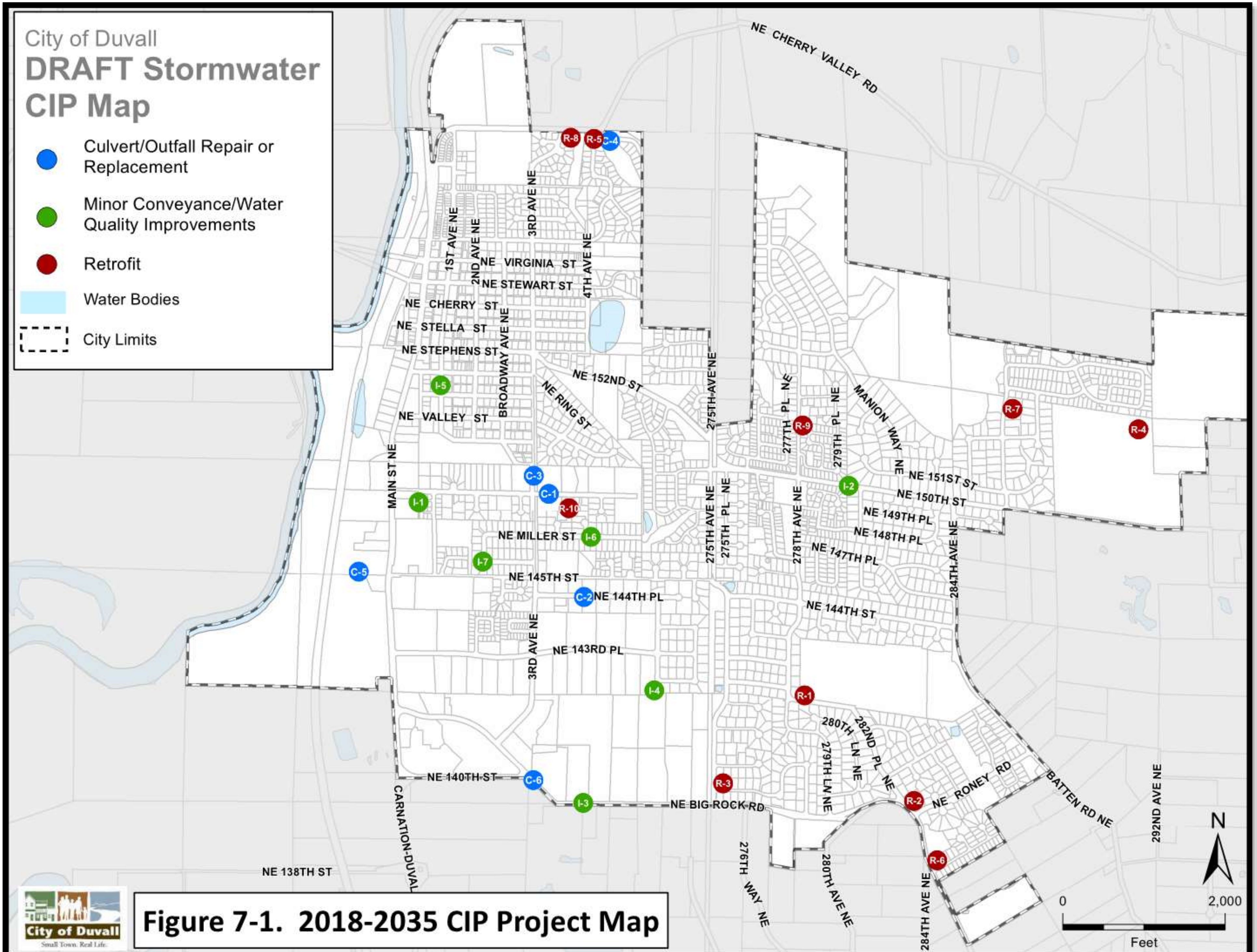

Figure 7-1. 2018-2035 CIP Project Map

7.2 IMPROVEMENT PROJECTS AND PROGRAMS

7.2.1 RETROFIT PROJECTS

The CIP incorporates ten of the highest-ranking stormwater retrofit projects identified in Chapter 5, as well as two general "various" retrofits (pond and bioswale) whose locations may be selected at a future date based on opportunities such as nearby construction projects or available grant funding. These projects will improve water quality and detention and benefit downstream receiving water bodies. Facility retrofits will also incorporate LID BMPs such as bioretention, increased canopy cover, and other approaches as possible.

7.2.2 CULVERT / OUTFALL REPAIR OR REPLACEMENT PROJECTS

Repair and or replacement of undersized or non-functioning culverts along creek reaches within City limits will reduce potential flooding issues, eliminate fish barriers, and provide improved access to upstream habitat. The creeks identified for culvert replacement in the CIP list include Coe Clemons Creek, Thayer Creek, Cherry Creek Tributary, and an Unnamed tributary of the Snoqualmie River that crosses beneath NE Big Rock Road.

7.2.3 MINOR CONVEYANCE AND/OR WATER QUALITY IMPROVEMENT PROJECTS

Improvements to conveyance include removal of pollution generating impervious surfaces (PGIS), ditch maintenance, improving existing conveyance pipe, and adding structures when necessary. The approach to these projects are similar to the *Retrofit Projects*, but on a smaller scale. The purpose of minor conveyance and or water quality improvements are to minimize flooding and mitigate impacts as shown in Table 7-1.

7.2.4 CITYWIDE IMPROVEMENT PROGRAMS

The Surface and Stormwater Management Plan includes eleven Citywide improvement programs:

- Annual Pipe Replacement/Cured-In-Place Pipe (CIPP) Program/Root Removal Program;
- Facility Tree Planting Program;
- Disconnect Downspouts;
- Rain Garden Program;
- Education and Outreach Program;
- General Old Town Water Quality Improvement Program;
- Chain Link Fence Upgrades;
- Catch Basin Cleaning;

- Maintenance and Operations;
- Stormwater Facility Baseline Mapping and Asset Management; and
- Surface and Stormwater Management Plan Update.

The *Annual Pipe Replacement/Cured-In-Place Pipe (CIPP) Program/Root Removal Program* will be used to preserve and enhance the City's existing and planned stormwater system. The program provides the City with a systematic approach for evaluating piped conveyance networks for pipe/structure condition, root intrusion, blockages, sediment accumulation, and other similar conveyance issues. The City will need to consider allocating a significant annual budget including funding for staff resources to administer the maintenance, operations, and capital programs to ensure that the stormwater infrastructure is preserved in a cost-effective manner. For regional improvements, staff resources will be used to prepare grants and coordinate with local and federal governing entities.

The *Facility Tree Planting Program* will be used by the City to improve tree canopy area to enhance water quality, shading, and facility screening. The program will focus on locations not covered by a specific capital project shown in Table 7-1, and will allow the City to fill gaps in canopy coverage that are needed to provide habitat, improved interception and evapotranspiration, and other associated benefits.

The *Disconnect Downspouts,* the *Rain Garden Program* and the *Education and Outreach Program* will be used in conjunction with the NPDES Permit requirements to promote LID techniques and BMPs for stormwater management.

The *General Old Town Water Quality Improvement Program* includes incorporating LID techniques and water quality features where no stormwater management facilities exist. This program will work with other City capital projects and programs to integrate LID BMPs into project design. Staff resources will be used to prepare grants and coordinate with local and federal governing entities.

The *Chain Link Fence Upgrades, Catch Basin Cleaning*, and *Maintenance and Operations* programs are key to maintaining proper function of stormwater infrastructure. These programs address public facilities including but not limited to ponds, pipes, structures, vaults, catch basins, bioswales, infiltration trenches, and ditches.

The *Stormwater Facility Baseline Mapping and Asset Management,* and *Surface and Stormwater Management Plan Update* programs include updating and maintaining records for asset management and complying with local and federal regulations and requirements.

7.3 PROJECT COST ESTIMATES

Cost estimates for Retrofit Projects R-1 through R-5 were based on specific engineering estimates for those projects. Cost estimates for the remaining Retrofit projects (R-6 through R-V2) were develop based on the cost estimates developed for this planning effort, costs from the 2017 Parkwood Estates Retrofit project, and recent project work.

Cost estimates for Culvert/Outfall repair and replacement projects C-1 to C-6 and Minor Conveyance and/or Water Quality Improvements projects I-1 to I-7 were developed based on historical costs from the 2017 Parkwood Estates Retrofit project, the 2016-2017 Main Street Project, and recent project work. Citywide program costs were developed based on historical costs associated with existing programs along with estimates for new programs based on project level of effort.

The proportion of City Funds, Developer Capital Charges, and possible grant funds were developed based on review of past project funding, available grant funding, and an evaluation of developer-related burden. These funding sources are discussed below, and additional information concerning funding and economic analysis is presented in Chapter 6, Funding and Financing Program.

7.3.1 GRANTS:

Over the past several years the City has secured grants for several Citywide improvement projects. Based on the recent past grant revenues, this source could provide up to $1.5 million in revenues to fund the Plan. Grant funding is typically tied to specific improvement projects and is distributed on a competitive basis. However, the City has also received "Capacity Grants" from Ecology for general stormwater improvements. Recent grant funding is shown below in Table 7-2.

Table 7-2. Grant funding received between 2008-2016

Fiscal Year (FY)	Project Name	Amount Received
FY 08-10	NE 145th Street / 275th Avenue NE	$90,000
FY 10-11	Ecology Pass-Through Grant	$50,000
FY 11	Ecology Capacity Grant	$85,834
FY 11	Pond Retrofit (Carrie Rae)	$140,400
FY 11	Sub-Regional Opportunity Fund	~$30,000
FY 13	Ecology Capacity Grant	$30,000
FY 14	Ecology Capacity Grant	$50,000
FY 14	Pond Retrofit (Parkwood)	$120,000
FY 14	Sub-Regional Opportunity Fund	~$64,000
FY 15-17	Ecology Biennial Capacity Grant	$50,000
FY 16	Ecology Natl. Estuary Program Grant	$199,674
FY 17-19	Ecology Biennial Capacity Grant	$50,000
	Total	**$959,908**

Given the many demands on City funds and the limited applicability of developer capital charges, the City will need to secure significant amounts of grant funding to fully implement the CIP. Ecology grants may be available for major retrofit improvements including the projects identified in this Plan, and local, regional, state, and federal grants may be available for other types of projects.

7.3.2 DEVELOPER CAPITAL CHARGES:

Improvement projects R-1 to R-12, C-1 to C-6, I-1 to I-7, and O-11 are eligible for developer capital charge funding. The proportion of Developer Capital Charges to total project cost for these projects were developed based on the ratio of existing development with respect to the forecast of total anticipated development within the 2015 Comprehensive Plan. This calculation is shown in Table 7-3.

Table 7-3. Existing and anticipated changes in development within the City

	Parcel Area (Acres)	Dwelling Units
2015 Existing Total Development	963	2,657
2035 Anticipated Total Development	1,412	3,884
2015-2035 Anticipated Change in Development	449	1,227
2015 – 2017 Actual Development	20	145
2018 – 2035 Anticipated Change in Development	429	1,082
% Increase 2018-2035	*43%*	*38%*
Average %	40%	

7.3.3 CITY FUNDS:

City funds for stormwater improvements come from the City's general fund, or the 404 Fund. The amount of City funding required to complete each project was derived by subtracting potential Grant funding and Developer Capital Charges from the total project cost.

7.4 IMPLEMENTATION SCHEDULE, PERFORMANCE MEASURES AND STRATEGIES

7.4.1 IMPLEMENTATION SCHEDULE

This section provides a framework for the City to prioritize and fund the improvements identified in this document. For each project included on the CIP list (Table 7-1. Stormwater System Capital Improvement Program Project List (2018-2035)., an implementation schedule is provided in the 'timeframe' column. The schedule is based on short, mid, and long-term timelines developed based on factors such as project priority, the opportunity for partnerships with other entities, and possible efficiencies associated with adjacent private or public construction projects. The implementation schedule also considers grant opportunities and associated coordination with other jurisdictions such as Ecology and King County. Other considerations include the need to address existing infrastructure issues and programs to ensure coordination with development to address issues and fund stormwater improvements necessary to support new growth.

7.4.2 Performance Measures

Elements of the Comprehensive Plan and this Surface and Stormwater Management Plan anticipate the needs and conditions of future stormwater infrastructure which allows the City to plan until the 2035 horizon year. Regular updates are necessary to ensure the plan remains current and relevant. The planning and financing strategies outlined in this document attempt a balance between revenues and expenditures over the life of the Plan. However, the City is committed to reassessing their stormwater needs and funding sources each year as part of their annual Six-Year CIP update. This allows the City to match the financing program and other opportunities with the shorter-term improvement projects, funding, and grant opportunities.

7.4.3 Monitoring and Evaluation Strategy

The City will go through a formal process of updating the Plan every five to eight years as part of the City's regular Comprehensive Plan amendment cycle, which ensures proposed changes go through a public review process before the amended Plan is adopted by the City. Proposed updates may include shifts in City priorities, compliance with regulations and requirements, or the changes in the relevance of certain Plan components.

The City will review identified projects and programs and assess whether the CIP is adequately addressing the implementation strategies necessary to ensure the stormwater infrastructure continues to grow in line with the City's objectives. Establishing and implementing a re-evaluation process allows the City to understand progress made while implementing the CIP, as well as identifying new needs that have developed since the previous update.

As part of this process, the City will review its future project list and update the CIP as needed. Policies, strategies, and funding approaches will also be evaluated to ensure consistency with the City's vision, regulatory requirements, and future funding opportunities. The City will apply the following principles to maintain and develop this Plan and the City's stormwater system:

- Balance improvement costs with available revenues as part of the annual Six-Year CIP Update process;
- Coordinate with local and federal agencies to secure grants and other funding for improvements;
- Pursue grants and economic assistance programs to improve Old Town water quality in accordance with the NPDES Permit, and;
- Work with private developers to implement LID improvements as identified in this Plan and with respect to the Goals & Polices within the City's Comprehensive Plan and other relevant Plans, Programs, Codes, and Standards.

CHAPTER 8. OPERATIONS AND MAINTENANCE

8.1 OPERATIONS AND MAINTENANCE

Under the 1997 Stormwater Management Plan, the City's stormwater operations and maintenance program had three primary functions (Gardner Consultants, 1997). They were to:

- Maintain the functional use of the public drainage system;
- Maximize the water quality benefits of the existing drainage system facilities; and
- Provide for emergency response to flooding and water quality problems resulting from drainage system restriction, hazardous material spills or illegal dumping.

New federal and state regulations, coupled with a growing population, require the City to update its regulations and operations and maintenance for the management of stormwater. In 2010, the City adopted the 2009 KCSWDM, including any subsequent amendments, to help guide these efforts. Since 2007, the NPDES Permit requires the development of a SWMP, which must address the operations and maintenance of post-construction stormwater facilities (as discussed in Chapter 2).

Currently, key tasks of the operations and maintenance program include:

- Annual inspections of public and privately-owned stormwater facilities, ensuring proper function and maintenance;
- Annual cleaning and maintenance of pipes, ditches, catch basins, culverts, and other storm drainage system components;
- Repair and maintenance of other structural elements of the storm drainage system, including water quality facilities;
- Cleaning streets and public parking lots to remove sediment, leaves and debris that could plug inlets, catch basins and pipes;
- Routine observation and monitoring of flow and water quality during storm events and wet weather months; Investigating sources of water contamination;
- Training staff for emergency response with regards to hazardous material spills, illegal dumping, and flooding;
- Assembling emergency spill response equipment;
- Develop a plan to deal with heavy rainfall and blockages in highly susceptible and critical drainage systems;
- Construction Site Inspection of TESC plans.

8.1.1 FACILITY AND CONVEYANCE INSPECTION AND CLEANING

There are 170 stormwater facilities within the City in 2017. Of these, 134 are owned and maintained by the City, with the remaining 36 being privately-owned and maintained. Additionally, the City owns and maintains over 40 miles of stormwater conveyance pipe, approximately 7-miles of ditches, and over 2,000 catch basins.

Annual inspection and cleaning of these facilities is performed to comply with NPDES Permit requirements, as well as in response to reports of localized flooding or other drainage issues. Catch basin inspections and necessary cleaning is also completed by Public Works crew, consistent with updates to the NPDES Permit requirements. The types of stormwater facilities and infrastructure inspected and maintained include:

- Ponds (detention/retention and water quality)
- Tanks, vaults, detention pipes (underground)
- Vegetated (grass-lined) swales and ditches
- Stormfilters
- Catch basins/oil-water separators
- Sand Filters
- Infiltration or dispersion trenches
- Conveyance pipe
- Bioretention systems

Traditional stormwater ponds and swales require regular cleaning in addition to mowing, vegetation control, tree removal, and fence maintenance. Cleaning and vegetation control activities help maintain proper function of the stormwater system, which protects downstream water quality and minimizes sediment transport through the system. These activities are completed annually by the Public Works crew.

Since 2014, the Public Works crew has rented a Vactor-Truck for four to six weeks during the summer months to perform jet-cleaning of conveyance pipe, and manual removal of sediment and debris to complete catch basin cleanings (Figure 8-1). All routine and found deficiencies are documented and repaired within one year.

Figure 8-1. Example of a Vactor-Truck for catch basin cleaning and conveyance pipe jetting.

Catch Basins and Piped Conveyance

Current Catch Basin Inspection and Cleaning Protocol: Catch basins, as well as other stormwater facilities, collect sediment, vegetation, contaminants, and other materials, which build up and can inhibit proper functioning of the stormwater system. When catch basins become approximately 60 percent full, they no longer effectively remove sediment. Therefore, inspection and cleaning is completed by the City at a frequency necessary to avoid catch basins reaching this threshold. The most recent Permit required inspection of all catch basins by August 2017; Public Works met this permit requirement.

The City tracks inspection and cleaning activities through a system of field notes, inspection forms, GIS database, and in-office spreadsheets.

New NPDES Permit Requirements: The NPDES Permit, effective August 1, 2013, requires an increased frequency of catch basin inspection from once every five years to every two years (Ecology, 2018a). If it is determined that a catch basin needs cleaning, the work must be done within six months of the inspection.

As of 2017, Public Works staff have split the City into four maintenance zones which allow for the required inspection and cleaning of catch basins to be streamlined. This systematic approach allows approximately half of the City's catch basins to be inspected and cleaned (as required) every year, therefore resulting in 100% compliance with updated NPDES Permit requirements.

Ditches

The City has approximately seven miles of publicly maintained ditches and grass-lined swales, primarily associated with older residential areas surrounding Old Town. Ditches fill with sediment and vegetation over time, reducing their capacity. This occurs naturally, however, improper erosion and sediment control can speed the process. Maintaining grass-lined ditches is important to both slow storm runoff and provide basic filtration before discharge to downstream receiving waters. Properly maintained ditches sustain conveyance, reduce the risk of flooding, and protect water quality.

The Public Works crew implement regular maintenance of all public ditches, including mowing and weed-eating to clear accumulated grasses and other weedy vegetation, and removal of trash debris.

8.1.2 Flood Response and Non-routine Maintenance

Significant storm events can trigger the need for emergency maintenance, repairs, or cleaning to protect infrastructure or private property from flooding. The City also performs spot checks of permanent treatment and flow control facilities (not including catch basins) after storm events equal to or greater than 10-year, 24-hour storms and regularly during October through May. If these spot check inspections indicate widespread damage and maintenance needs, the Public Works crew inspects all stormwater facilities that may be affected and conducts appropriate repairs or maintenance actions.

8.1.3 Maintenance Repairs

The City utilizes maintenance standards contained within the adopted KCSWDM. Inspections of stormwater facilities are completed following schedules and standards described in 8.1.1, more detail can be found in Appendix C of the City's Facility Maintenance Manual. When maintenance repairs are determined necessary, they are performed as follows:

- Within one year for standard maintenance of facilities (not including catch basins).
- Within six months for catch basins.
- Within two years for maintenance that requires capital construction of less than $25,000.
- If maintenance cannot be completed within the above time frame, then the City completes the maintenance activities as soon as possible and documents/monitors the circumstances.

8.1.4 Spill Response and Illicit Discharge Elimination (IDDE)

The City implements an IDDE program to detect and remove illicit discharge, illicit connections, and improper disposal, including any spills into the stormwater system without a permit. As part of the IDDE program, the City:

- Performs ongoing investigations of stormwater infrastructure:
  - Since 2011 – completed annual dry weather outfall screenings at three locations; and
  - Since 2015 – added screenings to the annual catch basin cleaning program.
- Maintains a publicly listed hotline and email for non-emergency reporting.
- Implements ongoing training for IDDE response staff.
- Tracks IDDE activities.

8.1.5 CONSTRUCTION SITE INSPECTION

In addition to annual street sweeping, catch basin cleaning, and infrastructure inspections, City staff inspect sites prior to clearing and construction. During construction activities, City inspectors verify proper installation of Temporary Erosion and Sediment Control (TESC) BMPs and ensure they are functioning properly to minimize the probability of silt laden waters from leaving the site. Following the completion of construction, City inspectors ensure proper installation and function of permanent stormwater facilities, structures, and conveyance systems.

8.1.6 OTHER MAINTENANCE ACTIVITIES

Street Sweeping: The City hires a third-party contractor to conduct street sweeping activities on the last Thursday of every month to prevent flooding or damage to infrastructure or private property. Street sweeping removes debris from the road that can otherwise end up in stormwater infrastructure and increase the need for structure and pipe cleaning. Currently, the streets that are swept include arterials and roadways with ditches and curb and gutters.

Vegetation Management: Most stormwater facilities have a vegetated functional element to slow flows, and improve water quality. Improper maintenance can negatively impact the functionality of these systems, causing widespread problems such as flooding. The City maintains pond vegetation and roadside ditches during the dry months to reduce sediment transportation. LID BMPs such as rain gardens, Stormfilters, modular wetland systems, and bioretention swales require a range of specific maintenance techniques. LID BMPs will be maintained per manufacturer specifications and maintenance is the responsibility of the facility owner.

8.2 REVIEW AND RECOMMENDATIONS FOR OPERATIONS AND MAINTENANCE BEST MANAGEMENT PRACTICES (BMPS)

The City has grown rapidly over the last 25 years, with corresponding expansion of public storm drainage infrastructure. This growth, paired with limitations on staffing resources, warrants implementation of new operations and maintenance program BMPs. These BMPS are intended to provide increased efficiencies, streamlined and improved tracking, and rapid/consistent identification of facility or conveyance deficiencies.

Recommendation: Implement an asset management system to track maintenance and inspection activities, including utilization of mobile technologies (GPS-enabled tablets) and standardized, digital field forms.

Current erosion and water quality issues stemming from less rigorous, previously required stormwater standards include: increased flows, sediment transport, stream channel erosion, slope failures, and under-treated runoff from PGIS. In the past, actions required to improve these issues have included slope and channel stabilization, upper basin pond retrofits, and downstream culvert replacement. The intent of this Plan is to go one step further and require implementation (to the maximum extent feasible) of LID BMPs to mimic natural pre-developed conditions.

Recommendation: Develop a training program for Public Works staff to understand and successfully maintain LID infrastructure type facilities, which are anticipated to become common place with new development and redevelopment activities in the years ahead. Specific goals of an LID infrastructure training program would include:

- Best practices for maintenance of pervious pavement.
- Best practices for maintenance of bioretention swales and infiltration-type facilities.
    - If the City is to support vegetated LID facilities with emergent vegetation and/or shrub species, Public Works crew will require direction for annual maintenance needs of these facilities. *Additional landscaping and horticulture skills may be required, and additional training may be necessary to support increased maintenance needs*.
- Best practices for maintenance of modular wetland systems, Filterra™, and other emerging technologies.

8.3 Operations and Maintenance of Private Facilities

There are approximately 36 privately-owned stormwater facilities in the City consisting of ponds, vaults, detention pipes, and bioswales. These facilities are typically associated with commercial development and are inspected annually by Public Works staff. If deficiencies are found, responsible parties are notified in writing and given a time frame in which to correct identified deficiencies.

Private facilities generally drain into City owned and maintained stormwater conveyance systems, and if not properly maintained, these facilities can contribute pollutants and excess sediments to receiving water bodies. If privately-owned facilities operate as designed and are properly maintained, a stormwater utility fee discount is awarded. This process is outlined in DMC 9.06. However, if the privately-owned facilities are not functioning or maintained civil penalties may be applied to the responsible party by the City.

CHAPTER 9. POLICIES AND REGULATION

9.1 SURFACE AND STORMWATER POLICY

Adopted City policies for stormwater management are included in the 2015 Comprehensive Plan, 2015 Watershed Plan and the 1997 Stormwater Management Plan. Adopted policies provide direction for City staff when implementing NPDES Permit requirements and concurrently meeting City priorities for future development and economic growth, infrastructure management, and environmental protection.

9.1.1 2015 COMPREHENSIVE PLAN

The City's adopted 2015 Comprehensive Plan includes goals and policies that are directly relevant to the management of surface and stormwater infrastructure. These goals and policies, along with the other described plans and regulations, guided development of the Surface and Stormwater Management Plan Update. For some of the goals, only one or two of the underlying policies are related to stormwater. All relevant goals and policies from the 2015 Comprehensive Plan considered in developing this Plan are listed below.

Chapter 2 – Land Use Element

Goal LU-3: Building and site design for residential, commercial, industrial, and mixed-use development promote and ensure visual and functional consistency with adopted plans.

- Policy LU 3.5: Provide flexibility in the administration of design standards to allow for innovative products and creative, effective solutions to site challenges.
- Policy LU 3.9: Update subdivision and site plan standards, as needed, to reflect changes in design methodologies, technology, products, or adopted goals and policies relating to desirable development design.

Chapter 7 – Capital Facilities Element

Goal CF-8: Duvall's stormwater management system is effective, efficient, and enhanced to meet present and future population needs.

- Policy CF8.1: Manage the quality and quantity of stormwater runoff to protect public health, safety, and surface and groundwater quality, and to minimize potential erosion and sedimentation within natural drainage systems such as rivers, streams, lakes and wetlands.
- Policy CF8.2: Require development regulations that encourage the use of Low Impact Development (LID) measures, reduce impervious surface coverage, and retain natural vegetation.

- Policy CF8.3: Require design of new development to allow for efficient and economical provision of storm drainage facilities and require new development to pay general facility charges.
- Policy CF8.5: Comply with all National Pollution Discharge Elimination System (NPDES) Phase II permit requirements, including regular review and updates of stormwater development standards.

Goal CF-9: Transportation improvement plans and programs provide for future road projects throughout the City to allow growth-related improvements.

- Policy CF9.3: When improving new roads, facilities should be undergrounded where feasible, and sewer, water, and stormwater facilities that are in disrepair should be repaired or replaced if funding allows.

Chapter 8 – Environment and Sustainability Element

Goal ES-16: Protect wetlands from encroachment and degradation, and promote wetland restoration, especially at sites that provide important ecological functions.

- Policy ES16.5: Prohibit stormwater management facilities within wetlands and limit such facilities within wetland buffers; ensure that wetland hydrology and water quality is maintained as adjacent development occurs.

GOAL ES-17: Maintain and protect stream resources that provide multiple functions, including surface water transport, fish and wildlife habitat, and aesthetic value.

- Policy ES17.4: Manage the quality and quantity of stormwater runoff entering streams, to protect public health and safety, surface and groundwater quality, and the ecological functions of natural drainage systems.

GOAL ES-20: Improve important watershed processes and functions through progressive review and updates of land use designations, development practices, and infrastructure improvements.

- Policy ES20.2: Update zoning, subdivision, sensitive areas, and storm drainage standards and other development standards consistent with the subbasin management group framework established in the Watershed Plan.

GOAL ES 21: Improve watershed processes by investing in stormwater infrastructure, parks, open spaces, and restoration in the City's capital improvement program.

- Policy ES21.4: Identify and prioritize stormwater retrofits to address impaired watershed processes and reduce effective impervious surface areas based on the findings of the Watershed Plan.
- Policy ES21.5: Explore the feasibility of building and maintaining centralized stormwater facilities in Management Groups 2B and 2C in the urban growth area (UGA) to offset onsite detention requirements.

Goal ES-23: Improve City-wide stormwater systems to maintain and enhance water flow and water quality processes through implementation of low impact development techniques.

- ES 23.1: Improve stormwater management based on the findings of the Watershed Plan by expanding low impact development requirements, creating incentives, and establishing green infrastructure standards for public roadways in the Duvall Municipal Code.
- ES 23.2: Encourage property owners to use low impact development best management practices for improved stormwater systems by establishing voluntary programs, and partnering with not-for-profit organizations and governmental agencies.

9.1.2 2015 WATERSHED PLAN

The 2015 Watershed Plan (WSP) provides guidance for improving stormwater management in the City based on watershed assessment results and the subbasin management groups established by that Plan. During development of the WSP, each strategy was reviewed by the Advisory Committee and ranked by feasibility and importance for achieving the City's stormwater management goals. Relevant strategies from the 2015 WSP considered in developing this Plan are listed below.

- **Action SW-1: Define the most useful and applicable LID BMPs and require their use in new development activities.** Currently, the City encourages developers to implement LID measures in accordance with the Public Works Development Design Standards (PWDDS), the requirements of Appendix A of the NPDES Permit, and requirements of the King County Surface Water Design Manual (KCSWDM).

The WSP recommended that new standards for using LID BMPs should be incorporated within stormwater management regulations (DMC 9.06) to reinforce adopted City policies and standards. This section of the Plan detailed LID BMP facility categories (dispersion by maintaining/restoring natural drainage patterns, infiltration/partial infiltration, filtration, and rain capture/reuse), including identification of specific BMPs and potential opportunity for use within the City.

Recommendations under Action SW-1 apply to all subbasin management groups City-wide. As stated in the WSP "the feasibility of individual strategies varies throughout the City and depends on land ownership, existing topography, soils, hydrology and land cover."

- **Action SW-2: Improve soil amendment BMP in DMC 14.38.130 for clarity, ease of understanding and enforcement.** The City's current code provides soil specifications for enhancing hydrologic benefits of disturbed soils (after clearing and grading) and for maintaining soils around existing trees that are preserved on a development site.

Recommendations of Action SW-2 include suggestions for updating and clarifying these standards, to improve both expectations and outcomes as soil-disturbing activities (land development) occur in the City. Specific subbasins are identified where mapped soils show very low soil permeability, with the suggestion made that these areas would benefit from soil amendments. Recommendations of Action SW-2 apply to all sub-basin management groups City-wide.

- **Action SW-3: Small-site Stormwater Enhancement.** This action recommends defining the most useful and applicable LID BMPs and stormwater enhancement approaches for small sites, and requiring their use in new development and redevelopment activities on small sites. The Action also suggests implementing voluntary and/or incentive-based programs to encourage residential property owners to disconnect downspouts and install rain gardens and rain barrels.

The WSP recommendations of Action SW-3 should be focused within Management Groups 2B, 2C and 3. Generally, the WSP notes that application of small-site strategies that include infiltration will likely be more successful in the Old-Town, Coe-Clemmons – Lower, and Cherry Creek B subbasins, than will efforts in other subbasins. The other subbasins have either low percentages of permeable soils or no mapped permeable soils.

- **Action SW-4: Establish Flow Control Exemption.** The WSP recommends creating a flow control exemption for portions of the City that are predominantly built-out and already drain directly to the Snoqualmie River through pipe and/or ditch infrastructure. Currently, projects that discharge to the Snoqualmie River floodplain within a ¼ mile of improved flow path (pipes or ditches) are flow control exempt per Section 1.2.3 of the KCSWDM.

This action refers to portions of the City that already drain directly to the Snoqualmie River through pipes or ditches. Runoff from this limited area does not adversely impact local stream bed and banks and impacts on the Snoqualmie River are negligible. The City could create an expanded flow control exemption for projects in the highly developed Management Group 3 subbasins, to incentivize the increased use of LID BMPs focused on water quality treatment. The City could also consider development of a program to provide stormwater control transfer to focus rehabilitation in priority project assessment units (PAUs), maximizing environmental benefit.

- **Action SW-5: In UGAs, explore opportunity for centralized stormwater facilities to off-set onsite detention requirements.** Current City code does not prohibit centralized stormwater management approaches, but also does not establish a preference for such facilities. This WSP action suggests that such approaches should be considered in areas where significant development is expected, and where there is sufficient open space and conditions to warrant a centralized approach. This action is identified as a lower priority strategy, applicable to subbasin management groups 2B and 2C within the UGA.

- **Action SW-6: Incentivize stormwater LID standards.** "LID BMPs could be encouraged throughout the City using an incentive program. Incentives that could be considered include a relaxation of buffer limits for sensitive areas (especially in subbasins within subbasin management groups 2C and 3), or allowances that provide additional development opportunity within a given site (density increases, increased lot coverage, or other similar strategies)."

- **Action SW-7: Improve Standards for Landscape Strips in Roadways.** "Adjust the landscape strip for street trees to be a minimum of 6-8 feet in width to ensure adequate space for successful growth, which would provide the added benefit of increased infiltration and retention of stormwater (SDOT, 2014). An incentive for wider landscape strips could include allowing the proposed increased direct discharge exemption or through providing open space credit when developers dedicate more area for landscape strips. In addition to providing more room for successful landscaping and tree growth, wider landscape strips also provide opportunities for LID stormwater approaches to be integrated into the streetscape."

As additional recommendations, the action directs the City to consider allowances for sidewalks adjacent to curb-line on internal roadways (sub-collectors, sub-access and minor access streets) for roadways with dedicated on-street parking. Sidewalks adjacent to curb-line could be considered on the condition that equivalent landscape strip area is provided adjacent to private residential landscape or other compensatory landscape area. This approach would "provide opportunity to maximize landscape width and viability"; and landscape strip consolidation to one side of the street maximizing available width (within limits).

- **Action SW-8:** Enhance the current City of Duvall NPDES educational outreach program. This recommendation recognizes the City's existing educational outreach efforts, and suggests updates to implement other actions within the WSP and to incorporate new and targeted educational materials.

9.1.3 1997 Stormwater Management Plan

Although dated, the City's 1997 Stormwater Management Plan was reviewed for identified goals and policies. The following Water Quality Program goals were established and emphasized by the Plan, given "enforcement by the U.S. EPA of the NPDES Permits as a requirement of Clean Water Act":

1. Identify and document the locations, sources, and magnitude of water quality problems within the existing drainage system.
2. Institute a program of water quality source control measures, including an expanded operation and maintenance program, regulation of development and private property, and public education with respect to water quality issues.

9.1.4 Duvall Municipal Code Regulations

The adopted Storm Drainage Utility regulations (DMC Chapter 9.06) establish the City's primary mechanism for implementation of the Stormwater Management Program consistent with NPDES Permit requirements. Current components of City's Stormwater Management Program are detailed in Chapter 2 – Surface and Stormwater Management Background. Chapter 2 consists mainly of Duvall-specific standards, programs, and requirements associated with the Storm Drainage Utility. However, this Plan recommends removal of adopted 2017 regulations that duplicate KCSWDM requirements to simplify and clarify Storm Drainage Utility language. The following summarizes key sections of DMC Chapter 9.06:

DMC Chapter 9.06 Purpose: *The City Council finds that this Chapter is necessary to promote sound development policies and construction procedures which respect and preserve the City's watercourses; to minimize water quality degradation and control of sedimentation of creeks, streams, ponds, lakes, and other water bodies; to protect the life, health, and property of the general public; to preserve and enhance the suitability of waters for contact recreation and fish habitat; to preserve and enhance the aesthetic quality of the waters; to maintain and protect valuable groundwater quantities, locations, and flow patterns; to ensure the safety of City roads and rights-of-way; to comply with federal and state requirements; and to decrease drainage-related damages to public and private property.*

- **DMC 9.06.030 – Incorporation of King County manual.** Adopts the current edition of the KCSWMD, including any subsequent amendments, as the primary basis for management of stormwater runoff from new development, redevelopment and construction site activities.

- **DMC 9.06.035 - Illicit discharge detection and elimination.** Provides the City Engineer authority to develop an inspection program for illicit discharge and illicit connection to surface waters and stormwater infrastructure, and additionally defines what constitutes an illicit discharge, and what discharges are allowable.

- **DMC 9.06.040 - Requirements for small parcels.** For new development of single family residential lots and duplexes, and other new developments that result in creation or addition of less than 2,000 square feet of impervious area, or clearing/grading activities of less than 7,000 square feet. This section provides Duvall specific criteria primarily for management of runoff during project construction.

- **DMC 9.06.050 - Requirements for large parcels.** For new development and redevelopment activities not meeting the small parcel definition, this section provides minimum criteria for management of runoff during project construction, for permanent stormwater facilities, and for assessment of potential impacts and mitigation for adjacent sensitive areas and downstream waters.

- **DMC 9.06.060 - Operation and maintenance requirements.** Establishes minimum standards for ongoing operation and maintenance of all stormwater facilities, supplemental to the standards in the incorporated KCSWDM. See Chapter 8 of this Plan for details.

- **DMC 9.06.120 – Fees and 9.06.125 - Service charges.** Provides the City with development fee and service charge authority for operations, maintenance, and capital improvements for surface and stormwater infrastructure. See Chapter 7 of this Plan for details.

- **DMC 9.06.140 - Adoption of Comprehensive Plan.** This section adopts the City’s official Stormwater Management Plan. The current adopted plan is from 1997, which will be replaced at adoption of this Storm and Surface Water Plan.

9.2 PROGRAMMATIC OPPORTUNITIES FOR SURFACE AND STORMWATER MANAGEMENT

9.2.1 EXPANDED FLOW CONTROL EXEMPTION TO FLOODPLAIN

Adopted City policy identifies creation of a flow control exemption for portions of the City that are predominantly built-out and already drain directly to the Snoqualmie River and associated floodplain through pipe and/or ditch infrastructure (WSP Action SW-4).

Currently, projects that discharge to the Snoqualmie River and floodplain through a ¼ mile of improved flowpath (human-made pipes or ditches), are flow control exempt per Section 1.2.3 of the KCSWDM. Both the Department of Ecology and King County designate the Snoqualmie River as a “major receiving water” eligible for the direct discharge exemption. For projects that are determined eligible for this flow control exemption, discharges cannot be conveyed through tributary streams or hydrologically sensitive wetlands.

By providing limited expansion of the area eligible for direct discharge exemption to ½ mile, the City will provide additional opportunity or incentives for development and redevelopment consistent with 2015 Comprehensive Plan priorities. This Plan sets a framework and identifies policies and development review criteria that:

1. Are consistent with KCSWDM allowances;
2. Require use of LID BMPs to improve water quality from existing and new impervious surfaces; and
3. Ensure adequate evaluation is provided of the downstream flowpath between the development site and the floodplain.

Limited Geographic Direct Discharge Expansion: The expansion of the existing flow control exemption would only apply to properties occurring in Management Group 3 subbasins (prioritized by the 2015 Comprehensive Plan and 2015 WSP for additional development) where runoff is already conveyed to the Snoqualmie River floodplain through pipe and/or ditch infrastructure (see Old Town, Coe-Clemmons – Lower, and Thayer Creek subbasins on Figure 1-1).

Once implemented, Public Works should consider whether additional development opportunity, and/or development cost-savings, provide adequate incentive for applicants to implement qualifying criteria within the direct discharge expansion area. If additional participation is a priority for Public Works to facilitate developments that use LID, and are consistent with the 2015 Comprehensive Plan, then Public Works should consider use of additional incentives for qualifying projects. Incentives could include reduced stormwater fees, increases in development opportunity, and/or other strategies identified based on community and/or development interest input.

Direct Discharge Expansion Qualifying Criteria:

1) Low Impact Development: To be approved for "extended" flow control exemption, proposals must maximize implementation of LID approaches per KCSWDM Core Requirement 9, reducing site runoff through use of permeable pavers or grassed modular grid pavement, pavers or wheel strip driveways, amended soils, minimum 6- to 8-foot wide landscape strips, planting of trees, or other approved alternatives.

2) Low Impact Development: Ensuring the soil moisture holding capacity of new pervious surfaces throughout the development site.

3) Downstream review: Ensure consistency with requirements for Direct Discharge Exemption (page 1-41 of the KCSWDM).

4) Core Requirement 2 review per KCSWDM for any projects discharging to surface waters (wetlands and/or tributary streams) within the Snoqualmie River floodplain (as opposed to improved conveyance all the way to the Snoqualmie River channel):

    a) Erosion - completing downstream analysis from the point of discharge through to end of tributary surface water. Level 1 review, and potentially Level 2 if warranted.

    b) Temperature - Requiring implementation of on-site and off-site measures focused on tributary surface water temperature. Provide shrub vegetation around on-site swale features to add additional shade. Implement offsite riparian planting within floodplain open space areas, targeting stormwater outfall into wetlands, tributary streams and other opportunities to increase shade over surface waters.

    c) Annual monitoring of sensitive receiving areas within the floodplain after project completion. Review would assess channel and bank conditions (tributary streams) or changes in hydrology (wetlands) to ensure no indications of new erosion or other adverse impacts over a 5-year monitoring period with final plat specific provisions and performance-bonded mitigation measures for erosion and/or vegetation impacts during the monitoring period. Adaptive management required when necessary.

    d) Built-in "adaptive management" requirements if new indications of erosion or other adverse impacts are observed – could include providing bank and bed control measures at targeted areas (bank plantings, large woody debris, and/or other grade control structures within the channel), or native plantings within wetland areas appropriate to post-project conditions.

9.2.2 Low Impact Development Toolbox for Future Development

The City established a toolbox of required and optional/incentivized LID measures to ensure LID techniques and BMPs are implemented to the maximum extent feasible based on the unique conditions and soil types specific to the Duvall landscape conditions and anticipated development patterns. Table 9-1 indicates all LID measures required and incentivized for development. Development-type specific tables on the following pages indicate preferred LID BMPs that must be considered for all developments requiring flow control and water quality treatment. Additionally, criteria for BMP selection will also consider the following:

- **Environmental Benefit:** This includes stormwater management infrastructure type, ecosystem service, and community livability.
- **Cost:** This includes capital and operational costs (for City owned facilities and infrastructure).
- **Implementation:** Ease of implementation and probable success will be evaluated.
- **Ownership and Management:** This will include issues related to public versus private ownership, management, and maintenance.

In most cases traditional grey (hard/concrete) infrastructure BMPs provide only a single benefit, where LID (green) infrastructure BMPs may provide multiple benefits. The use of natural systems (or engineered systems that mimic nature), allow surface and stormwater to be managed and treated near its source. LID and more natural systems deliver environmental, social, and in most cases economic benefits which ultimately lead to a sustainable community.

Table 9-1. LID measures required by project type.

Development Type	Maintain Natural Drainage	Protect Wetlands	Protect Streams and Rivers	Soil Amendment	On-Site Stormwater Management	Flow Control	Water Quality Treatment	Native Vegetation Retention or Revegetation	Minimize Impervious Surface Coverage
SFR on existing lot	R	R	R	R	R	NR	NR	O	O
SFR Short plat	R	R	R	R	R	R	R	O	O
SFR Long plat/subdivision	R	R	R	R	R	R	R	O	O
Multi-family residential and non-residential developments (e.g., commercial, institutional, mixed-use)	R	R	R	R[1]	R	R	R	O	O
Roadway	R	R	R	R[1]	R	R	R	NR	NR
Sidewalk/trail	R	R	R	R[1]	R[2]	NR	R[1]	NR	NR
R = Required, **O =** Optional/Incentive-based**, NR =** Not required/Not applicable									

1. Protect and amend soil in areas not being developed, where feasible.

2. Required for pollution generating surfaces or those surfaces that contribute flow directly to pollution generating surfaces or adjacent properties. Not required for trails or sidewalks that shed non-point source drainage directly to wetlands, streams, floodplains, associated buffers, or other naturalized areas if low risk of erosion, flooding, or other impacts has been documented and approved by the City during project planning.

The following provide standard descriptions for LID measures identified in Table 9-1. During implementation of the LID toolbox into storm drainage standards for future development and redevelopment, Duvall will review each LID measure category to establish development-type specific criteria.

Maintain Natural Drainage: Drainage patterns shall be maintained and discharges shall occur at the natural location, to the maximum extent feasible. Stormwater discharged from the site, retained or infiltrated on-site, shall not cause a significant adverse impact to receiving waters or downstream or upstream properties.

Protect Wetlands: Projects discharging into a wetland or its buffer, either directly or indirectly through a drainage system, shall prevent impacts to wetlands that would result in a net loss of functions and values.

Protect Stream and Rivers: Projects discharging to a stream or river (either directly or indirectly through a drainage system) shall maintain the water quality of any affected stream or river by selecting, designing, installing, and maintaining permanent controls.

Soil Amendment: Retain and protect undisturbed soil in areas not being developed. Prior to completion of the project, amend all new, replaced, and disturbed topsoil (including construction laydown areas) with organic matter.

On-Site Stormwater Management: Manage stormwater at its source; applicable on-site stormwater management BMPs include, but are not necessarily limited to: dispersion structures, infiltration trenches, rain gardens, bioretention facilities, rainwater harvesting, permeable pavement, vegetated roof systems, cisterns, drywells, etc.

Flow Control: Detention/retention facilities must be designed to match the pre-developed (forested) flow duration standard.

Water Quality Treatment: Water quality treatment BMPs shall be installed to treat flows from pollution generating impervious surfaces.

Native Vegetation Retention/Revegetation: Provided via interception, transpiration, and increased infiltration by retaining existing or installing native vegetation (trees and shrubs).

Minimize Impervious Surface Coverage: Minimize impervious surface coverages, below the maximum allowed by City code.

To meet required flow control and water quality treatment BMPs, the development-type specific tables below indicate preferred LID BMPs that must be considered for all developments requiring flow control and water quality treatment. BMPs are listed in priority categories 1 – 4 along with Optional, Incentive-Based BMPs. The City will require use of BMPs within the highest feasible categories; when lower category BMPs are proposed, development applicants will be required to document that higher category BMPs would not be feasible.

Table 9-2. Single-family residential (platted subdivisions), Multi-family

Category	BMP
1	Full Dispersion
	Infiltration Trenches
	Bioretention
2	Dry Wells
	Permeable Pavement outside of Public ROW
	Sheet Flow Dispersion
	Concentrated Flow Dispersion
3	Splash-block Downspout Dispersion
	Trench Downspout Dispersion
4	Perforated Stub-out Connections
	Site Soil Improvements
Optional, Incentive-Based	Single-family Residential Cisterns
	Newly Planted Trees
	Raingardens
	Rainwater Harvesting
	Vegetated Roofs

Table 9-3. Roadway, Trails, and Sidewalk Projects

Category	BMP
1	Full Dispersion
	Trench Drains
2	Bioretention
	Sheet Flow Dispersion
3	Permeable Pavement Surfaces
	Newly Planted Trees

Table 9-4. Commercial Projects (may use Table 9-2 when applicable)

Category	BMP
1	Full Dispersion
	Trench Drains
2	Bioretention
	Stormwater Filtration
	Permeable Pavement Surfaces
3	Sheet Flow Dispersion
	Concentrated Flow Dispersion
	Newly Planted Trees

9.3 RECOMMENDATIONS FOR PLAN IMPLEMENTATION

The recommendations of this Surface and Stormwater Management Plan include updates to SWMP activities, City policy and Storm Drainage Utility code (DMC Chapter 9.06), and adoption of a new surface and stormwater CIP. Updates will support the City in meeting the requirements of the NPDES Phase II permit and the objectives and policies in the 2015 Comprehensive Plan, including retrofit actions to address drainage and water quality problems. This section provides a recommended implementation sequence, and commitments for future Plan evaluation to ensure both annual progress reporting and periodic updates.

9.3.1 IMPLEMENTATION SEQUENCE

There are several opportunities and constraints to consider in the implementation of surface and stormwater projects and programs included in the CIP (Section 7.1). The City is fortunate to have many of the areas proposed for retrofit project actions (as well as associated with ongoing stormwater programs) within public ownership, but community support of effective management and improvements to stormwater systems will contribute to the long-term success of this Plan. The overall strategy for implementation is to: 1) encourage future development to provide stormwater infrastructure that maximizes use of LID and integrated site planning measures; 2) provide effective maintenance of existing systems (maximizing operational function); 3) gain public support for program improvements and retrofit actions that minimize runoff and improve drainage detention capacity and water quality treatment; and 4) pursue grant funding for CIP retrofit projects to supplement the financing program (Chapter 6).

The following provides a recommended sequence for Plan implementation consistent with this overall strategy:

1. Implement updates to DMC Chapter 9.06 (Storm Drainage Utility) to codify policy within this Plan, including:
    - Minor updates to Operations and Maintenance Requirements (DMC 9.06.060) section as necessary to implement recommendations from Plan Chapter 8.
    - Updates to Service Charges (DMC 9.06.125) section to implement updates to the Storm Drainage Acreage Charge and new incentives encouraging LID along with new General Facility Charge as recommended in Plan Chapter 6.
    - Develop and adopt standards and/or Public Works Development Design Standards (PWDDS) that formalize Programmatic Opportunities for Surface and Stormwater Management as recommended by Plan Section 9.2.
    - Update to Adoption of Comprehensive Plan (DMC 9.06.140) section to replace reference to the 1997 Duvall Stormwater Management Plan with reference to this 2018 Surface and Stormwater Management Plan.

2. Rely on updated DMC Chapter 9.06 standards, including the KCSWDM, to maximize protection of existing forest canopy, native soils (quality and depth), and other prioritized LID BMPs through a combination of incentives and regulations for new development integrated across DMC Chapter 9.06 (Storm Drainage Utility) and key chapters of DMC Title 14 (Unified Development Regulations).

3. Update City programs to ensure consistency with objectives of the 2015 Comprehensive Plan and this Plan.

    - Continue public outreach efforts per NPDES Phase II permit requirements to educate residents, businesses, industries, elected officials, policy makers, and City staff with the aim of reducing or eliminating behaviors that cause or contribute to adverse stormwater impacts, and to build support for this Plan.

    - Implement an asset management system to track maintenance and inspection activities, including utilization of mobile technologies (GPS-enabled tablets) and standardized, digital field forms (consistent with Plan Section 8.2). Support Public Works Operations and Maintenance (O&M) Crew through training and roll-out of asset management tracking system.

    - Develop and implement a training program for Public Works O&M crew to understand and successfully maintain LID infrastructure type facilities (consistent with Plan Section 8.2).

4. Focus City resources to implement ‘Short’ timeframe projects listed within each project category:

    - Retrofit Projects – select projects for focus consistent with CIP prioritization, support from project partners / adjoining property owners, and with resources available through the *409 Storm Drainage Capital Improvement Utility Fund*.

    - Culvert/Outfall Repair or Replacement Projects – select projects for focus consistent with CIP prioritization.

    - Minor Conveyance and/or Water Quality Improvement Projects – select projects for focus consistent with CIP prioritization.

5. Leverage CIP prioritization, pre-design resources, and the City’s record of successful project completion to receive grant funding support from King County, Ecology, and other granting agencies. Target grants consistent with the specific benefits and funding needs associated with prioritized retrofits and other CIP projects.

9.3.2 Future Evaluation and Updates

The Surface and Stormwater Management Plan anticipates the needs and conditions of future surface and stormwater system management. Nonetheless, both the constructed and natural drainage networks across the City and associated UGAs are dynamic, with changing circumstances beyond the scope and influence of this Plan. Regular updates are necessary to ensure the Plan remains current and relevant.

The funding and financing strategy attempts a balance between revenues and expenditures; however, the City is committed to reviewing and documenting Plan progress and implementation challenges each year as part of SWMP annual reports. Annual review allows the City to regularly track progress and provide an opportunity to ensure that shorter-term improvement projects and ongoing programs are being funded consistent with the financing program and grant opportunities.

The City will complete a formal process of updating the Plan every five to eight years as part of the City's regular Comprehensive Plan amendment cycle. Formal updates will be completed consistent with the monitoring and evaluation strategy detailed in Section 7.4.3.

CHAPTER 10. REFERENCES

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APPENDIX A - ASSESSMENT AND RANKING METHODOLOGY

Methodology

To support ongoing surface and stormwater (SW) planning efforts, City Staff propose using available and recently developed geospatial layers to assess existing stormwater facilities and prioritize stormwater facility retrofit projects within the City based on their anticipated benefit. Similar landscape geospatial analysis is also being used to identify the most useful tools for managing stormwater from anticipated future development/redevelopment. This document presents the City's proposed assessment and ranking approach for retrofit actions. The approach is shown graphically in Figure 1 and was performed in three phases:

- ***Characterization:*** Mapping of existing stormwater facilities on a plat drainage basin level including type, size, water quality and detention design parameters at the time of development, outfall location, tree canopy cover, and impervious area.
- ***Assessment:*** Assigning scores to each of the factors developed in the above-mentioned Characterization and combine them into a facility rank in each of three categories: Opportunity, Performance, and Downstream Waters using formulas developed for this effort.
- ***Ranking and Feasibility Review:*** Using assessment scoring results as a basis for a priority retrofit ranking list. With the list established, the City is considering constraints and opportunities such as ownership, retrofit cost/benefit, known deficiencies, upstream and/or downstream conditions and opportunities, etc.

Figure 1: A diagram outlining the facility assessment and ranking process including the factors in each scoring category.

CHARACTERIZATION

The stormwater systems geodatabase is the primary data source for assessing opportunities for retrofit. During the Characterization phase, City staff collected the following data for every drainage plat (primarily existing residential plats) within City limits:

- **The Facility Type** - The type of existing stormwater facility is one of the biggest factors when determining the cost and complexity of a retrofit.
- **The Design Basis** - The adoption date of the King County Surface Water Design Manual (KCSWDM) or pre-KCSWDM standard used to design each stormwater facility. Stormwater facilities that have been designed to meet more recent standards generally provide a higher level of detention and water quality treatment.
- **The Outfall Location** - Facilities discharging to fish-bearing streams, steep slopes, or other sensitive areas were given a higher priority for retrofit.
- **Tree Canopy Cover -** Increased canopy cover reduces impacts on the stormwater system and can improve water quality.
- **Impervious Surface Coverage** - The percentage of the drainage plat covered by impervious surfaces (surface that water can't soak through), such as pavement or buildings. A plat with a high percentage of impervious area will generally produce more runoff than a similarly-sized plat with a low impervious percentage.

Using this data, Public Works developed a stormwater performance map for all impervious surfaces within the City, shown below in Figure 2.

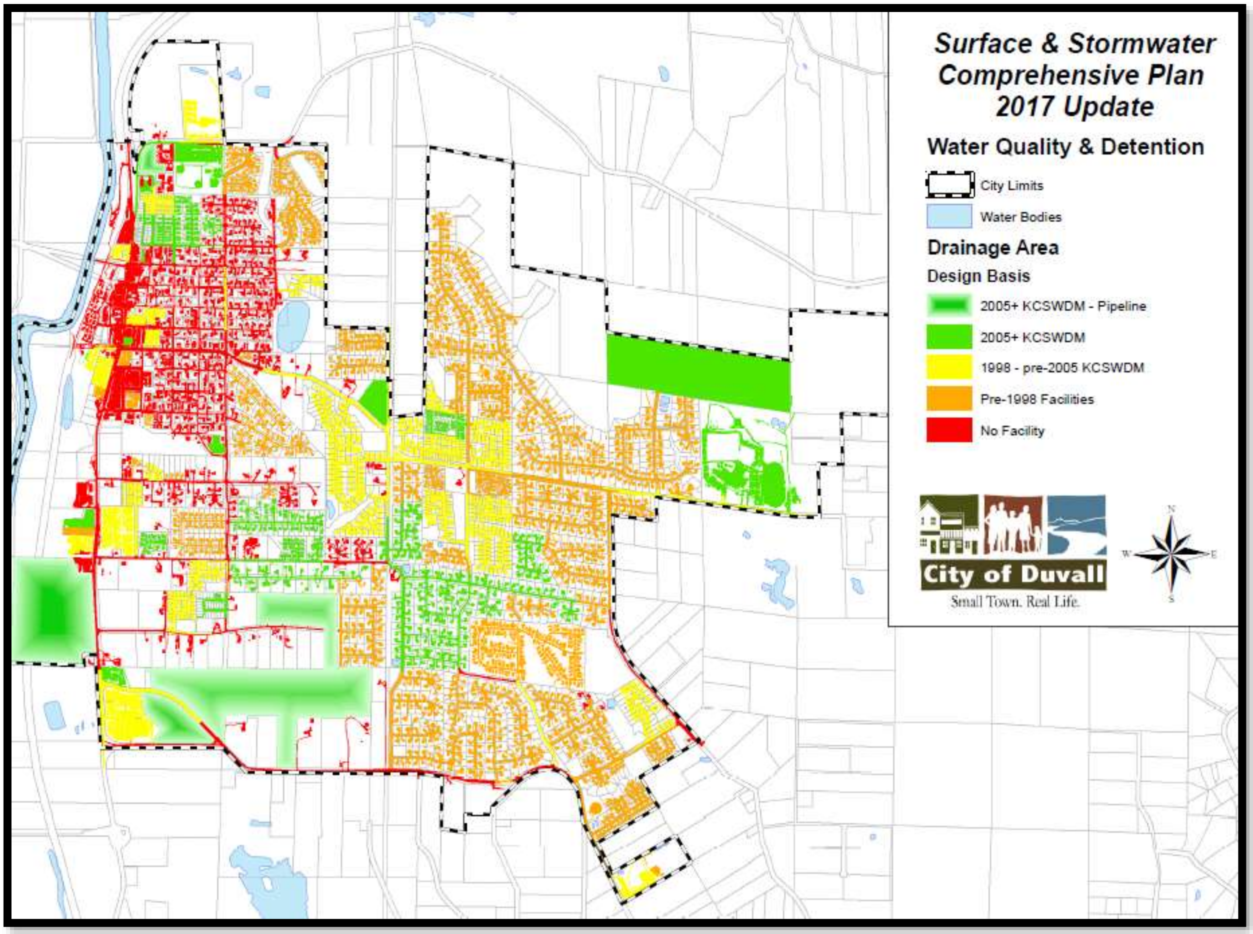

Figure 2: Stormwater drainage areas across the City, mapped per the adoption date of the KCSWDM that was in effect at the time of development.

ASSESSMENT

To assess the performance and importance of each stormwater facility and associated drainage plat, scores were developed based on key factors within each assessment category. Two factors (design basis, and receiving water) were scored separately based water quality need and erosion risk due to functional differences. For example, a concrete vault may perform very well at preventing erosion, but very poorly at improving water quality.

This analysis was completed for both existing and planned (associated with permitted plats) facilities. This approach is similar to that which was used for the City's adopted Watershed Plan. Results then provided a ranking that would better help understand the drainage system and sensitive resources, while still identifying opportunities for water quality and/or erosion control improvements through retrofit actions.

Stormwater facilities were scored independently on three categories to identify retrofit opportunities which address specific erosion and/or water quality issues:

- Opportunity (ease of retrofit)

- Performance (design standards used for the facility)
- Downstream Water (sensitivity of the receiving water body)

This approach highlights important differences in facility performance, key vegetation indicators, and the sensitivity of the receiving waterbody. For the facility assessment, the opportunity score is solely based on the facility type. The performance score is based on the design manual used when the facility was installed and the current percentage of tree canopy cover. Finally, the outfall location score is determined by the receiving water body and the impervious surface coverage of the drainage plat. These three scores are then multiplied together, resulting in an aggregate score.

Opportunity Score:

The opportunity score is based on the existing facility type, and the facility outlet (e.g. the conveyance feature – such as a pipe, ditch, bioswale, or stream – immediately downstream of the facility). The following opportunity scores have been developed to reflect the ease of retrofitting a facility based on the conditions, constraints, and costs that would be associated with structural changes to existing facilities. Consideration of the facility outlet is provided to give weight to the area immediately adjacent to each facility. Where discharge is to a natural or pervious feature there is likely greater opportunity for retrofit, compared to facilities that discharge to hard structures (pipes, or additional facilities). The most difficult retrofit options have a lower score. The opportunity score is provided as an initial (and coarse) indication of retrofit cost. For drainage plats prioritized for retrofit actions, this score will be augmented with additional assessment of feasibility, including a cost/benefit analysis, to determine retrofit actions.

Table 1: Table summarizing Opportunity criteria scoring for assessment of retrofit opportunity.

Existing Facility and Outfall Type	*Opportunity Factor*
Vault to MWS (filter facility) Vault to no outfall Vault to pipe Vault to Stormfilter	1.5
Vault to bioswale Vault to creek Vault to wetland	2.5
Detention Pipe to detention pipe Detention Pipe to pipe	3
Detention pipe to bioswale Filter to detention pipe Filter to pipe Filter to Stormfilter Structure to pipe	4
Detention pipe to wetland Filter to stream Filter to wetland Structure to wetland	5

Existing Facility and Outfall Type	***Opportunity Factor***
Pond to pipe	6
Pond to bioswale Pond to dispersion trench Pond to ditch Pond to pond	7
Pond to creek Pond to floodplain Pond to wetland Bioswale to detention pipe Bioswale to pipe Bioswale to pond Infiltration trench to pipe	8
Bioswale to bioswale Bioswale to creek Bioswale to floodplain Bioswale to Lake Rasmussen Bioswale to wetland	9

Drainage plats that currently have no stormwater facility are ranked on a separate list (without the Opportunity Score included). Separate scoring and ranking of drainage plats with no facility recognizes the additional cost and complication of installing a new facility in an area where one has not previously existed, as well as the potential benefits based on the Performance Scores and Downstream Water Scores (as detailed below).

Performance Score:

The total performance score is calculated by multiplying the Design Basis factor by the Tree Reduction factor.

Design Basis: The design basis factor is based on the KCSWDM or pre-KCSWDM standard used at the time of development. Each manual was given a score based on relative requirements as compared to current regulations. For example, if the facility for a drainage plat was designed and constructed in 1990, water quality was not a strict design guideline. Therefore, the facility would have a higher score for water quality than for erosion, indicating a greater need for a water quality type retrofit.

Table 2: Table summarizing Performance criteria (consistent with stormwater facility design basis) and associated primary scoring for assessment of Erosion and Water Quality retrofit opportunity. A higher score indicates lower expected performance.

Higher score indicates greater need for retrofit based on performance

Erosion		Water Quality	
Performance (Design Basis)	***Factor***	***Performance (Design Basis)***	***Factor***
(Green) - Current KCSWDM + on-site	0.5	(Green) - Current KCSWDM + on-site	0.5
(Green) - 2005+ KCSWDM	1.5	(Green) - 2005+ KCSWDM	1.5
(Yellow) - 1998 – pre-2005 KCSWDM	3	(Yellow) - 1998 – pre-2005 KCSWDM	4
(Orange) - pre-1998 facilities / unknown design basis	6	(Orange) - pre-1998 facilities / unknown design basis	8
(Red) - No facility	9	(Red) - No facility	9

Tree Reduction Factor: The extent of tree canopy cover within each drainage plat is a key factor in understanding the present-day performance. Increased tree canopy can improve water quality by providing shade to reduce temperatures and reducing flow rates and erosion potential through evaporation, transpiration, storage and absorption into the root structure. For older developments with little or no stormwater detention and/or treatment, the extent of remaining tree canopy cover is an important consideration in the need for retrofit. It also builds on the understanding of what types of retrofit strategies could be most beneficial.

The tree reduction factor is derived by subtracting the existing canopy cover percent within each drainage plat from 100% and converting to a decimal (i.e., 12% canopy cover results in a Tree Reduction Factor of (1.0 - 0.12) = 0.88). Through this approach, developments with more extensive tree canopy cover (more trees and/or mature trees) will be weighted lower than developments with immature tree cover, or where trees have been removed. The tree reduction factor excludes areas set aside in Sensitive Areas tracts (as wetlands, streams, and landslide hazard areas, and associated buffers) because these portions of the development (drainage plat) were not included in determining the treatment and detention requirements (size) of existing facilities when they were designed and constructed.

Downstream Water Score:

The downstream water score is calculated by multiplying the Receiving Water Factor by the Impervious Surface Factor.

Receiving Water Factor: The receiving water factor is based on the water body that each drainage plat ultimately discharges to. Each water body is scored separately for Erosion and Water Quality retrofit opportunities according to the City's understanding of its ecological importance (and/or impairment) for each receiving water body. For example, the City sees that there is less erosion concern on Thayer Creek than on Coe-Clemons Creek (which occurs in a steep ravine with active erosion along the channel);

however, recognizes the relatively consistent importance of water quality (both streams are used by salmon and trout populations).

Table 3: Table summarizing Outfall Location scores for assessment of Erosion and Water Quality retrofit opportunity.

Ultimate outfall location: The primary score for the Y-axis is based on the receiving water body that each drainage plat

Erosion		Water Quality	
Receiving Water	***Factor***	***Receiving Water***	***Factor***
LID (all stays on-site)	1	LID (all stays on-site)	1
Direct to Snoqualmie River	2	Direct to Snoqualmie River	5
Thayer Creek	4	Thayer / Coe Clemons Creek / Unnamed Southern Tributary	7
Coe Clemons Creek	6	Cherry Creek tributaries	8
Discharges to creeks / slopes of Cherry Valley tributaries (including Lk. Rasmussen), Big Rock Road, or mapped undeveloped erosion / landslide areas	9	Lake Rasmussen	9

Percent Impervious Factor: The extent of impervious surface cover influences both the timing and volume of runoff from each plat drainage plat – key parameters that can result in erosion and water quality impairment. Incorporating existing impervious surface coverage within each drainage plat into this score better reflects the potential for watershed process impact to surface waters and erosion/landslide hazard areas.

The Percent Impervious Factor is determined directly from the extent of impervious surface within each plat drainage plat (i.e., 27% impervious results in a percent impervious factor of 0.27).

Assessment Outputs:

The aggregate score for each facility within a drainage plat or development was determined by multiplying the three assessment category results: opportunity, performance, and downstream water. For example, facilities that score very high in all three categories received high aggregate scores, suggesting high prioritization for retrofit actions based on erosion prevention (water flow) and/or water quality needs.

For drainage plats with existing facilities, the aggregate score was determined using all three assessment categories.

For drainage plats without existing facilities, the aggregate score was determined using only the Performance assessment and Downstream Water assessment scoring. For these drainage plats, any retrofit action would be providing a new facility and/or implementing new low impact development (LID) approaches to reduce runoff.

For all drainage plats, aggregate scores were determined independently for erosion (water flow) and water quality factors, and as an overall score. The overall aggregate score was determined by averaging these factors for the Performance and Downstream Water assessment results, and then multiplying assessments together. Figures 3 and 4 below display distribution of drainage plat assessment scores.

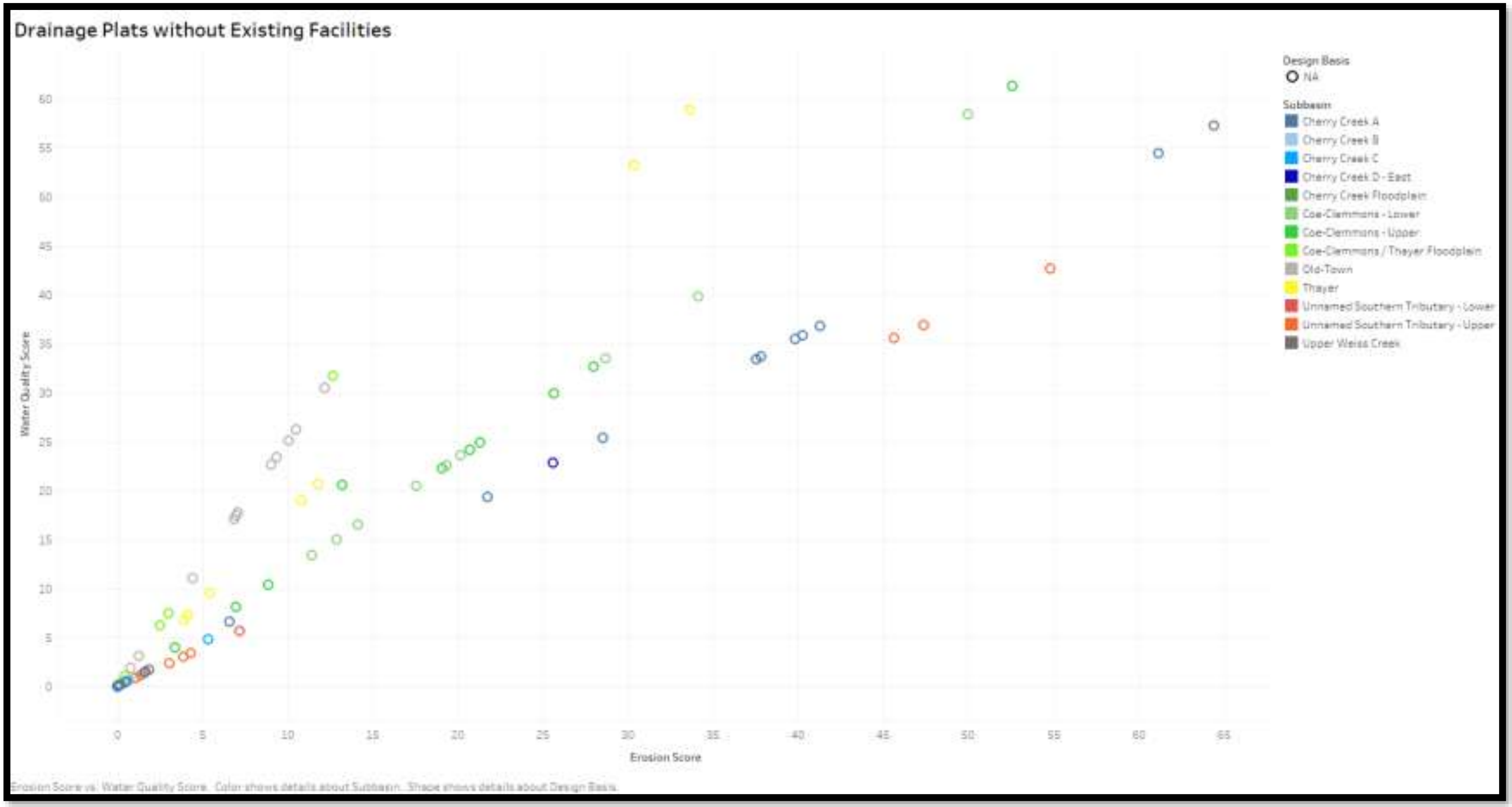

Figure 3: Assessment scores for Erosion and Water Quality for subbasins without existing facilities, distributed by subbasin management group

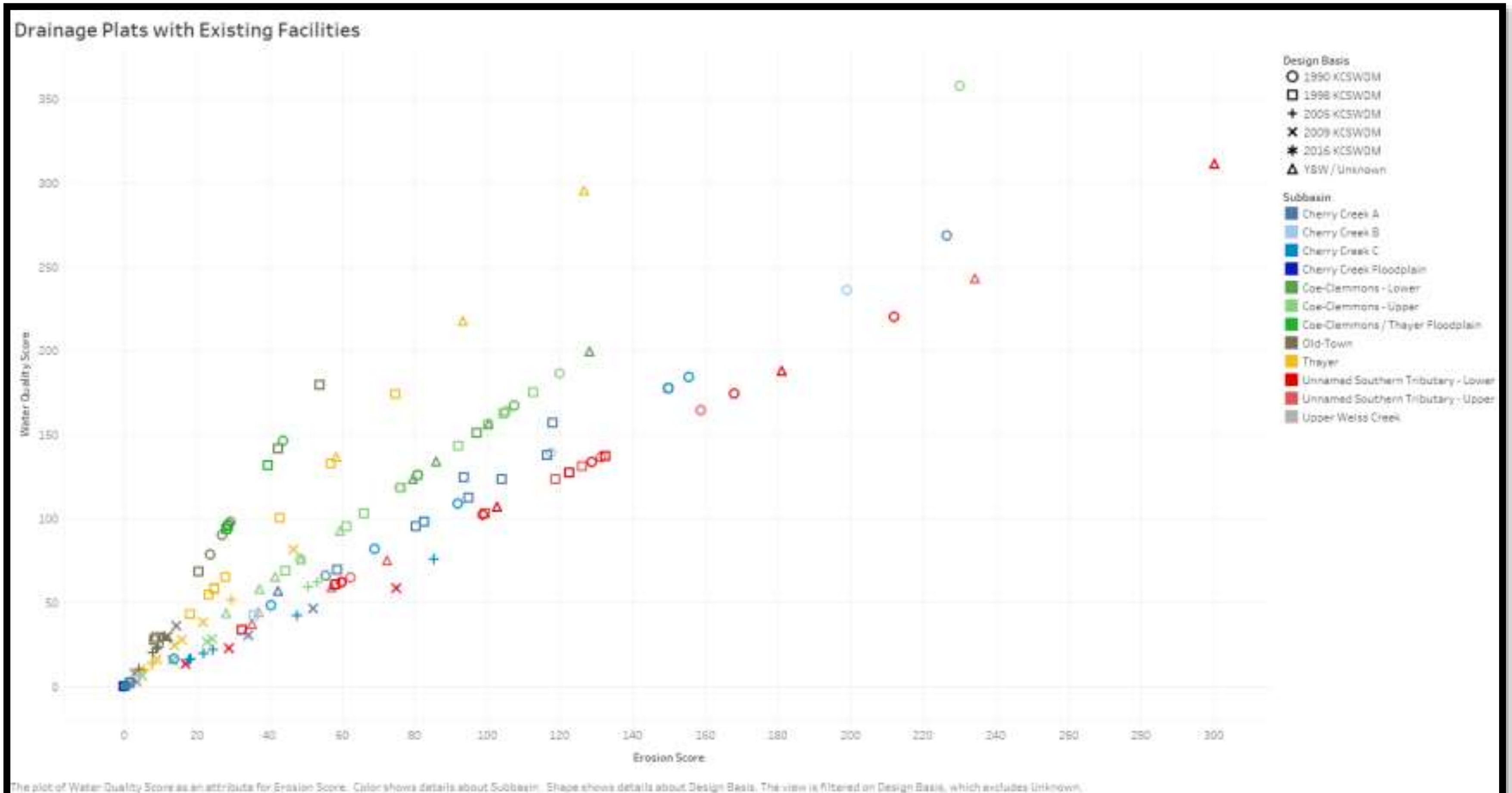

Figure 4: Assessment scores for Erosion and Water Quality for subbasins with existing facilities, distributed by design basis and subbasin management group.

RANKING AND FEASIBILITY

During the ongoing ranking and feasibility phase, the Public Works project team is reviewing the aggregate scoring and individual assessment factor information to identify and assess retrofit priorities across the City's drainage plats. Higher total scores suggest greater importance for retrofit action, based on existing facility type, performance, outfall location, tree canopy, and impervious surface cover.

This upfront review of retrofit scoring results will allow Public Works staff to ensure that assessment metrics are being correctly queried from underlying databases, and that the assessment approach is presenting useful results and giving the project team an understanding of the on-ground conditions within each drainage plat. The final scores will then be arranged into an ordered list and converted to ranks. The following tables present initial results and rankings for the top fifteen scoring drainage plats without existing facilities, and the top fifteen scoring drainage plats with existing facilities.

Table 4: Retrofit Ranking for drainage plats without existing stormwater facilities (top 15)

Subbasin Name	Maj-Min	Name	Subbasin Group	Design Basis	Erosion New Facility Score	*Erosion New Facility Ranking*	WQ New Facility Score	*WQ New Facility Ranking*	Overall New Facility Score	*Overall New Facility Ranking*
Upper Weiss Creek	W3-W3-5	Fox Hollow & Kaelins Gate	Group 3	1990 KCSWDM	64	*1*	57	*4*	60.8	*1*
Cherry Creek A	C3-27	Cherrybrooke	Group 2C	1990 KCSWDM	61	*2*	54	*5*	57.7	*2*
Unnamed Southern Tributary - Upper	D7-17	Kaspar Heights Div. 2	Group 2C	1990 KCSWDM	55	*3*	43	*7*	48.7	*5*
Coe-Clemmons - Upper	D5-41	Taylors Ridge Div. 3 and 4	Group 2B	1990 KCSWDM	53	*4*	61	*1*	56.9	*3*
Coe-Clemmons - Lower	D6-20	Taylors Ridge Div. 3 and 4	Group 2B	1990 KCSWDM	50	*5*	58	*3*	54.2	*4*
Unnamed Southern Tributary - Upper	D7-18	Kaspar Heights Div. 1	Group 2C	1990 KCSWDM	47	*6*	37	*9*	42.1	*7*
Unnamed Southern Tributary - Upper	D7-16	Big Rock Ridge Div. 1-3	Group 2C	1990 KCSWDM	46	*7*	35	*12*	40.6	*9*
Cherry Creek A	C3-21	Legacy Ridge	Group 2A	1990 KCSWDM	41	*8*	37	*10*	39.0	*10*
Cherry Creek A	C3-24	Taylor's Ridge I #2	Group 2A	1990 KCSWDM	40	*9*	36	*11*	38.0	*11*
Cherry Creek A	C3-28	Big Rock Ridge Div. 1-3	Group 2C	1990 KCSWDM	40	*10*	35	*13*	37.6	*12*
Cherry Creek A	C3-23	275th Ave	Group 2C	1990 KCSWDM	38	*11*	34	*14*	35.7	*14*
Cherry Creek A	C3-26	Cedar Grove	Group 3	1990 KCSWDM	38	*12*	33	*16*	35.4	*15*
Coe-Clemmons - Lower	D6-21	Taylors Ridge Div. 2, 3, 4, 5	Group 2B	1990 KCSWDM	34	*13*	40	*8*	36.9	*13*
Thayer	D4-23	Castillo Building	Group 3	1990 KCSWDM	34	*14*	59	*2*	46.2	*6*
Thayer	D4-34	Taylor's Ridge I #1	Group 3	1990 KCSWDM	30	*15*	53	*6*	41.7	*8*

Table 5: Retrofit Ranking for drainage plats with existing stormwater facilities (top 15)

Subbasin Name	Maj-Min	Name	Subbasin Group	Design Basis	Erosion New Facility Score	*Erosion New Facility Ranking*	WQ New Facility Score	*WQ New Facility Ranking*	Overall New Facility Score	*Overall New Facility Ranking*
Unnamed Southern Tributary - Lower	D1-22	Duvall Highlands Mobile Home Park & Crestview Estates 3	Group 2C	Y&W	300.1	*1*	311.2	*2*	311.2	*1*
Unnamed Southern Tributary – Upper	D7-2	City of Duvall / Parks & Open Space	Group 2C	Unknown	234.3	*2*	242.9	*5*	242.9	*4*
Coe-Clemmons - Upper	D5-13	Fox Hollow & Kaelins Gate	Group 3	1990 KCSWDM	230.2	*3*	358.1	*1*	290.9	*2*
Cherry Creek A	C3-15	Cherrybrooke	Group 2C	1990 KCSWDM	226.5	*4*	268.4	*4*	249.5	*3*
Unnamed Southern Tributary - Lower	D1-10	Kaspar Heights Div. 2	Group 2C	1990 KCSWDM	212.0	*5*	219.8	*8*	219.8	*5*
Cherry Creek B	C4-5	Taylors Ridge Div. 3 and 4	Group 2B	1990 KCSWDM	199.0	*6*	235.9	*6*	219.3	*6*
Cherry Creek B	C4-5	Taylors Ridge Div. 3 and 4	Group 2B	1990 KCSWDM	199.0	*6*	235.9	*6*	219.3	*6*
Unnamed Southern Tributary - Lower	D1-6	Duvall Highlands Mobile Home Park & Crestview Estates 3	Group 2C	Y&W	181.1	*8*	187.8	*11*	187.8	*9*
Unnamed Southern Tributary - Lower	D1-11	Kaspar Heights Div. 1	Group 2C	1990 KCSWDM	167.9	*9*	174.1	*18*	174.1	*10*
Unnamed Southern Tributary - Upper	D7-24	Big Rock Ridge Div. 1-3	Group 2C	1990 KCSWDM	158.8	*10*	164.7	*21*	164.7	*14*
Cherry Creek C	C5-3	Legacy Ridge	Group 2A	1990 KCSWDM	155.5	*11*	184.3	*13*	171.3	*11*
Cherry Creek C	C5-24	Taylor's Ridge I #2	Group 2A	1990 KCSWDM	149.9	*12*	177.7	*15*	165.2	*12*
Upper Weiss Creek	W3-W3-7	City of Duvall / Parks & Open Space	Group 2B	1998 KCSWDM	149.7	*13*	177.4	*16*	164.9	*13*
Unnamed Southern Tributary - Lower	D1-14	Safeway Plaza	Group 2C	1998 KCSWDM	132.4	*14*	137.3	*35*	137.3	*20*
Unnamed Southern Tributary - Upper	D7-9	Big Rock Ridge Div. 1-3	Group 2C	1990 KCSWDM	131.4	*15*	136.3	*37*	136.3	*21*

City staff will review retrofit scoring results by drainage plat and perform adjustments as necessary based on additional considerations of retrofit feasibility. These considerations will include the following (in no particular order):

- Private/Public partnership potential
- Ownership
- Known facility deficiencies – “hot spots”
- Cost/Benefit analyses
- Site specific information regarding retrofit ease/difficulty (whether or not drainage plat and/or existing facility locations and constraints provide ‘room’ for retrofit actions)
- Potential to implement Low Impact Development (green stormwater) solutions
- Upstream or downstream retrofit opportunity

Initial review has been completed for the retrofit ranking of example drainage plats listed in Tables 4 and 5. Review of results, ranking, and considerations of feasibility will be presented in our Advisory Committee meeting next week.

APPENDIX B – PRE-DESIGN REPORTS

May 4, 2018

City of Duvall Stormwater Retrofit Facilities Report

Conceptual Design Report

SDA Project #374-001-16

Prepared for:

City of Duvall Public Works
14525 Main St NE
Duvall, WA 98019
(425) 788-3434

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TABLE OF CONTENTS

1. Executive Summary

The attached conceptual design reports review options for improving stormwater mitigation for five stormwater facilities in the City of Duvall. The City of Duvall devised a scoring system to rank all of the developments within the City. The scoring system takes into place the performance of these systems and its relation to sensitive receiving bodies. Five of the worst facilities scored were identified for potential retrofit.

Each facility has an attached conceptual design report that describes the facility, its basin, and alternatives to improve the existing stormwater system. Two stormwater modelling programs were used, MGSFlood and WWHM2012, to model the existing stormwater facilities as well as provide alternatives that would pass under the 2016 King County Stormwater Design Manual (KCSWDM) requirements. These requirements can be seen in Section 2. Two program were used because MGSFlood is the preferred model for its ease of use, while WWHM2012 was used for any project that has an existing detention tank. MGSFlood does not model detention tanks, so a second program was required.

2. Analysis of Minimum Requirements (Phase II NPDES for Western Washington)

Bringing the five selected developments up to current phase II NPDES standards should include a review of core and special requirements relevant to new developments. The existing developments each contain more than 2,000 square feet of developed impervious, which is a threshold for a stormwater control. A new project proposing 2,000 square feet or more of impervious area is subject to the provisions for a Full Drainage Review as outlined in the 2016 King County Stormwater Design Manual (KCSWDM). The KCSWDM contains a list of 9 core requirements in addition to 5 special requirements for stormwater. The following is a brief review of the relevant core and special requirements. Final design will include a more detailed analysis of these requirements.

- Core Requirement #1 – Discharge at Natural Location
  - The existing drainage discharge location for each development will be maintained with a new facility.
- Core Requirement #2 – Offsite Analysis
  - Reconstructing the existing facilities to current flow control standards should decrease drainage issues downstream.
- Core Requirement #3 – Flow Control
  - According to the 2016 KCSWDM, a Level 2 flow control requires maintaining the durations of high flows at their predevelopment levels for all flows greater than one-half of the 2-year peak flow up to the 50-year peak flow. The predevelopment peak flow rates for the 2-year and 10-year runoff events cannot be exceeded when applying Level 2 flow control. The predevelopment condition to be assumed for matching durations varies depending on the County's conservation/protection goals for the downstream drainage system. The three different predevelopment conditions are existing site conditions, historic site conditions (forested), and 75/15/10 conditions. In this instance, historic site conditions were applied.

- Core Requirement #4 – Conveyance System
    - The stormwater conveyance system for each development will be altered.
- Core Requirement #5 – Erosion & Sediment Control
    - Erosion & Sediment Control will be a requirement for any retrofit option that includes disturbance of soil. These requirements will be incorporated into final design plans for the new facility.
- Core Requirement #6 – Maintenance & Operations
    - Maintenance and operations of the proposed storm drainage facilities can be found in Appendix A of the 2016 King County Stormwater Design Manual. The maintenance of the new facilities will be provided by the City.
- Core Requirement #7 – Financial Guarantees & Liabilities
    - This section relates to construction performance for facilities funded by private entities. The new facilities will be public, constructed by the City, so this core requirement does not need to be addressed.
- Core Requirement #8 – Water Quality
    - The proposed combined water quality and flow control facilities will have a permanent wetpool. See Section 5 of each report for the proposed alternative with water quality. See Section 6 of each report for the proposed alternative's wetpool information.
- Core Requirement #9 – Flow Control BMPs
    - On-site BMPs associated with each unit is not feasible because the sites and its stormwater infrastructure are already fully developed.
- Special Requirement #1-5
    - No Special Requirements apply to this project.

3. Conceptual Design Reports

These reports are conceptual. All information should be verified as retrofit projects progress. SDA does not warranty information contained in these reports. Coordinate with the City to verify future work.

The City of Duvall devised a scoring system to rank all of the developments within the City. Site numbers are based on the ranking on the retrofit priority list. Basin areas were identified through several outlets, including as-builts, LIDAR contours, and the King County 2015 Aerial Imagery provided by the City. Existing stormwater facility information was acquired from as-builts, drainage reports, and LIDAR contours. MGSFlood and WWHM2012 were used to model the existing stormwater facilities as well as provide alternatives that would pass under the 2016 King County Stormwater Design Manual (KCSWDM) requirements.

Duvall Highland Mobile Park Homes

Site #3 - Conceptual Design Report

28000 NE 142nd Pl
Duvall, WA 98019

SDA Project #374-001-16

Prepared for:

City of Duvall Public Works
14525 Main St NE
Duvall, WA 98019
(425) 788-3434

SDA

CIVIL ENGINEERING | PROJECT MANAGEMENT | PLANNING
1724 W. Marine View Drive, Suite 140, Everett, WA 98201 | 425.486.6533 | www.sdaengineers.com

Duvall Highland Mobile Park Homes

Site #3 - Conceptual Design Report

Prepared For:

City of Duvall Public Works
14525 Main Street NE, Duvall , WA 98019
425-788-3434

City of Duvall Public Works
14525 Main St NE
Duvall, WA 98019
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Prepared By:

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TABLE OF CONTENTS

1. Executive Summary

This conceptual design report reviews options for improving stormwater mitigation for Duvall Highland Mobile Park Homes (MHP).

The MHP site is located in the NW ¼ of Section 19, Township 26 North, Range 7 East, W.M. More specifically, the development is located at 28000 NE 142nd Place, Duvall, WA 98019. It occupies King County tax lot number 1926079005. A vicinity map has been included as Figure 1 following this section.

The existing shallow asphalt lined “flow-through” pond manages stormwater for the majority of the MHP and a few homes to the north of the property. The pond is privately owned and located on the southwest corner of the mobile park, north of NE 142nd Place. The proposed concept will build a new facility in the existing location. The City has proposed to either create a partnership with the property owners or take over ownership and maintain the new facility themselves.

Based on the original design, the existing pond has little to no storage or water quality attributes. To bring the facility up to 2016 standards, a larger and deeper combined flow control and water quality facility would be required. The downstream conveyance in NE 142nd Place would also need to be low enough to accommodate the proposed deeper pond. It is clear that the available site area will not accommodate a flow control facility compliment with 2016 standards, but improvements can be made.

Facility Opportunities and Efficiencies

This stormwater facility ranked third in the City’s watershed based approach to improve stormwater management. Based on the age of the facility and 2016/2017 stormwater management standards, the opportunity to add water quality and increase detention volumes will protect and improve downstream systems. Ideally this project would incorporate a larger, deeper stormwater pond to comply with 2016 KCSWDM flow control and to meet water quality standards as well as incorporating low impact development (LID) techniques. There is insufficient area to provide a flow control facility that is large enough so the concept attempts to reduce existing release rates as much as possible. These LID approaches include but are not limited to: increased tree canopy coverage, water quality components, and right-of-way (NE 142nd Place) bioretention options. This retrofit site also provides unique opportunities including:

- Reduced peak flow and improved water quality to the Unnamed South Tributary - Lower watersheds and sensitive downstream conditions associated with the NE Big Rock Road drainage.
- A public/private partnership between the City and MHP
- Treatment and detention for offsite properties located north of the MHP that currently drain to the MHP facility.
- Treatment, detention, and possible coordinated construction for the NE 142nd Non-motorized improvement project (TIP# C-1 and C-2)
- Incorporation of BMP T7.30: Bioretention Cells
- Incorporation of BMP T5.16: Tree Retention
- Incorporation of BMP T5.13: Post Construction Soil Quality and Depth
- Incorporation of BMP T10.40: Combined Detention and Wetpool Facilities

These reports are conceptual. All information should be verified as retrofit projects progress. SDA does not warranty information contained in these reports.

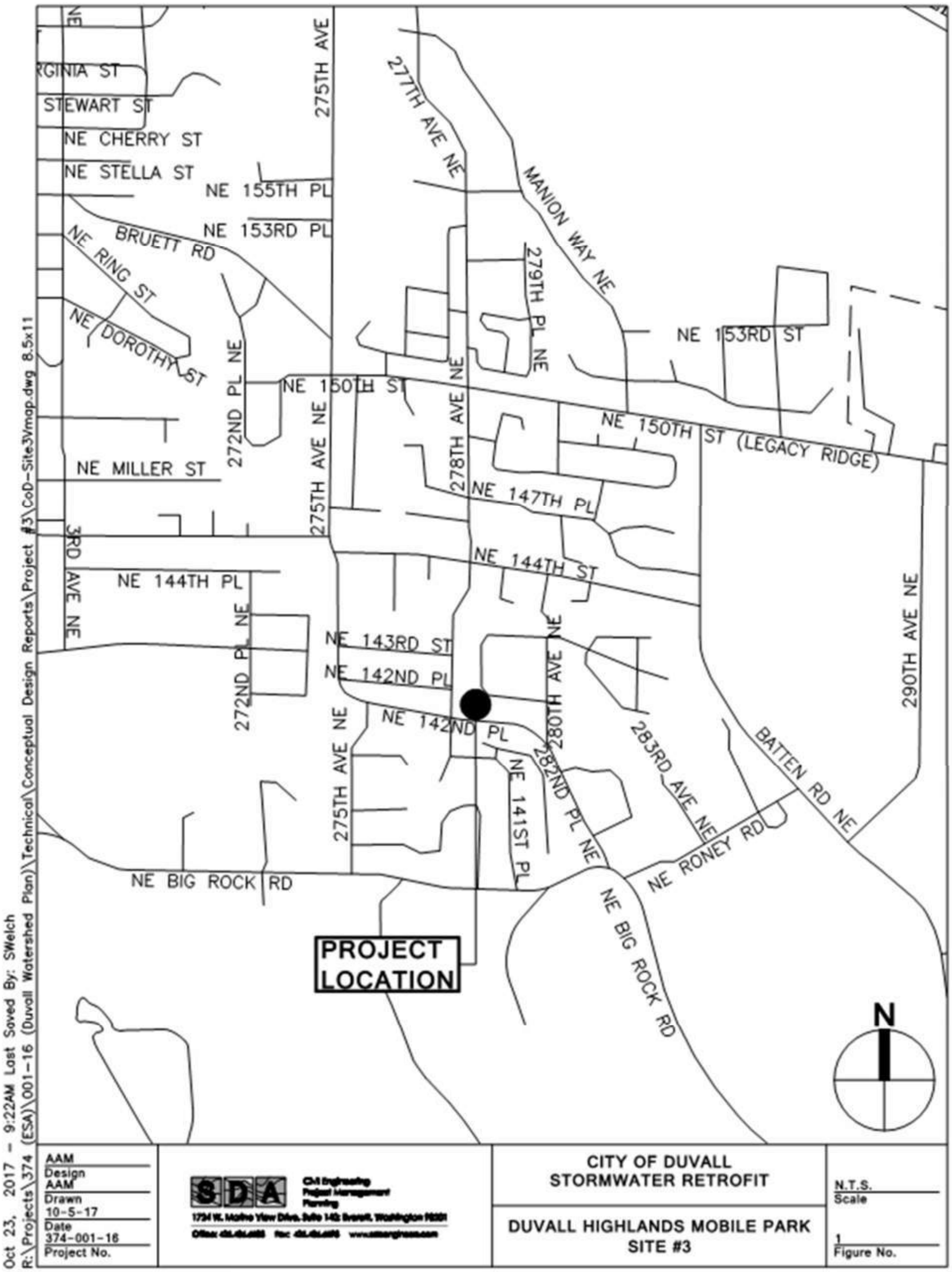


Figure 1: Vicinity Map

2. Basin Description

The MHP stormwater facility serves 28.4 acres, consisting of 12.2 acres of impervious area and 16.2 acres of pervious area. See Duvall Watershed Plan in Appendix A for a basin area map. Stormwater runs from the northeast to the southwest through a piped stormwater conveyance system, discharging to the asphalt lined pond. Additionally, a portion of NE 142nd Place drains into the facility through a ditch system along the north side of the road.

3. Existing Conditions

Site Description

A total of 121 units from the MHP drain to the stormwater facility. Additionally, 8 single-family homes from the Crestview Estate development to the north are routed to the facility. The 121 units account for 24.1 acres and are bordered by residential developments to the north and west, a vacant forested parcel to the east, and NE 142nd Place to the south. The 8 single-family homes account for approximately 4.3 acres of Crestview Estates (development to the north).

Existing Facilities

Shallow Asphalt Lined Pond

No drainage report was available for the MHP pond, but a survey was performed in December 2017. With this information, the existing pond configuration was recreated in WWHM2012 to assess performance compared to 2016 KCSWDM flow control standards. See Section 2 of the title page for the 2016 King County Stormwater Design Manual requirements. The existing pond volume at the riser crest is 24,529 cubic feet (cu-ft), which does not meet the volume required to comply with the 2016 KCSWDM flow control standards. The flow duration plot as seen in Figure 2 shows that none of the target thresholds are met with the available storage volume.

The pond contour areas were created using the survey and were entered into the SDA Equivalent Pond Sizing Calculation Spreadsheet. WWHM2012 does not have an option to enter pond contour areas and volumes directly into the program, so this spreadsheet was used to calculate an equivalent rectangular pond. A 74’ by 72’ rectangular pond with side slopes of 3:1 was calculated as an equivalent pond and entered into WWHM2012.

The SDA Equivalent Pond Sizing Calculation Spreadsheet, MHP survey, as-builts, area maps, and complete WWHM2012 report can be found in Appendix A.

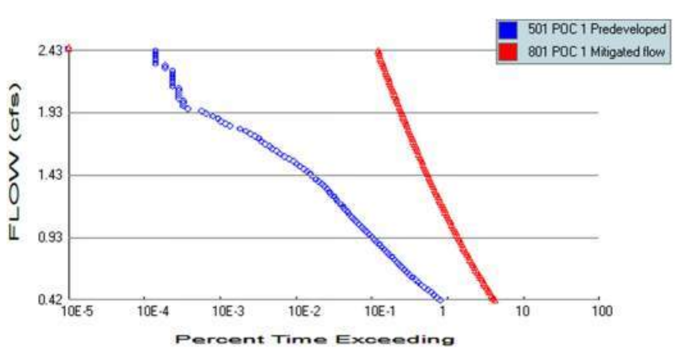


Figure 2: Current Detention Facility

4. Retrofit Alternatives Considered

Facilities That Cannot Be Accommodated in the Available Area

Modification Option 1: Flow Control Compliant Combined Flow Control and Water Quality Facility – 3:1 Slope

As seen in Figure 2, a larger facility is required to accommodate the existing MHP site. A rectangular pond with a bottom area of 190 feet by 190 feet, storage depth of 8 feet, and side slopes of 3:1. This preliminary design will meet the 2016 KCSWDM flow control standards, however this proposed facility cannot be accommodated in the available area. The Flow Duration Plot for this proposed pond design can be seen in Figure 3. This is an example of the size of facility that is required to meet the 2016 KCSWDM flow control standards.

The complete WWHM2012 report can be found in Section 8.

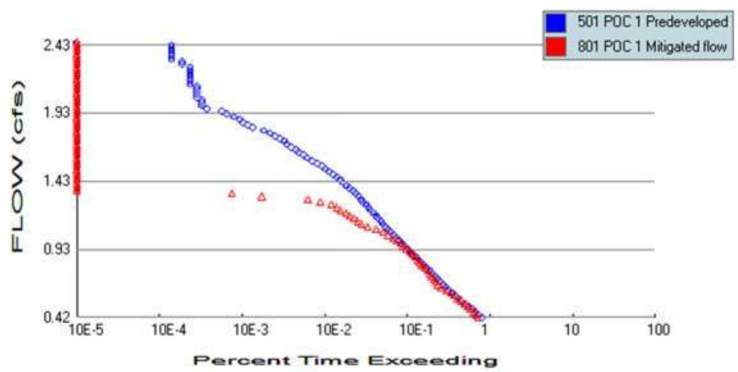


Figure 3: Modification Option 1: Combined Flow Control and Water Quality Facility

Facility That Can Be Accommodated in the Available Area

Modification Option 2: Proposed Combined Flow Control and Water Quality Facility – Maximize Footprint and Walls

A rectangular pond with dimensions of 179 feet by 76 feet, storage depth (from bottom of pond to riser crest) is 4.5 feet, and pond walls will fit within the available area, it will not meet the 2016 KCSWDM flow control standards. The Flow Duration Plot for this proposed pond design can be seen in Figure 4. The flow control portion of this pond is 1' deeper than the existing facility.

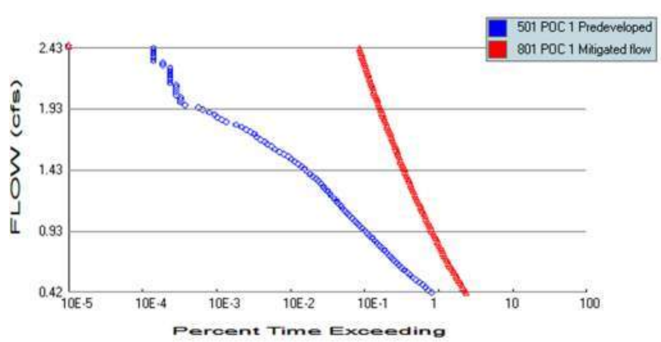


Figure 4: Modification Option 2: Proposed Combined Flow Control and Water Quality Facility – Maximize Footprint and Walls

Comparison to Existing Facility

This combined water quality and detention facility does not meet flow control standards, but it will reduce impacts to the sensitive area downstream. Table 1 compares the existing 2, 10, and 100 year MHP pond release rates to the proposed water quality and detention facility's release rates.

Table 1: MHP Existing and Proposed Release Rates Comparison

Year of Event	Ex. MPH Facility (cfs)	Proposed MPH Combined Facility (cfs)	% of Release Reduction
2	5.526	4.325	21.7
10	9.270	7.750	16.4
100	14.834	12.930	12.8

5. Quantified Water Quality Benefit

A combined flow control and water quality facility incorporates a permanent pool of water ("wetpool") below the flow control storage to settle particulate pollutants in the pond. According to the 2016 KCSWDM, the basic wetpond volume is equal to 91% of the total runoff volume, as estimated by an approved continuous runoff model.' Using WWHM2012, the wetpond volume was calculated to be 1.8543 ac-ft. This can be seen in the complete WWHM2012 report in Appendix A. The following equation was used to calculate the wetpool depth for treatment:

$$h = \frac{V}{A} = \frac{1.8543\ ac.ft}{1\ \text{ac.ft}} x \frac{43{,}560\ cf}{11{,}799\ sf} = 6.8'$$

Where: h = wetpool depth (ft)

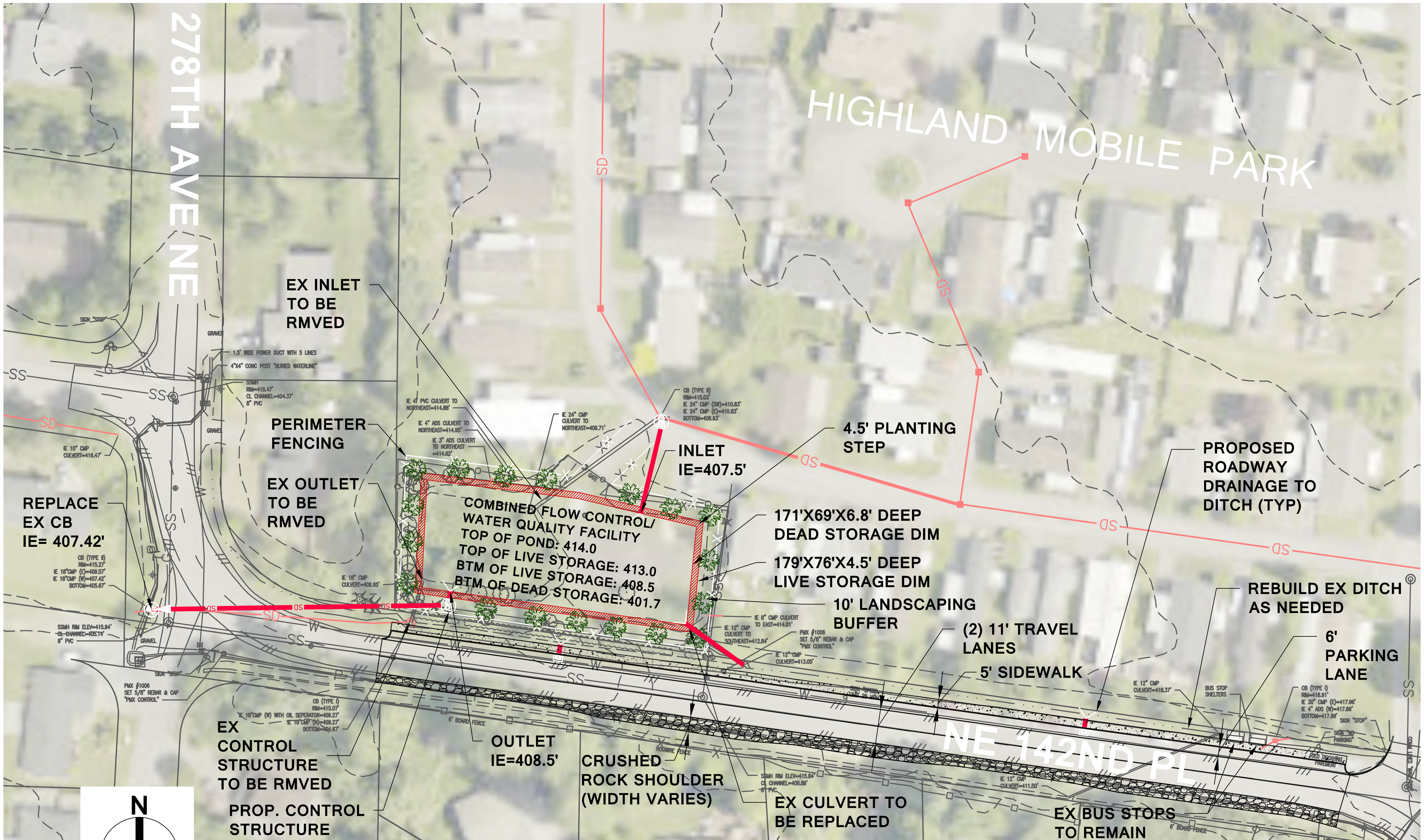
V = wetpond volume (ac.ft) - 1.6458 ac.ft

A = bottom area of pond (sf) – 171' x 69' = 11,799 sf

The bottom area used for this calculation is based on Modification Option 2 – Maximized Footprint and Walls. The calculated water quality depth is 6.8 feet.

6. Summary

Meeting 2016 KCSWDM flow control standards requires a larger stormwater facility footprint than the allotted area allows. The addition of walls will increase storage within the available footprint. Modification Option 2 does not meet flow control standards, but provides some flow reduction to downstream sensitive areas. It represents the most feasible solution to improving flow control, but the expense of construction may outweigh the benefits. Alternative flow control targets and pond configurations should be reviewed with the City and regulators with the goal of improving flow control. Modification Option 2 provides adequate water quality storage by using walls rather than traditional side slopes. See Figure 5 for the conceptual design. Other options would likely require additional area which may not be feasible at this site.



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1"= 60' 0 60 Scale Feet

SMW	Design
AAM	Drawn
2017-10-24	Date
374-001-16	Project No.

SDA Civil Engineering Project Management Planning
1724 W. Marine View Drive, Suite 140; Everett, Washington 98201
Office: 425.486.6533 Fax: 425.486.6593 www.sdaengineers.com

DUVALL WATERSHED PLAN
DUVALL HIGHLAND MOBILE PARK

CONCEPTUAL DESIGN

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Big Rock Ridge Division 1 & 3 - North pond

Site #5 - Conceptual Design Report

NE corner of the intersection at NE Big Rock Road and NE Roney Road
Duvall, WA 98019

SDA Project #374-001-16

Prepared for:

City of Duvall Public Works
14525 Main St NE
Duvall, WA 98019
(425) 788-3434

SDA

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Big Rock Ridge Division 1 & 3 - North pond

Site #5 - Conceptual Design Report

Prepared For:

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City of Duvall Public Works
14525 Main St NE
Duvall, WA 98019
(425) 788-3434

Prepared By:

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1. Executive Summary

This conceptual design report reviews options for improving stormwater mitigation for Big Rock Ridge Division 1 & 3. There is also the potential to improve stormwater mitigation for nearby Laura Vera Estates and a portion of NE Big Rock Road and 282nd Place NE.

The Big Rock Ridge Division 1 & 3 pond is located in the NW ¼ of Section 19, Township 26 North, Range 7 East, W.M. More specifically, the plat is located at the northeast corner of the intersection at NE Big Rock Road and NE Roney Road. It occupies King County tax lot number 0808300250. A vicinity map has been included as Figure 1 following this section.

There is an existing stormwater facility for Big Rock Ridge Division 1 & 3 that is owned and maintained by the City. The pond is located on the west side of the subdivision, north of NE Big Rock Road. Laura Vera Estates is served by a detention pipe which is located to the northwest of the Big Rock Ridge facility on a vacant, City owned parcel (King County tax lot 4213500170). A nearby section of 282nd Place NE is served by a bioswale on a City owned parcel (King County tax lot 6672930380). The bioswale is located in the northeast corner of the intersection at NE Big Rock Road and 282nd Place NE.

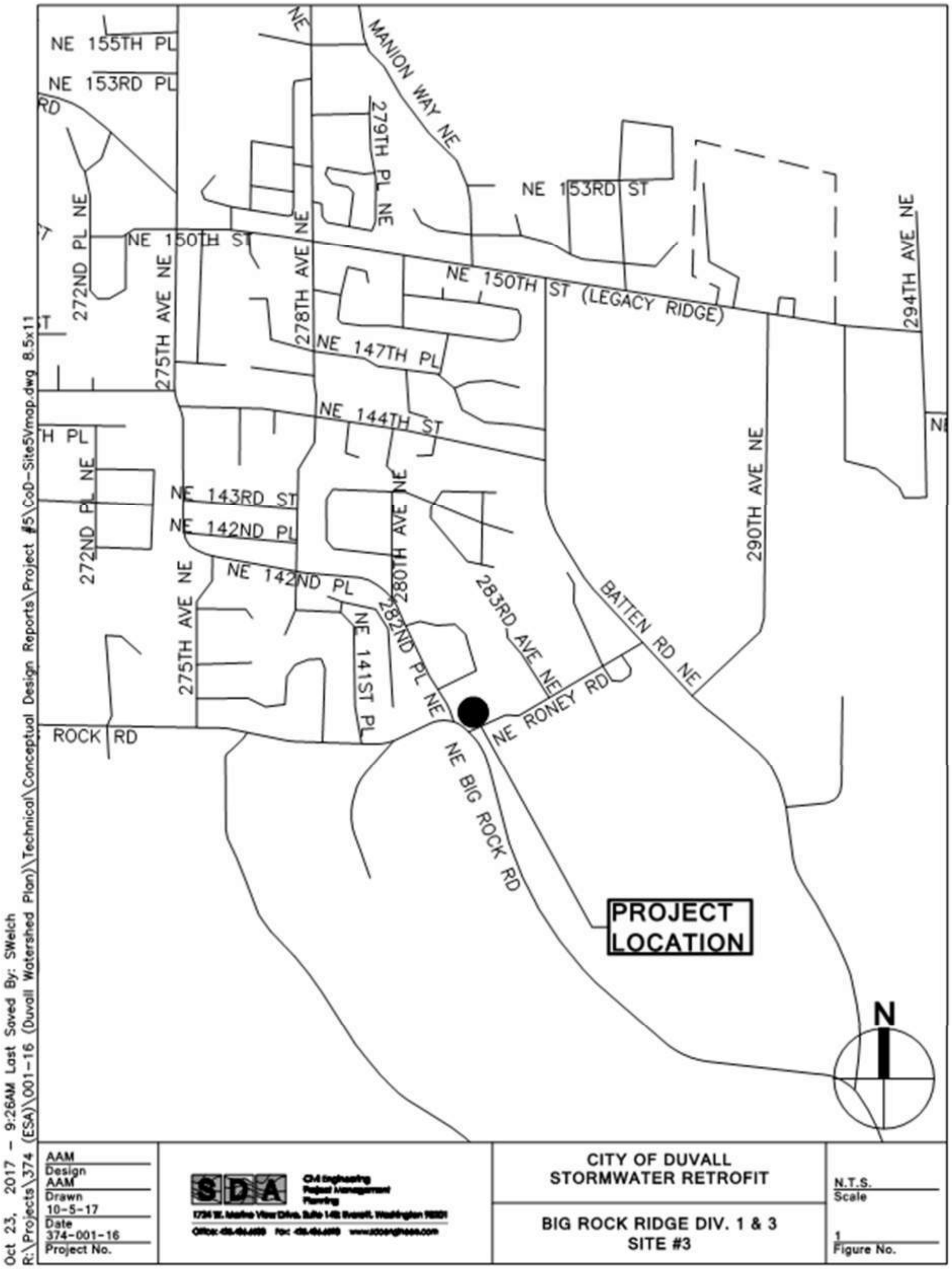
This conceptual report reviews options to add storage and water quality to the existing Big Rock Ridge pond. Extended options include consolidating the stormwater mitigation for Laura Vera and the nearby portion of 282nd Place NE into a larger regional facility and adding water quality via a bioretention area. The Big Rock Road bioswale and Laura Vera Estates detention pipe are both situated to the northwest of the Big Rock Ridge pond. Both the detention pipe and bioswale are on City property. Combining stormwater mitigation in a new Big Rock Ridge facility could incorporate other uses for the City parcels.

Facility Retrofit Opportunities and Efficiencies

This stormwater facility ranked fifth in the City's watershed based approach to improve stormwater management. There is a possibility to regionalize this facility to add water quality and increase detention volumes to protect and improve downstream systems. This project will incorporate a larger, deeper stormwater pond to comply with 2016 KCSWDM flow control and water quality standards as well as incorporating low impact development (LID) techniques. These LID approaches include but are not limited to: increased tree canopy coverage, large bioretention components, and right-of-way (282nd Place NE and NE Big Rock Road) water quality options.

- Reduced peak flow and improved water quality to the Unnamed South Tributary - Upper watersheds and sensitive downstream conditions associated with the NE Big Rock Road drainage.
- Possible consolidated drainage with the Laura Vera Facility (located upstream and to the north) and 282nd Ave NE intersection bioswale.
- Incorporation of BMP T7.30: Bioretention Cells
- Incorporation of BMP T5.16: Tree Retention
- Incorporation of BMP T5.13: Post Construction Soil Quality and Depth
- Incorporation of BMP T10.40: Combined Detention and Wetpool Facilities

These reports are conceptual. All information should be verified as retrofit projects progress. SDA does not warranty information contained in these reports.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NE 153RD PL
MANION WAY NE
279TH PL NE
NE 153RD ST
272ND PL NE
NE 150TH ST
278TH AVE NE
275TH AVE NE
NE 150TH ST (LEGACY RIDGE)
294TH AVE NE
NE 147TH PL
NE 144TH ST
290TH AVE NE
272ND PL NE
NE 143RD ST
NE 142ND PL
280TH AVE NE
275TH AVE NE
NE 142ND PL
283RD AVE NE
BATTEN RD NE
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ROCK RD
NE BIG ROCK RD
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Design
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Drawn
10-5-17
Date
374-001-16
Project No.
SDA
CITY OF DUVALL
STORMWATER RETROFIT
BIG ROCK RIDGE DIV. 1 & 3
SITE #3
N.T.S.
Scale
1
Figure No.

Figure 1: Vicinity Map

2. Basin Description

The Big Rock Ridge Division 1 & 3 detention pond serves 12.34 acres of developed area consisting of 4.20 acres of impervious area and 8.14 acres of pervious area. See the Duvall Watershed Plan in Appendix B for drainage basin areas. Stormwater runs through the development from east to west in a piped conveyance system. The Big Rock Ridge facility consists of a pre-treatment bioswale that discharges to a large three-celled detention pond. The facility discharges through a culvert under NE Big Rock Road to the west, into a sensitive drainage area.

The Laura Vera detention pipe serves 9.22 acres of developed area consisting of 5.41 acres of impervious area and 3.81 acres of pervious area. See the Duvall Watershed Plan in Appendix B for drainage basin areas. Stormwater runs from the southeast to the west through a piped conveyance system to the detention pipe. From the detention pipe, the stormwater is conveyed to the southwest under 282nd Place NE and continues west through the existing stormwater conveyance system along NE Big Rock Road.

The Big Rock Road biofiltration swale serves a portion of 282nd Place NE and one lot from Laura Vera Estates. See the Duvall Watershed Plan in Appendix B for drainage basin areas. Stormwater runs from the north to the south through a piped stormwater conveyance system in 282nd Place NE, ultimately discharging to the bioswale. From the bioswale, the stormwater discharges west along the north side of Big Rock Road.

3. Existing Conditions

Site Description

Big Rock Ridge Division 1 contains 24 lots and Division 3 contains 15 lots. This plat is bordered by residential developments to the north and south, NE Big Rock Road to the west, and a forested area to the east.

Laura Vera Estates contains 25 lots, but only 24 lots drain to the detention pipe. This plat is bordered by residential developments to the north and south, 282nd Place NE to the west, and a forested area to the east.

The Big Rock Road bioswale drainage basin contains 1 lot from Laura Vera Estates and the southern portion of 282nd Place NE. This bioswale is bordered by residential developments to the north, east, and west and NE Big Rock Road to the south.

Existing Facilities

Big Rock Ridge Plat

According to the drainage report titled, “TIR for Big Rock Ridge” (1997), the stormwater facility in Tract A serves 12.34 acres of developed area consisting of 4.20 acres of impervious area and 8.14 acres of pervious area. See Appendix B for the drainage areas depicted in the TIR and the Duvall Watershed Plan.

The facility consists of a pre-treatment biofiltration swale and a combined water quality and flow control pond. The drainage facility components were originally designed to comply with the 1990 King County

Surface Water Design Manual. The pond was sized to match peak flows from the developed 2-year and 10-year storm events to existing conditions and a 30 percent safety factor was added to the resulting volume.

The current Big Rock Ridge pond configuration was recreated in MGSFlood using an as built drawing in order to identify whether the facility meets current flow control standards. See Appendix B for Big Rock Ridge pond as built details. See Analysis of Minimum Requirements, Core Requirement #3 in the title page for the flow control requirements. The existing pond volume is 52,570 cubic feet (cu-ft), which does not meet the volume required to comply with the 2016 KCSWDM flow control standards. See Appendix B for the MGSFlood report.

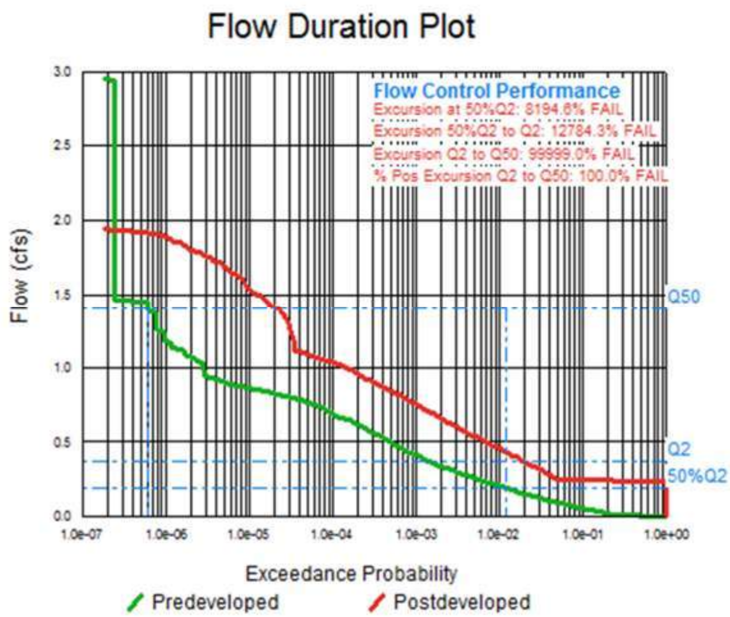


Figure 2: Current Detention Pond Facility

Laura Vera Estates

According to the drainage report titled, "Laura Vera Estates Pond Volume" (1989), the existing detention pipe serves 9.22 acres and 0.45 acres bypass the system to the Big Rock Road Bioswale mentioned in the next section. Aerial imagery and contours produced from LIDAR were used to delineate the existing detention pipe drainage basin areas. It was determined using aerial imagery that approximately 50% of each lot was covered with impervious surface, resulting in a total of 5.41 acres of impervious area and 3.81 acres of pervious area. The 96" diameter detention pipe is 121 linear feet (LF) with a 54" control structure that provides flow restriction and oil pollution control. See Appendix B for the Laura Vera Estates Pipe Volume calculations and the Duvall Watershed Plan for drainage basin areas.

The current Laura Vera Estates detention pipe configuration was recreated in WWHM2012 using an as built drawing in order to identify whether the facility meets current flow control standards. WWHM2012 was used instead of MGSFlood because MGSFlood does not have the option to use a detention pipe. This facility has insufficient volume to meet current flow control standards.

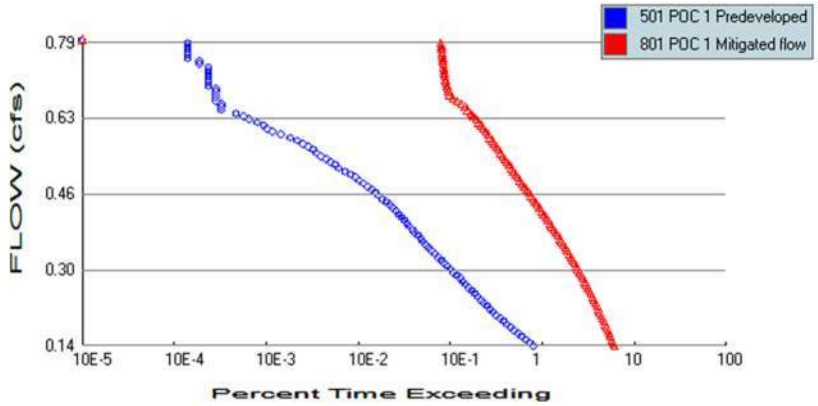


Figure 3: Current Detention Pipe Facility

Big Rock Road Bioswale

No drainage report was provided for the Big Rock Road biofiltration swale. The as built drawings provided by the City show the stormwater conveyance improvements to 282nd Place NE draining to the bioswale. Aerial imagery and contours produced from LIDAR were used to delineate the existing bioswale drainage basin areas. It was determined that 1.28 acres is being collected from Laura Vera Estates and the roadway improvements, 0.53 acres being impervious and 0.76 acres being pervious. See Duvall Watershed Plan in Appendix B for a basin area map and Big Rock Road plan sheet for bioswale details.

4. Retrofit Alternatives Considered

Modification Option 1: Combined Flow Control and Water Quality Facility – Big Rock Ridge Plat Only, Side Slope 3:1

The existing pond has three cells separated by two berms. A new water quality and flow control facility would require one interior berm and the bioswale would be removed in favor of another water quality treatment system.

As seen in the existing conditions Flow Duration Plot in Figure 2, a larger facility is required to accommodate the existing Big Rock Ridge site. A proposed rectangular pond would require a bottom area of 165 feet by 100 feet with a storage depth of 6 feet and side slopes of 3:1 to meet the 2016 KCSWDM flow control standards. The Flow Duration Plot for this proposed pond design is shown in Figure 4. The MGSFlood report can be found in Appendix B. This proposed facility cannot be accommodated in the existing area with side slopes of 3:1. This is an example of the size of facility that is required to meet current flow control standards.

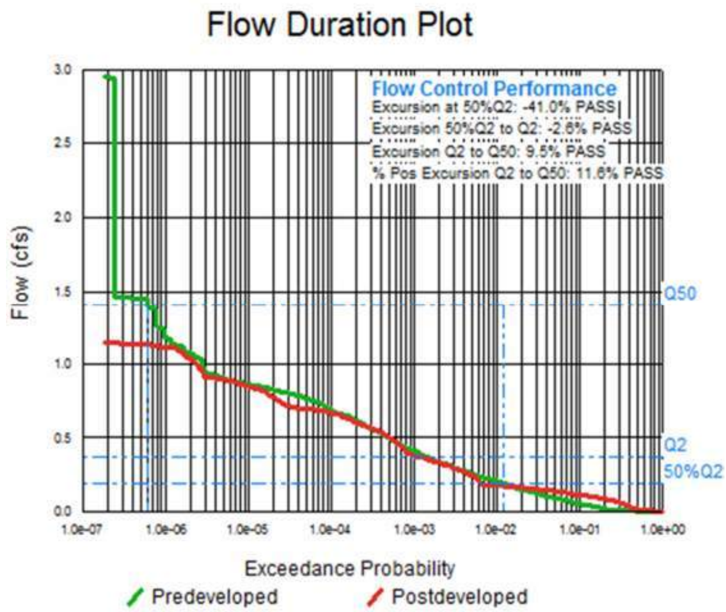


Figure 4: Modification Option 1: Combined Facility – Big Rock Ridge Plat Only, Side Slopes 3:1

Modification Option 2: Combined Flow Control and Water Quality Facility – Big Rock Ridge Plat and Laura Vera Estates, Pond Walls

This option incorporates the Laura Vera Estates development, currently served by a substandard detention pipe. In order to have a pond that meets the 2016 KCSWDM flow control requirements, the pond depth and footprint are larger than the pond serving Big Rock Ridge, as stated in Modification Options 1 and 2. For this modification option, a proposed rectangular pond with dimensions of: 350 feet by 190 feet, storage depth of 6 feet, and pond walls will meet the 2016 KCSWDM flow control standards. The Flow Duration Plot for this proposed pond design is shown in Figure 5. This proposed facility cannot be accommodated within the available area. The MGSFlood report can be found in Appendix B.

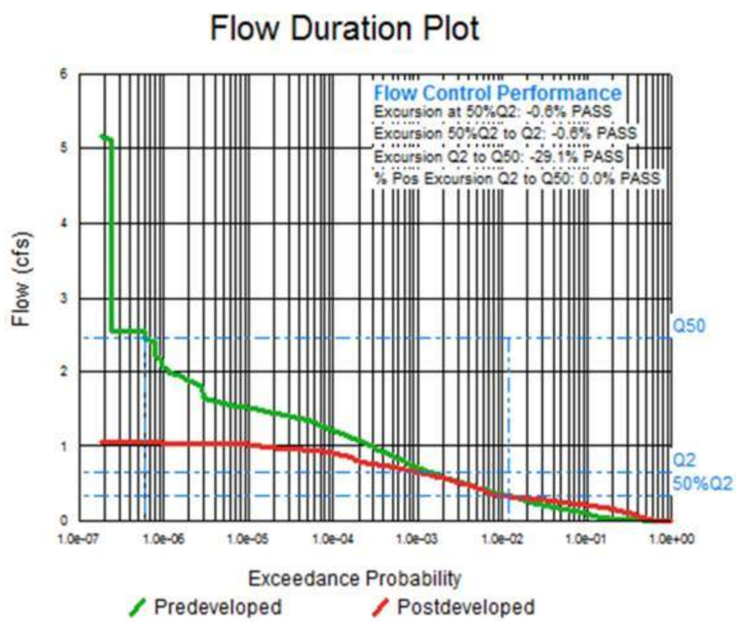


Figure 5: Modification Option 2: Combined Flow Control and Water Quality Facility – Big Rock Ridge Plat and Laura Vera Estates, Pond Walls

Modification Option 3: Combined Flow Control and Water Quality Facility – Big Rock Ridge Plat, Laura Vera Estates, and Big Rock Road Bioswale

With further analysis of the existing stormwater conveyance, it was found that the Big Rock Road bioswale was 10' deeper than the Big Rock Ridge proposed facility. Due to this elevation difference, the stormwater conveyance from the bioswale drainage basin area will not flow to a new proposed facility.

Modification Option 4: Maxed Out Combined Flow Control and Water Quality Facility – Big Rock Ridge Plat and Laura Vera Estates, Pond Walls

For this modification option, a proposed rectangular pond with dimensions of: 200 feet by 128 feet, storage depth of 8 feet, and pond walls was analyzed. It will not meet the 2016 KCSWDM flow control standards, but it does improve flow control performance. The Flow Duration Plot for this proposed pond can be seen in Figure 6. The flow control portion of this pond is 5 feet deeper than the existing facility, and this can be accommodated by lowering the conveyance system downstream. This should be verified for future work on this retrofit project. The existing outfall pipe runs at a higher than minimum slope and therefore can be realigned to accommodate the additional required storage depth. The control structure would also need to be reconstructed with this proposed pond design.

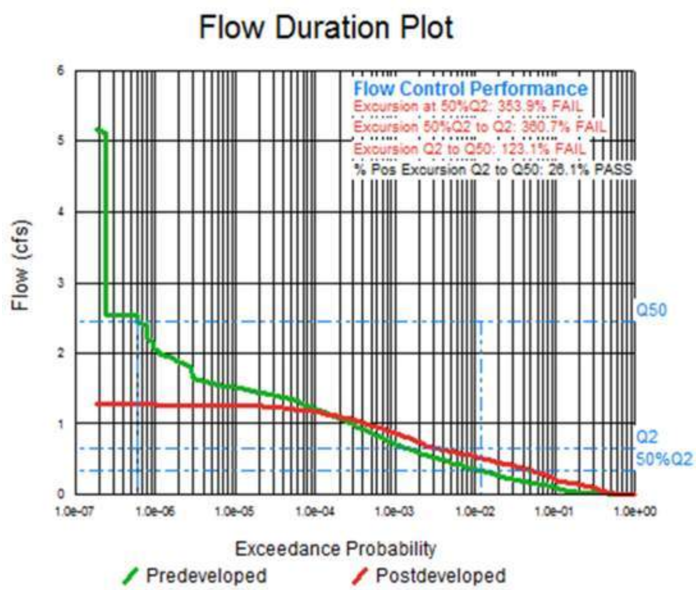


Figure 6: Modification Option 4: Maxed Out Combined Flow Control and Water Quality Facility – Big Rock Ridge Plat and Laura Vera Estates, Pond Walls

Comparison to Existing Facility

In order to ensure the proposed combined water quality and detention facility reduces impacts to the sensitive area downstream, the existing and proposed flows were compared. Table 1 compares the combined release rates from the Laura Vera detention pipe and Big Rock Ridge pond to the proposed water quality and detention facility's release rates.

Table 1: Comparison of Release Rates

Year of Event	Ex. Laura Vera Estates Det. Pipe (cfs)	Ex. Big Rock Ridge Combined Facility (cfs)	Combined Flows (cfs)	Proposed Big Rock Ridge Combined Facility (cfs)	% of Release Reduction
2	1.941	0.755	2.696	0.651	76
10	3.803	1.047	4.850	1.009	79
100	6.441	1.795	8.236	1.254	85

As seen in Table 1, the release rates for the proposed facility provide significant reduction of flow rates compared to the existing facilities.

5. Quantified Water Quality Benefit

Dead storage is one method for providing water quality treatment. A combined flow control and water quality facility incorporates a permanent pool of water below the flow control storage (a "wetpool") to settle particulate pollutants in the pond. According to the 2016 KCSWDM, "the basic wetpond volume is equal to the 91% water quality treatment volume." Using MGSFlood, the wetpond volume was calculated to be 68,279 cu-ft. This can be seen in the MGSFlood report in Appendix B. The following equation was used in calculating the wetpond depth:

$$h = \frac{V}{A} = \frac{68{,}279\ cf}{23{,}124\ sf} = 3.0'$$

Where: h = wetpool depth (ft)

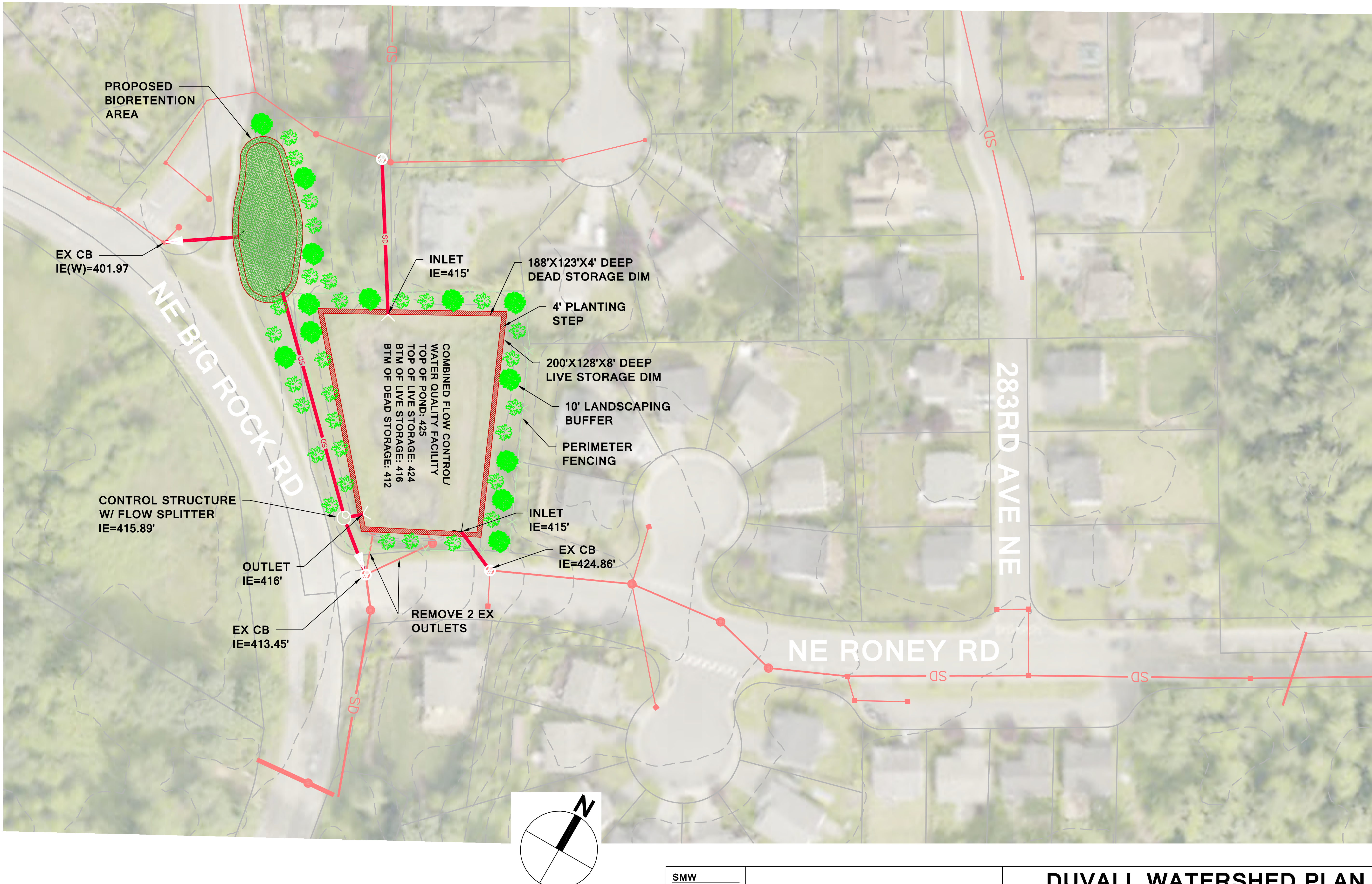
V = wetpond volume (cf) - 68,279 cf

A = bottom area of pond (sf) – 188'x123' = 23,124 sf

The bottom area used for this calculation is based on the pond option that maximizes available area. The calculated water quality depth is 3.0 feet, however this depth would need to be increased to 4 feet to meet 2016 KCSWDM minimum depth for wetpond storage. There is also an opportunity to incorporate a bioretention area (See Figure 7) in lieu of or in addition to dead storage in the proposed pond.

6. Summary

Meeting 2016 KCSWDM flow control standards requires a larger stormwater facility footprint than the available area will allow. A facility designed to fit within the available area will not meet the 2016 KCSWDM flow control standards. Adding a combined water quality and detention facility with walls increases the available storage. This results in release rates that are significantly less than the combined release rates for the existing detention pipe and combined stormwater facility. Water quality storage can be designed with dead storage to adequately meet 2016 KCSWDM requirements. This dead storage can be combined with or substituted by a bioretention area on available City property. While the proposed stormwater facility does not meet the 2016 KCSWDM flow control standards, the facility will improve existing flow control and provide water quality. See Figure 7 for the conceptual design.



1"= 80

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Scale Feet

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Design	AAM
Drawn	2017-10-24
Date	374-001-16
Project No.	

S D A Civil Engineering Project Management Planning

1724 W. Marine View Drive, Suite 140; Everett, Washington 98201

Office: 425.486.6533 Fax: 425.486.6593 www.sdaengineers.com

DUVALL WATERSHED PLAN BIG ROCK RIDGE (NORTH POND)

CONCEPTUAL DESIGN

Sheet: 7

Dec 19, 2017 - 10:39AM Last Saved By: SWelch

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Kasper Heights Division 1

Site #8 - Conceptual Design Report

NE corner of the intersection at 275th Avenue NE and NE 140th Place
Duvall, WA 98019

SDA Project #374-001-16

Prepared for:

City of Duvall Public Works
14525 Main St NE
Duvall, WA 98019
(425) 788-3434

SDA

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1724 W. Marine View Drive, Suite 140, Everett, WA 98201 | 425.486.6533 | www.sdaengineers.com

Kasper Heights Division 1

Site #8 - Conceptual Design Report

Prepared For:

City of Duvall Public Works
14525 Main Street NE, Duvall , WA 98019
425-788-3434

City of Duvall Public Works
14525 Main St NE
Duvall, WA 98019
(425) 788-3434

Prepared By:

SDA
1724 West Marine View Drive, Ste 140
Everett, WA 98201
(425) 486-6533

TABLE OF CONTENTS

1. Executive Summary

This conceptual design report reviews options for improving stormwater mitigation for Kasper Heights Division 1.

The Kasper Heights Division 1 site is located in the NE ¼ of Section 24, Township 26 North, Range 6 East, W.M. More specifically, the plat is located at the northeast corner of the intersection at 275th Avenue NE and NE 140th Place. It occupies King County tax lot number 3793400420. A vicinity map has been included as Figure 1 following this section.

There is an existing stormwater pond and bioswale which serve Kasper Heights Division 1. The facility is owned and maintained by the City. The pond is located towards the southwest corner of the subdivision, north of NE 140th Place. The bioswale is located on the same parcel and serves a water quality function.

This conceptual report reviews options to add storage and water quality in the location of the existing Kasper Heights Division 1 pond. The ultimate drainage outfall for this facility, south of NE Big Rock Road and out of City limits, is known to have drainage complaints. The intent of this report is to show options that will help reduce burdens on downstream conveyance.

Facility Retrofit Opportunities and Efficiencies

This stormwater facility ranked eighth in the City's watershed based approach to improve stormwater management. Based on the age of the facility and 2016/2017 stormwater management standards, the opportunity to add water quality and increase detention volumes will protect and improve downstream systems. This project will incorporate a larger, deeper stormwater pond to comply with 2016 KCSWDM flow control and water quality standards as well as incorporating low impact development (LID) techniques. These LID approaches include but are not limited to: increased tree canopy coverage, and improving water quality components.

- Reduced peak flow and improved water quality to the Unnamed South Tributary - Lower watersheds and sensitive downstream conditions associated with the NE Big Rock Road drainage and drainage complaints within unincorporated King County south of City Limits.
- Incorporation of BMP T5.16: Tree Retention
- Incorporation of BMP T5.13: Post Construction Soil Quality and Depth
- Incorporation of BMP T10.40: Combined Detention and Wetpool Facilities

These reports are conceptual. All information should be verified as retrofit projects progress. SDA does not warranty information contained in these reports.

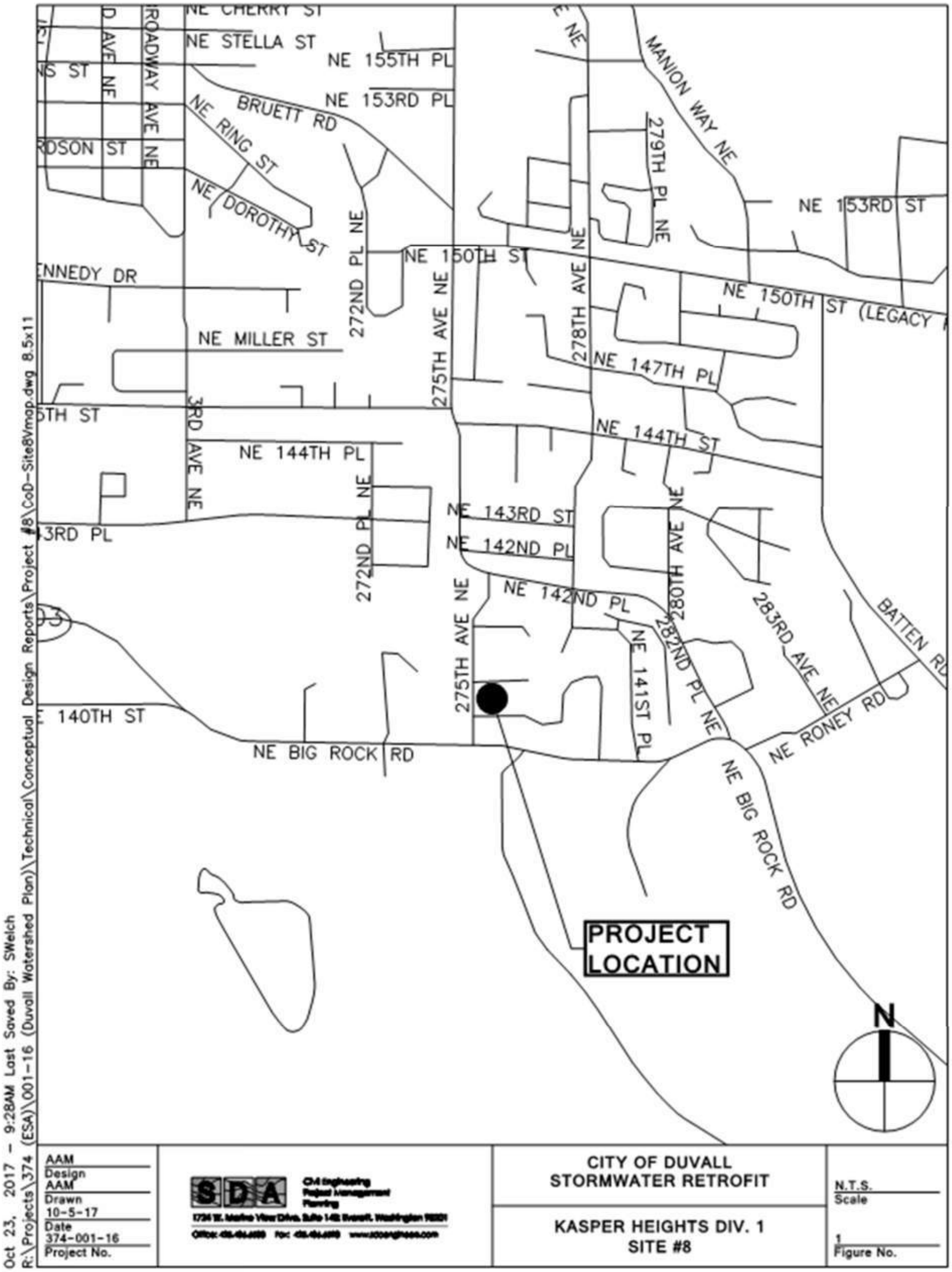


Figure 1: Vicinity Map

2. Basin Description

The Kasper Heights Division 1 facility serves 17.21 acres of developed area including 6.32 acres of impervious area and 10.89 acres of pervious area. Stormwater runs from the northeast to the southwest through a piped stormwater conveyance system. Once the stormwater outfalls the pond, it discharges into a bioswale. The bioswale then discharges into the stormwater conveyance system, which eventually flows west along NE Big Rock Road to a segmented conveyance network. The conveyance pipe crosses under NE Big Rock Road and drains south into a sensitive drainage area where previous drainage complaints have occurred. See Duvall Watershed Plan in Appendix C for a drainage basin area map.

3. Existing Conditions

Site Description

Division 1 of the Kasper Heights Development contains 40 lots totaling 17.21 acres. The site is bordered by residential developments to the north and east, farmland to the west, and NE Big Rock Road to the south.

Existing Facilities

Detention Pond & Biofiltration Swale Series

No drainage report was provided for the Kasper Heights development. Using the King County 2015 Aerial Imagery provided by the City, it was determined that the development consists of 6.32 acres of impervious area and 10.89 acres of pervious area. Approximately 17.21 acres drain to the detention pond, which then outfalls into a bioswale before leaving the site along NE Big Rock Road. See Duvall Watershed Plan in Appendix C for a basin area map.

The current Kasper Heights Division 1 flow control facilities mentioned above were recreated in MGSFlood using as-built drawings in order to identify whether the facilities meet 2016 KCSWDM flow control standards. See Appendix C for the Kasper Heights as-builts.

The existing pond volume is 37,058 cubic feet (cu-ft). This does not meet the volume required to comply with 2016 KCSWDM flow control standards. The flow duration plot in Figure 2 shows that none of the target thresholds are met with the available storage volume.

The complete MGSFlood report can be found in Appendix C as well as the Kasper Heights as-built drawings.

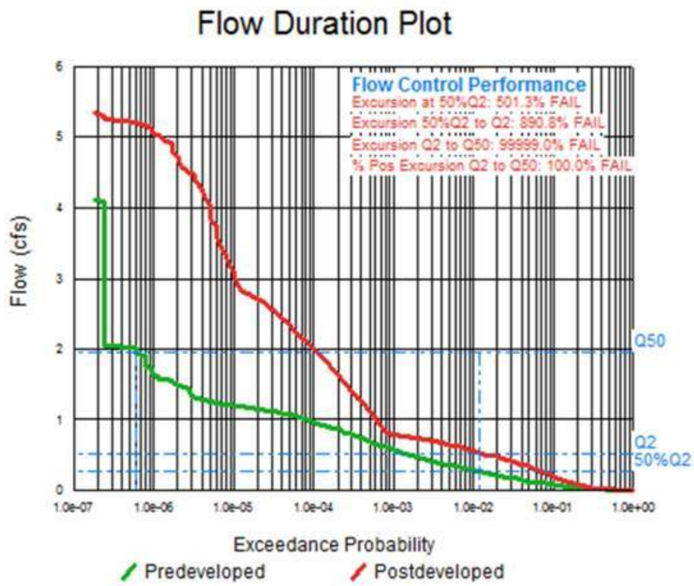


Figure 2: Current Detention Facility

4. Retrofit Alternatives Considered

Modification Option 1: Combined Flow Control and Water Quality Facility – 3:1 Slopes

A trapezoidal pond with bottom dimensions of 170 feet by 165 feet, a storage depth of 8 feet, and side slopes of 3:1 will meet 2016 KCSWDM flow control standards. The Flow Duration Plot for this proposed pond design can be seen in Figure 3.

The top of pond for this proposed pond design is 3 feet higher than the existing facility. The bottom of live storage is the same as the existing stormwater facility at an elevation of 301'. The required footprint discussed for this option will not fit in the available area. The largest top of pond size that would fit in the property limits is 150 feet by 105 feet. The complete MGSFlood report can be found in Appendix C.

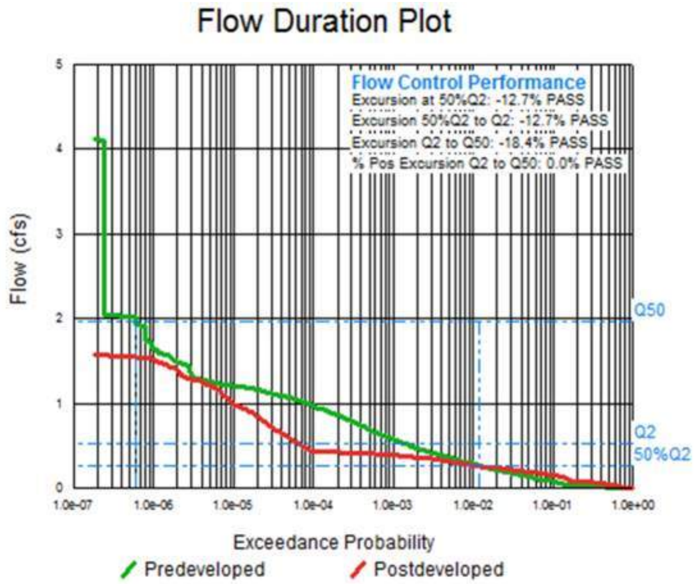


Figure 3: Modification Option 1: Combined Flow Control and Water Quality Facility – 3:1 Slopes

Modification Option 2: Maxed Out Combined Flow Control and Water Quality Facility – Pond Walls

The maximum dimensions for a proposed rectangular pond within the available area are: 150 feet by 105 feet, a storage depth of 8 feet, and pond walls. The top of pond for this proposed pond design is 3 feet higher than the existing facility, which would need to be accommodated by creating a berm around the facility. The required space to grade this berm will need to be confirmed. The bottom of live storage will remain the same as the existing stormwater facility at an elevation of 301'. This pond will not meet 2016 KCSWDM flow control standards, but it will provide significant improvements. The Flow Duration Plot for this proposed pond design can be seen below in Figure 4.

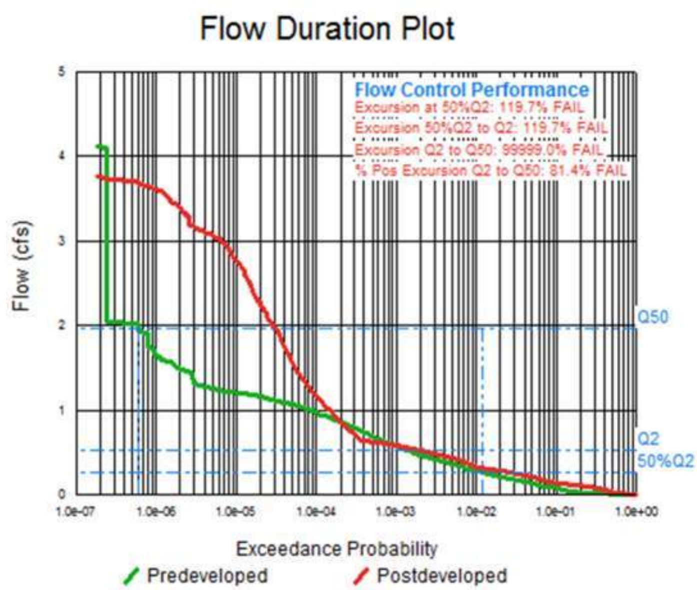


Figure 4: Modification Option 2: Maxed Out Combined Flow Control and Water Quality Facility with Walls

Comparison to Existing Facility

The proposed combined water quality and detention facility reduces impacts to the sensitive area downstream. Table 1 compares the release rates from the proposed stormwater facility during the 2, 10, and 100-year events to the current conditions.

Table 1: Comparison of Release Rates

Year of Event	Ex. Kasper Heights Flows (cfs)	Proposed Kasper Heights Combined Facility (cfs)	% of Release Reduction
2	0.955	0.451	53
10	2.576	1.398	46
100	5.135	3.418	33

5. Quantified Water Quality Benefit

A combined flow control and water quality facility incorporates a permanent pool of water (“wetpool”) below the flow control storage to settle particulate pollutants in the pond. According to the 2016 KCSWDM, “the basic wetpond volume is equal to 91% of the total runoff volume, as estimated by an approved continuous runoff model...” Using MGSFlood, the required wetpond volume was calculated to be 50,186 cu-ft. This can be seen in the complete MGSFlood report in Appendix C.

The following equation was used to calculate the wetpond depth for treatment:

$$h = \frac{V}{A} = \frac{50{,}186\ cf}{13{,}677\ sf} = 3.7'$$

Where: h = wetpool depth (ft)

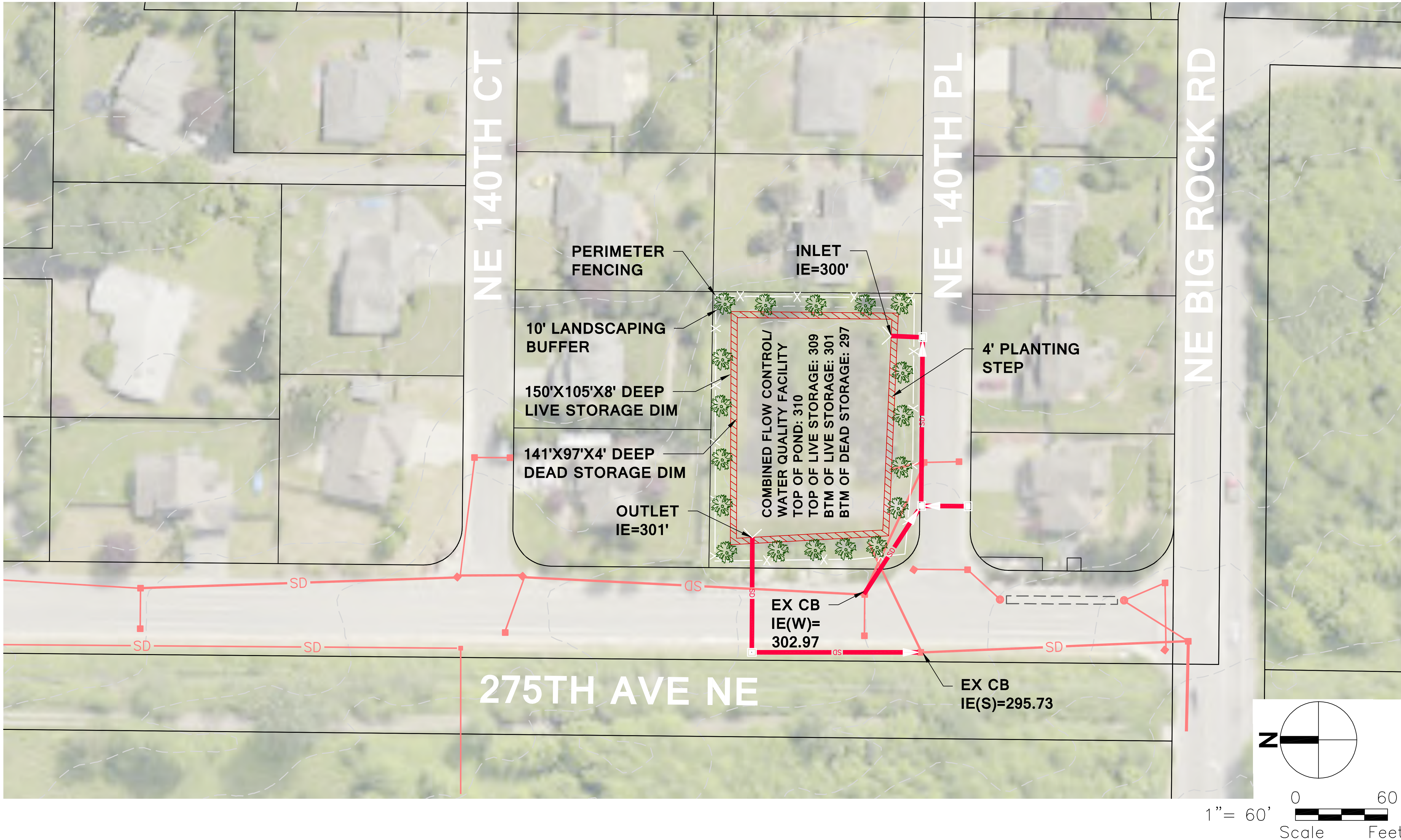
V = wetpond volume (cf) - 50,186 cf

A = bottom area of pond (sf) – 141’x97’ = 13,677 sf

The bottom area used for this calculation is based on the pond option that maximizes available area. The calculated water quality depth is 3.7 feet, but this depth would need to be increased to 4 feet to meet 2016 KCSWDM minimum depth for wetpool storage.

6. Summary

Meeting 2016 KCSWDM flow control standards would require a larger stormwater facility footprint than the available area allows. Maximizing the footprint and adding walls will increase available storage. Flow control targets and pond configurations should be reviewed with the City and regulators to determine a compromise that will improve flow control. Water quality storage can be designed with a walled pond to adequately meet 2016 KCSWDM requirements. See Figure 5 for a conceptual design.



SMW
Design
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Drawn
2017-12-14
Date
374-001-16
Project No.

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DUVALL WATERSHED PLAN
KASPER HEIGHTS DIV. 1

CONCEPTUAL DESIGN

Sheet: 5

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Cedarcrest High School - 1992 Pond

Site #9 - Conceptual Design Report

29000 NE 150th Street
Duvall, WA 98019

SDA Project #374-001-16

Prepared for:

City of Duvall Public Works
14525 Main St NE
Duvall, WA 98019
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Cedarcrest High School - 1992 Pond

Site #9 - Conceptual Design Report

Prepared For:

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Duvall, WA 98019
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TABLE OF CONTENTS

1. Executive Summary

This conceptual design report reviews options for improving the stormwater mitigation for a portion of the Cedarcrest High School site, which includes the track and football field, the parking lot east of the high school, the wetland area north of the high school, and the open space north of the track.

The Cedarcrest High School stormwater facility was constructed in 1992 is located in the SE ¼ of Section 18, Township 26 North, Range 7 East, W.M. More specifically, the site is located at 29000 NE 150th Street. It occupies King County tax lot number 1826079013. A vicinity map has been included as Figure 1 following this section.

The combined water quality and flow control facility was designed and built in 1992 during the construction of the high school. For the purposes of this analysis; the East pond was constructed in 1992, and altered in 2002 and 2012. According to the drainage report titled, "Hydraulics Report – Cedarcrest High School Phase 1" (1992), Basin C drains to the pond. While only the high school, a parking lot, and the pond were constructed in 1992, the pond was designed with future expansion in mind. The master plan for Basin C was intended to include 7.7 acres of impervious area and 6.8 acres of pervious area (14.5 acres in total). Using a series of grass lined swales, bordering the parking lot and along the east property line, the 14.5 acres drained from south to north to the East pond. The pond then discharged through a grass lined swale and level spreader to the north.

In 2002, the track and football field were constructed and the series of grass lined swales were removed and replaced with a piped stormwater conveyance system. The new piped system conveyed stormwater north to a new biofiltration swale, which then meandered north to the existing pond.

In 2012, Basin C was altered with a new parking lot and baseball field. This new addition drains to a new stormwater pond (to the west), and required the existing bioswale to be relocated. The 2012 bioswale became smaller and moved south of the East pond. The pond's control structure was also modified at this time.

A new residential development was built on the previously undeveloped property north of the high school property, creating the potential for downstream risk. This conceptual report reviews options to construct a new facility in the location of the East pond. The proposal would add storage, improve water quality, and relocate the discharge location to the northeast of the existing pond on School District property. The pond constructed in 2012 discharges at this location through an efficient dispersal/infiltration trench. A flow splitter structure could be used to route some flow to the existing discharge location.

Facility Retrofit Opportunities and Efficiencies

This stormwater facility ranked ninth in the City's watershed based approach to improve stormwater management. Based on the age of the facility and 2016/2017 stormwater management standards, the opportunity to add water quality and increase detention volumes will protect and improve downstream systems. This project may incorporate a deeper stormwater pond to comply with 2016 KCSWDM flow control and water quality standards as well as incorporating low impact development (LID) techniques. These LID approaches include but are not limited to: water quality and detention components with steep slopes, and improving existing dispersion/infiltration trench. This project will also include a public/public cooperation between the City and the Riverview School District.

- Reduced peak flow and improved water quality to steep slopes associated with the Cherry Creek C watersheds and sensitive downstream conditions associated with the Cherry Creek Tributary drainage.
- A partnership between the City and Riverview School District.
- Possible coordinated construction of a new outfall facility to improve dispersion and infiltration.
- Incorporation of BMP T7.20: Infiltration Trenches (depending on soil conditions).
- Incorporation of BMP T5.16: Tree Retention.
- Incorporation of BMP T5.13: Post Construction Soil Quality and Depth.
- Incorporation of BMP T10.40: Combined Detention and Wetpool Facilities

These reports are conceptual. All information should be verified as retrofit projects progress. SDA does not warranty information contained in these reports.

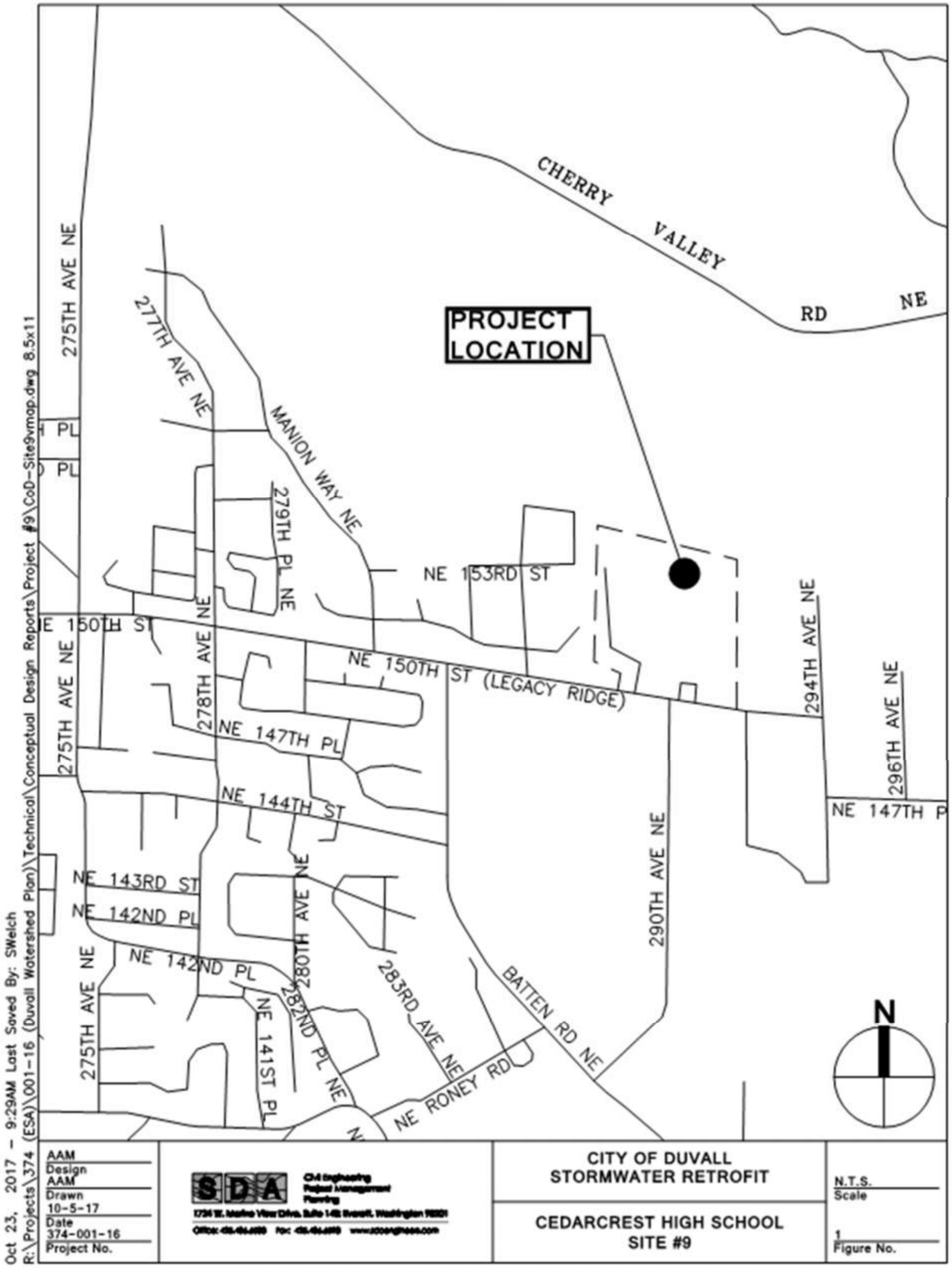


Figure 1: Vicinity Map

2. Basin Description

The Cedarcrest High School site currently has two combined water quality and flow control facilities. For the purposes of this analysis; the East pond is the facility proposed for upgrade. It was constructed in 1992, and altered in 2002 and 2012. The facility is described in Section 3 and manages stormwater from Basin C, described in the drainage report titled, "Hydraulics Report – Cedarcrest High School Phase 1" (1992). Stormwater from Basin C runs from the south to the north through a stormwater conveyance system, ultimately discharging to the East pond.

3. Existing Conditions

Site Description

The East pond combined water quality and flow control facility was designed and built in 1992 during the construction of the high school. According to the drainage report titled, "Hydraulics Report – Cedarcrest High School Phase 1" (1992), Basin C drains to the pond. While only the high school, a parking lot, and the pond were constructed in 1992, the pond was developed with future expansion in mind. The master plan for Basin C was intended to include 7.7 acres of impervious area and 6.8 acres of pervious area. Through the use of a series of grass lined swales, the 14.5 acres drained from the south toward the East pond. The pond was designed to discharge north to undeveloped property using a grass lined swale and flow spreader.

In 2002, the track and football field were constructed and the series of grass lined swales were removed and replaced with a piped stormwater conveyance system. The new piped system conveyed stormwater north to a new biofiltration swale, which then meandered to the East pond. The design report titled, "Supplemental Drainage Control Report" (2002) states that only 13.28 acres actually drain into the existing pond. The report from 2002 states that the pond was not actually constructed according to the 1992 plan set, so the pond size was modified in 2002 to accommodate the minimum volume of 98,322 cubic feet (cu-ft) per the 1992 drainage design. A 30 percent safety factor was added to the resulting volume in 2002.

In 2012, Basin C was altered with a new parking lot and baseball field. This new addition drains to a new stormwater pond (to the west), and required the existing bioswale to be relocated. The 2012 bioswale became smaller and moved south of the East pond. The pond's control structure was also modified at this time.

A new residential development (North Hill) was built on the previously undeveloped property north of the School District property, which moved the outfall from the East pond to the northwest and incorporated a dispersion/infiltration trench. This conceptual report reviews options to add storage, water quality, and possibly improve and expand the re-located dispersion/infiltration trench. The new pond constructed in 2012 discharges to a larger dispersion/infiltration trench to the northeast.

The drainage basin map, portion of the 2002 drainage report from 1992, and as-built information can be found in Appendix D.

Existing Facilities

East Pond

According to the design report titled, "Hydraulics Report – Cedarcrest High School Phase 1" (1992), the East pond serves Basin C which includes 14.5 acres of developed area consisting of 7.7 acres of impervious area and 6.8 acres of pervious area. The design report titled, "Supplemental Drainage Control Report" (2002) states that only 13.28 acres actually drain into the existing pond. The report from 2002 states that the pond was not actually constructed according to the 1992 plan set, so the pond size was modified in 2002 to accommodate the minimum volume of 98,322 cu-ft per the 1992 drainage design. A 30 percent safety factor was added to the resulting volume in 2002.

While the drainage reports stated that the pond served 14.5 acres and 13.28 acres, aerial imagery and contours produced from LIDAR were used to delineate the existing pond drainage basin areas. It was determined that the existing pond serves 12.20 acres, consisting of 7.84 acres of pervious area and 4.36 acres of impervious area. With the alterations in 2002 and 2012, the 1992 Master Plan for Basin C no longer applied. The second combined stormwater facility built in 2012 reduced the drainage area of Basin C. For this reason, delineations were performed to calculate the more representative basin areas. These areas should be verified as this retrofit option progresses. These areas were used in the MGSFlood models.

The current Cedarcrest High School East pond configuration was recreated in MGSFlood in order to identify whether the facility could meet current flow control standards. The existing pond volume is 98,361 cu-ft and does not meet the volume required to comply with the 2016 KCSWDM standards.

See Duvall Watershed Plan in Appendix D for a basin area map, as well as the complete MGSFlood report.

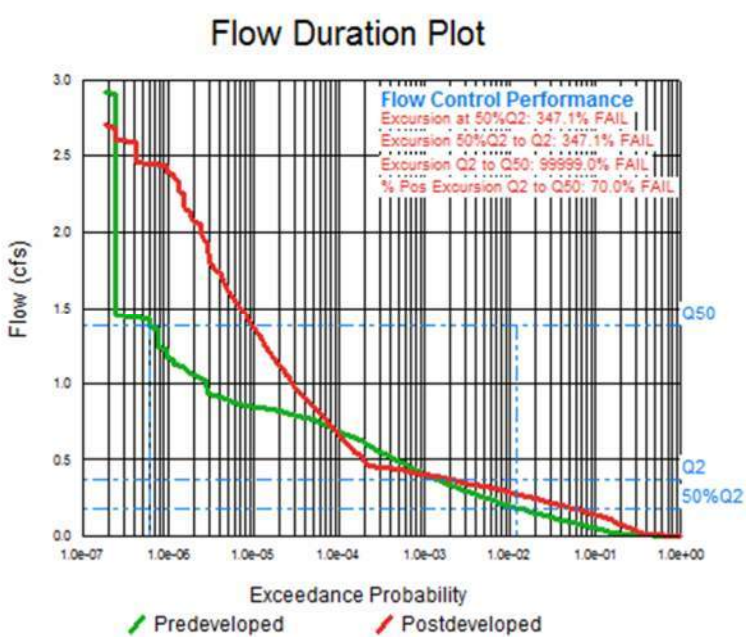


Figure 2: Current Detention Facility

4. Retrofit Alternatives Considered

Modification Option: Proposed Combined Flow Control and Water Quality Facility

As seen in the existing conditions Flow Duration Plot shown in Figure 2, a larger facility is required to accommodate the Cedarcrest High School site. A proposed rectangular pond with dimensions of: 250 feet by 125 feet, a storage depth of 6 feet, and pond walls, will meet 2016 KCSWDM flow control standards. The Flow Duration Plot for this proposed pond design is shown in Figure 3. This pond fit within the available area, but the flow control portion is 2 feet deeper than the existing facility. The existing outfall pipe runs at higher than minimum slope and it appears that it can be re-built to accommodate the additional required storage depth. The control structure would need to be reconstructed with the proposed pond design. This design would still require some alterations to the north outfall system.

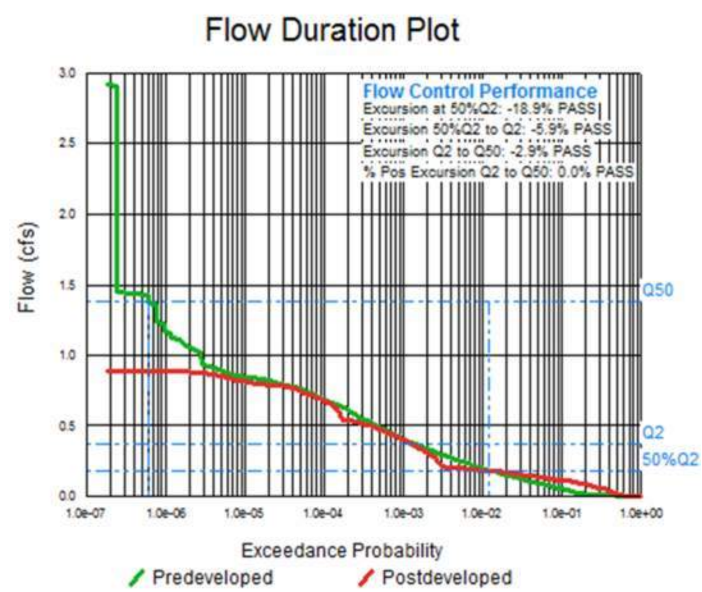


Figure 3: Modification Option 2: Proposed Combined Flow Control and Water Quality Facility - Walls

5. Quantified Water Quality Benefit

A combined flow control and water quality facility incorporates a permanent pool of water below the flow control storage (a "wetpool") to settle particulate pollutants in the pond. According to the 2016 KCSWDM, "the basic wetpond volume is equal to the 91% water quality treatment volume." Using MGSFlood, the wetpond volume was calculated to be 35,106 cu-ft. This can be seen in the MGSFlood report in Appendix D. The following equation was used in calculating the wetpool depth:

$$h = \frac{V}{A} = \frac{35{,}106\ cf}{28{,}314\ sf} = 1.2'$$

Where: h = wetpool depth (ft)

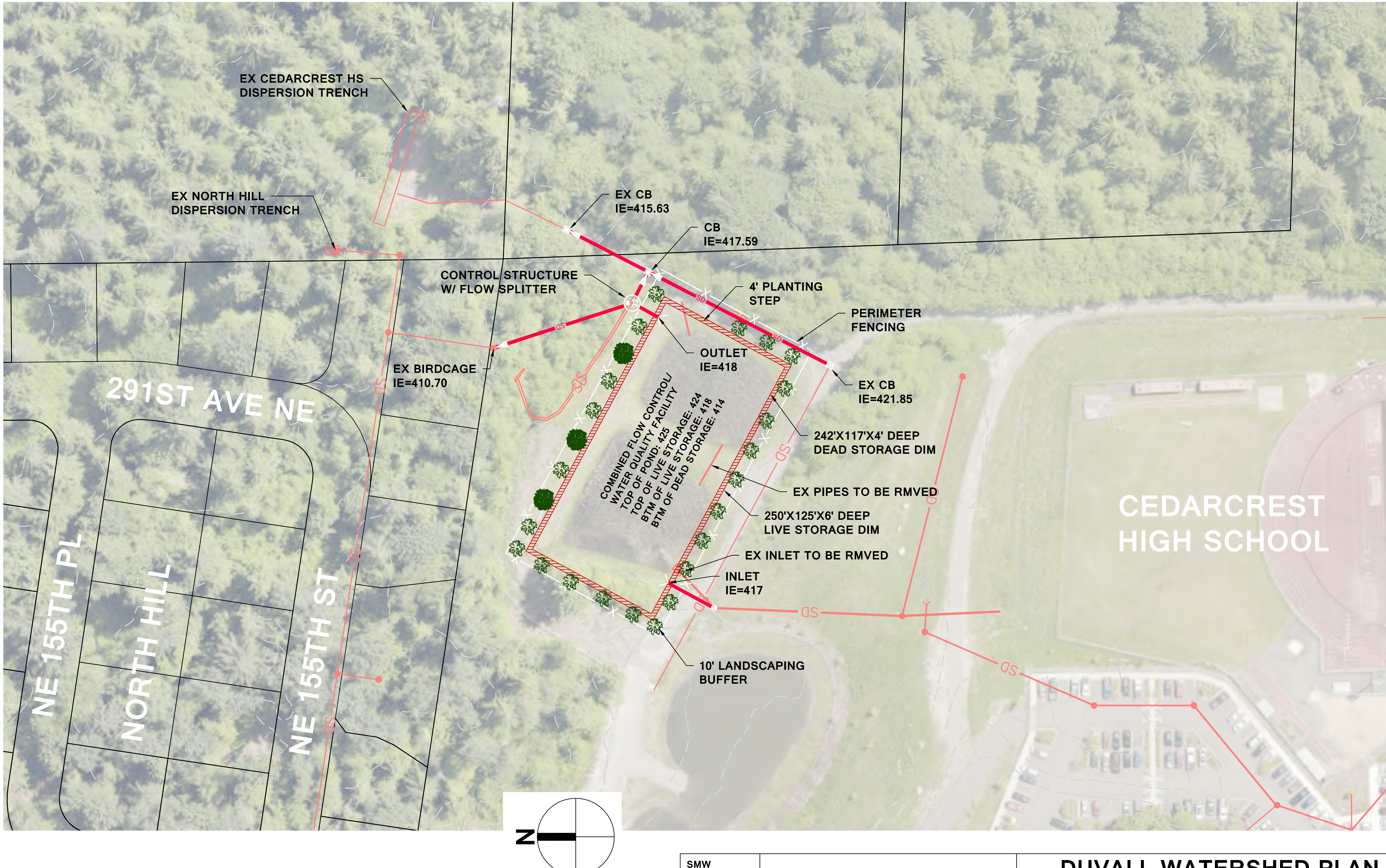
V = wetpond volume (cf) - 15, 099 cf

A = bottom area of pond (sf) – 242' x 117' = 28,314 sf

The bottom area used in this calculation is based on the required 4’ landscaping step. The top of pond area was offset 4’, providing a bottom of pond area of 242’ by 117’. The calculated water quality depth is 1.2 feet, but this depth would need to be increased to 4 feet to meet 2106 KCSWDM minimum depth for wetpool storage.

6. Summary

The proposed stormwater facility with walls will meet 2016 KCSWDM flow control and water quality standards while also fitting on the available property. Using a flow splitter structure to discharge flows from the East pond between the two dispersal/infiltration trenches is possible. The flow splitter will direct the lower event flows to the North Hill dispersion/infiltration trench and the higher event flows to the high school’s dispersion/infiltration trench. Currently water ponds around the North Hill trench when a heavy rainstorm events occurs. Since this proposal will increase the amount of water that flows to the dispersion/infiltration trench at lower events, modifications will be made to the North Hill dispersion/infiltration trench at final design. The high school’s dispersion/infiltration trench is currently working and will require no alterations. See Figure 4 for a conceptual design.



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SMW Design AAM Drawn 2017-10-24 Date 374-001-16 Project No.	SDA Civil Engineering Project Management Planning 1724 W. Marine View Drive, Suite 140; Everett, Washington 98201 Office: 425.486.6533 Fax: 425.486.6593 www.sdaengineers.com	**DUVALL WATERSHED PLAN** **CEDARCREST HIGH SCHOOL** CONCEPTUAL DESIGN	Sheet: 4

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Cherry Valley Vista

Site #21 - Conceptual Design Report

NE corner of the intersection of 270th Place NE and NE Rupard Road
Duvall, WA 98019

SDA Project #374-001-16

Prepared for:

City of Duvall Public Works
14525 Main St NE
Duvall, WA 98019
(425) 788-3434

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Cherry Valley Vista

Site #21 - Conceptual Design Report

Prepared For:

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(425) 788-3434

Prepared By:

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TABLE OF CONTENTS

1. Executive Summary

This conceptual design report reviews options for improving stormwater mitigation for Cherry Valley Vista. There is also the potential for mitigation or replacement of the 24" cross-culvert beneath NE Rupard Road which conveys a tributary to Cherry Creek.

The Cherry Valley Vista stormwater facility is located in the NE ¼ of Section 13, Township 26 North, Range 6 East, W.M. More specifically, the plat is located at the northeast corner of the intersection of 270th Place NE and NE Rupard Road. It occupies King County tax lot number 1558500320. A vicinity map has been included as Figure 1 following this section.

The existing stormwater biofiltration swale that serves the Cherry Valley Vista development is owned and maintained by the City of Duvall. The bioswale is located on the north side of the subdivision, near the corner of 270th Place NE and NE Rupard Road. There are also two detention pipes that run east to west and are located in NE Rupard Road. According to the City, the existing bioswale is no longer established or functioning. The existing detention pipes provide little storage capacity. For these reasons, there are significant water quality and flow control impacts downstream during the wet season. This conceptual report reviews options to add storage and water quality using a new combined detention and water quality pond.

Facility Retrofit Opportunities and Efficiencies

This stormwater facility ranked twenty-one in the City's watershed based approach to improve stormwater management. Based on the age of the facility and significant changes to stormwater management standards, the opportunity to add flow control and water quality features will protect and improve downstream systems. This project will incorporate a new combined stormwater quality and flow control pond to comply with 2016 KCSWDM flow control and water quality standards. LID techniques will also be incorporated where possible. These LID approaches include but are not limited to: water quality and detention components. The project will review the potential to improve fish passage by upgrading the culvert crossing NE Rupard Road.

- Improved water quality to the Cherry Creek A watersheds and sensitive downstream conditions associated with the tributary of the Cherry Valley Creek drainage.
- Possible coordinated construction and mitigation with the Rupert Road culvert fish passage barrier.
- Incorporation of BMP T7.30: Bioretention Cells
- Incorporation of BMP T5.16: Tree Retention
- Incorporation of BMP T5.13: Post Construction Soil Quality and Depth

These reports are conceptual. All information should be verified as retrofit projects progress. SDA does not warranty information contained in these reports.

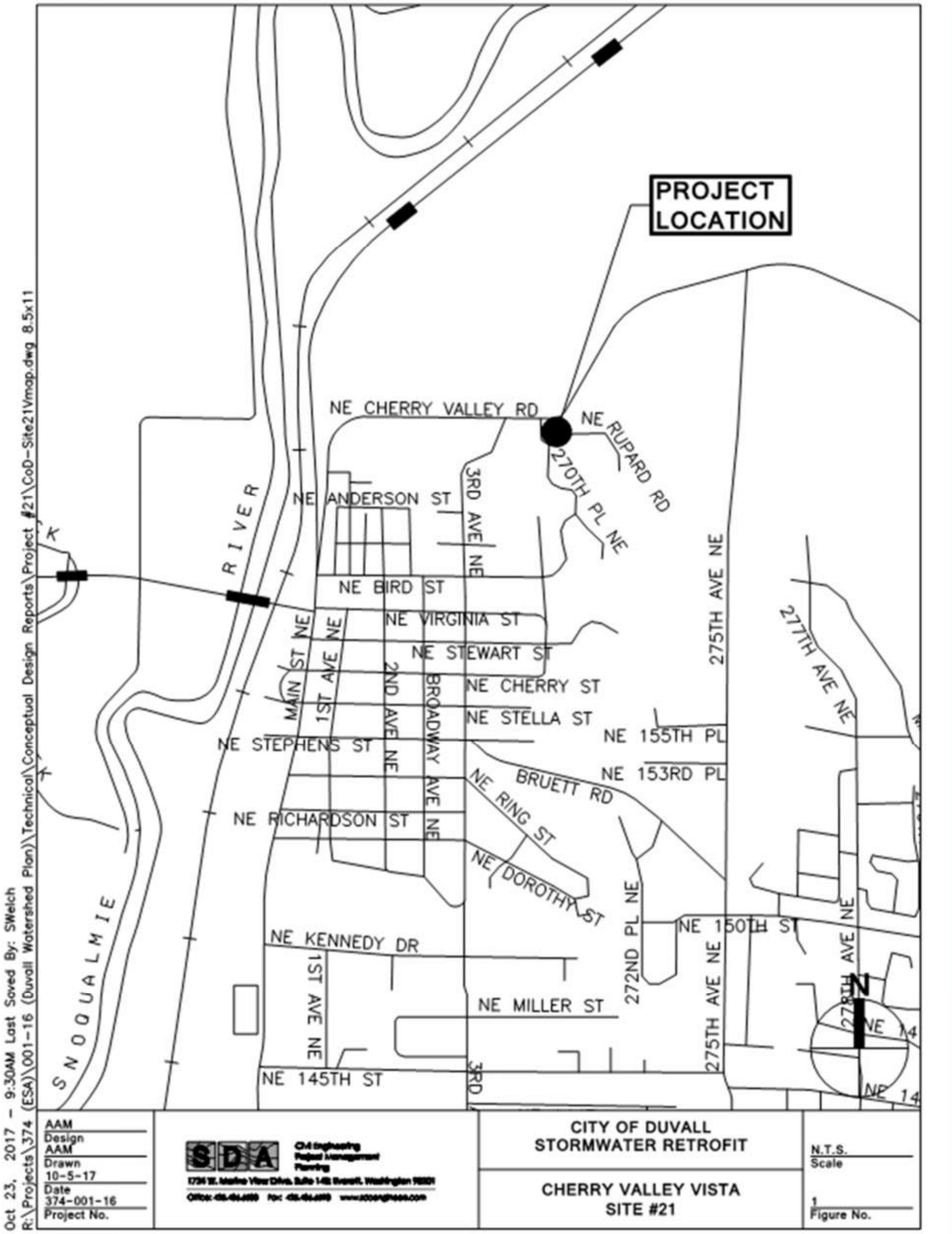

Figure 1: Vicinity Map

2. Basin Description

The bioswale and detention pipes for Cherry Valley Vista have a drainage basin of 6.72 acres of developed area consisting of 4.17 acres of pervious area and 2.55 acres of impervious area. Stormwater generally runs from the south to the north and discharges into the two parallel detention pipes located in NE Rupard Road. These pipes then drain to a bioswale area located at the intersection of 270th Place NE and NE Rupard Road. East of the bioswale is a wetland, which is designated as Wetland A in the survey performed on December 2017. Wetland A and the existing bioswale were intended to discharge to a culvert to the north. This culvert runs under NE Cherry Valley Road and outfalls directly to the floodplain north of the road.

3. Existing Conditions

Site Description

Cherry Valley Vista consists of 30 lots, totaling a drainage basin of 6.72 acres. The site is bordered by residential areas to the west and south, NE Cherry Valley Road to the north, and a forested area to the east.

Cherry Valley Vista drains to a series of stormwater components including a pair of parallel detention pipes, a bioswale, and a culvert. The detention pipes are located in the NE Rupard Road right-of-way, the culvert is under NE Rupard Road, and the bioswale is in the King County parcel at the intersection of 270th Place NE and NE Rupard Road.

Existing Facilities

According to the design report titled, "Drainage Report for Cherry Valley Vista" (1995), there are two basins on the property – Basins A and B. See "Figure: Post Development Conditions" in Appendix E for Basin locations. There are two 8-foot diameter x 80' long detention pipes in NE Rupard Road. These detention pipes mitigate stormwater from Basin A and B and were then intended to outfall to the biofiltration swale before discharging off site. The bioswale does not appear to function.

Current Detention Facility

Cherry Valley Vista currently contains two 80' long detention pipes that run parallel to each other in NE Rupard Road. This configuration was recreated in WWHM2012 using the information in the drainage report titled, "Drainage Report for Cherry Valley Vista" and the Cherry Valley Vista as builts. The basins and facility were modelled in WWHM2012 to determine whether the facility meets current flow control standards. The detention pipe information from the drainage report can be found in Appendix E. See Analysis of Minimum Requirements, Core Requirement #3 in the title page for the flow control requirements.

The two detention pipes do not meet the flow control requirements in the 2016 KCSWDM. The flow duration plot can be seen in Figure 2 and the WWHM2012 report can be found in Appendix E.

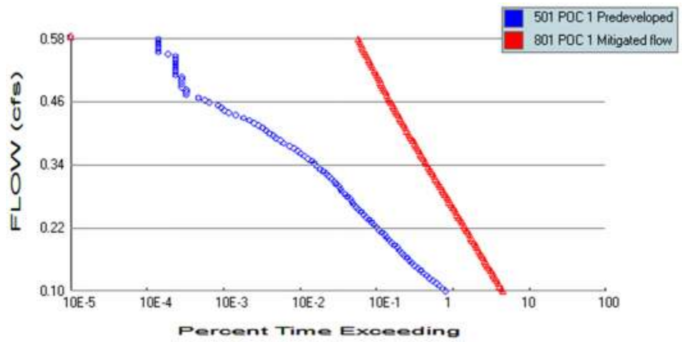

Figure 2: Current Detention Facility

4. Retrofit Alternatives Considered

Modification Option 1: Deeper Combined Flow Control and Water Quality Facility

As seen in Figure 2, a larger facility is required to accommodate both basins in the Cherry Valley Vista plat. A proposed rectangular pond, 159 feet by 90 feet with a storage depth of 5.75 feet and pond walls in conjunction with the existing detention pipes will meet the current flow control standards. The Flow Duration Plot for this proposed system can be seen in Figure 3. This pond footprint would not fit at the intersection of 270th Place NE and NE Rupard Road. Even with the removal of the existing biofiltration swale, the footprint would not be large enough for the new combined water quality and flow control facility.

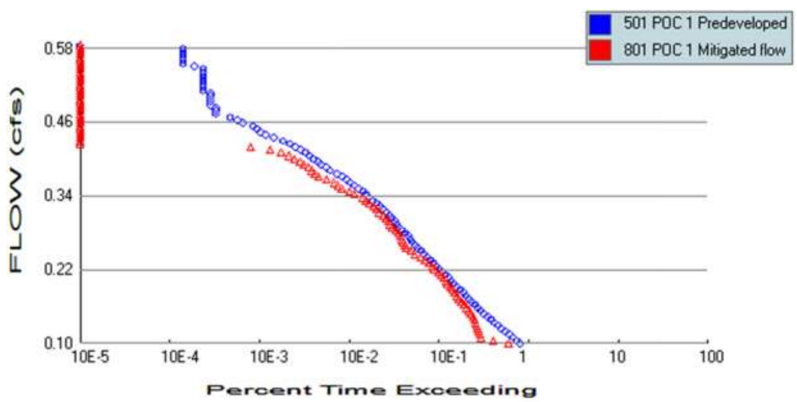

Figure 3: Modification Option 1: Deeper Combined Flow Control and Water Quality Facility

Modification Option 2: Proposed Combined Flow Control and Water Quality Facility – Maximize Footprint and Walls

A proposed rectangular pond 100 feet by 78 feet with a storage depth of 5.75 feet and pond walls in conjunction with the existing detention pipes will fit within the available area, but it will not meet the 2016 KCSWDM flow control standards. Sensitive areas were found on the available area and will require further investigation to determine feasibility of constructing this system. The Flow Duration Plot for this proposed system can be seen in Figure 4. The WWHM2012 report can be found in Appendix E.

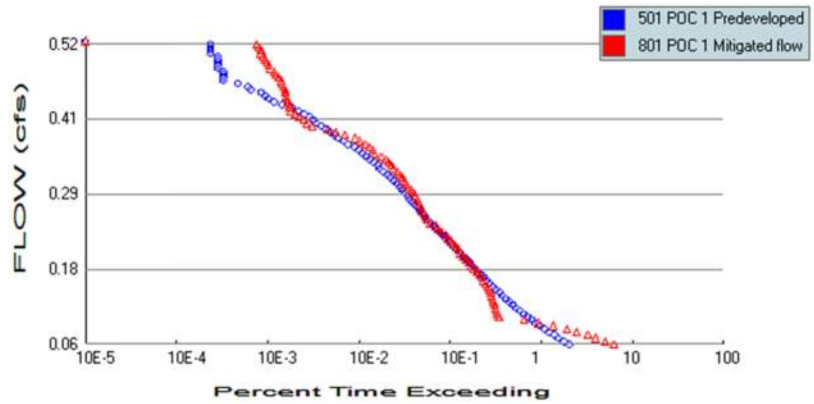

Figure 4: Proposed Combined Flow Control and Water Quality Facility – Maximize Footprint and Walls

Comparison to Existing Facility

In order to ensure the proposed combined water quality and detention facility reduces impacts to the sensitive area downstream, the existing and proposed flows were compared. Table 1 compares the combined release rates from the Cherry Valley Vista detention pipes to the proposed water quality and detention facility's release rates.

Table 1: Comparison of Release Rates

Year of Event	Ex. CVV Det. Pipes (cfs)	Proposed CVV Combined Facility (cfs)	% of Release Reduction
2	0.7393	0.1295	82
10	1.4122	0.2945	79
100	2.7485	0.6530	76

As seen in Table 1, the release rates for the proposed facility provide significant reduction of flow rates compared to the existing facilities.

5. Quantified Water Quality Benefit

A combined flow control and water quality facility incorporates a permanent pool of water below the flow control storage (a "wetpool") to settle particulate pollutants in the pond. According to the 2016 KCSWDM, "the basic wetpond volume is equal to the 91% water quality treatment volume." Using WWHM2012, the wetpond volumes for each facility option were calculated to be 0.1856 ac-ft. These can be seen in the WWHM2012 reports in Appendix E. The following equation was used in calculating the wetpool depths:

$$h = \frac{V}{A} = \ 0.1856\ ac.ftx\frac{43560\ cf}{1\ \text{ac. ft}}x\frac{1}{6{,}468\ sf} = 1.25'$$

Where: h = wetpool depth (ft)

V = wetpond volume (ac.ft) - 0.1856 ac-ft

A = bottom area of pond (sf) – 98' x 66' = 6,468 sf

A 4' minimum of wetpool is required according to the 2106 KCSWDM standards.

6. Summary

Meeting 2016 KCSWDM flow control standards requires a larger stormwater facility footprint than the allotted area allows. The addition of walls will increase storage within the available footprint. Modification Option 2 does not meet flow control standards, but reduces flow to downstream sensitive areas. It represents the most feasible solution to improving flow control. Alternative flow control targets and pond configurations should be reviewed with the City and regulators with the goal of improving flow control. Modification Option 2 provides adequate water quality storage by using walls rather than traditional side slopes. See Figure 5 for a conceptual design. Other options would likely require additional area which may not be feasible at this site. Sensitive areas in the proposed retrofit site may further limit available area. Further feasibility is required for this site.

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FOR: CHERRY VALLEY VISTA
JOB NO. 91021
PAGE 1 OF
PREPARED BY: HMD
DATE: 2/2/94
CHECKED BY:
SCALE:

PRE-DEVELOPED CONDITIONS

DEVELOPMENT AREA A - AREA WEST OF RAVINE

[redacted]

T_c

REACH 1

300 LF OF SHEET FLOW OVER FOREST FLOOR, $\Delta EL = 40'$

$L = 300$ FT $\quad P_2 = 2.10$

$S = 0.1333 \quad n_s = 0.40$ (TABLE 3.5.2C, KCSWDM)

FOR SHEET FLOW $$T_1 = \frac{0.42\left[(n_s)(L)\right]^{0.8}}{P_2^{0.5}\ S^{0.4}}$$

$$T_1 = \frac{(0.42)\left[(0.40)(300)\right]^{0.8}}{(2.10)^{0.5}\ (0.1333)^{0.4}} = 28.9 \text{ MIN}$$

REACH 2

[redacted]

$L = 280$ FT

$S = 0.179$

$k = 3$ FOREST (TABLE 3.5.2C KCSWDM)

$$V_2 = k\sqrt{S} = 3\sqrt{0.179} = 1.3 \text{ FT/SEC}$$

$$T_2 = \frac{L}{60V} = \frac{280\text{ FT}}{(60)(1.3\text{ FT})} = 3.6 \text{ MIN}$$

$$T_c = T_1 + T_2 = 32.5 \text{ MIN}$$

CURVE NUMBER

1.55 AC 2^{ND} GROWTH OVER TYPE C SOIL CN = 81

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PRE-DEVELOPED CONDITIONS (CONT)

DEVELOPMENT AREA A - AREA WEST OF RAVINE (CONT)

ON-SITE AREA

T_c

REACH 1

300 LF SHEET FLOW OVER FOREST FLOOR, ΔEL = 46 FT

$L = 300$ $P_2 = 2.10$
$S = 0.1533$ $n_s = 0.40$ (TABLE 3.5.2C KCSWDM)

$$T_1 = \frac{(0.42)\left[(0.40)(300)\right]^{0.8}}{(2.1)^{0.5}(0.1533)^{0.4}} = 28.3 \text{ MIN}$$

REACH 2

490 LF SHALLOW CONC. FLOW OVER FOREST FLOOR, ΔEL = 88 FT
$L = 490$ FT
$S = 0.1796$
$k = 3$ FOREST (TABLE 3.5.2C KCSWDM)

$$T_2 = \frac{490}{(60)(3)\sqrt{0.1796}} = 6.4 \text{ MIN}$$

$$T_c = 28.3 + 6.4 = 34.7 \text{ MIN.}$$

CURVE NUMBER

4.16 AC 2ND GROWTH BRUSH OVER TYPE C SOIL CN = 81
1.00 AC GRASS & BRUSH OVER TYPE C SOIL CN = 89

$$\overline{CN} = \frac{(81)(4.16\text{AC}) + (89)(1.00\text{AC})}{5.16\text{AC}} = 82.55$$

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PRE-DEVELOPED CONDITIONS (CONT.)

DEVELOPMENT AREA B - AREA EAST OF RAVINE

UPSTREAM CONTRIBUTORY AREA (OFF-SITE)

T_c

REACH 1

300 LF SHEET FLOW OVER FOREST FLOOR
ΔEL = 32 FT

L = 300 FT $P_2 = 2.10$
S = 0.1067 $n_s = 0.40$ (TABLE 3.5.2C KCSWDM)

$$T_1 = \frac{(0.42)\left[(0.40)(300)\right]^{0.8}}{(2.10)^{0.5}(0.1067)^{0.4}} = 32.7 \text{ MIN}$$

REACH 2

900 LF SHALLOW CONC FLOW OVER FOREST FLOOR ΔEL = 117 FT

L = 900
S = 0.1300
k = 3   FOREST   (TABLE 3.5.2C KCSWDM)

$$V_2 = 3\sqrt{0.13} = 1.08$$

$$T_2 = \frac{900}{(60)(1.08)} = 13.9 \text{ MIN}$$

$$T_c = T_1 + T_2 = 46.6 \text{ MIN}$$

CURVE NUMBER

1.77 AC   GRASS & BRUSH OVER TYPE C SOIL   CN = 89
4.69 AC   2ND GROWTH OVER TYPE C SOIL   CN = 81

$$\overline{CN} = \frac{(1.77)(89) + (4.69)(81)}{(1.77 + 4.69)} = 83.2$$

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PRE-DEVELOPED CONDITIONS (CONT.)

DEVELOPMENT AREA B (CONT.)

ON-SITE AREA

T_c

REACH 1

300 LF SHEET FLOW OVER FOREST FLOOR; ΔEL = 55'

L = 300 P_2 = 2.10
S = 0.1833 n_s = 0.40 (TABLE 3.5.2C KCSWDM)

$$T_1 = \frac{(0.42)\left[(0.40)(300)\right]^{0.8}}{(2.10)^{0.5}(0.1833)^{0.4}} = 26.3 \text{ MIN}$$

REACH 2

110 LF SHALLOW CONCENTRATED FLOW OVER FOREST FLOOR.
ΔEL = 35'

L = 110
S = 0.3182
k = 3 FOREST (TABLE 3.5.2 C KCSWDM)

$$V_2 = 3\sqrt{0.3182} = 1.7 \text{ FT/SEC}$$

$$T_2 = \frac{(110)}{(60)(1.7)} = 1.1 \text{ MIN}$$

REACH 3

250 LF CHANNEL FLOW IN GRAVEL BOTTOM SREAM
ΔEL = 24 FT

L = 250, S = 0.0960, k = 27

$$V_3 = 27\sqrt{0.0960} = 8.4$$

$$T_3 = \frac{250}{(60)(8.4)} = 0.5 \text{ MIN}$$

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PRE-DEVELOPED CONDITIONS (CONT.)

DEVELOPMENT AREA B (CONT.)

ON-SITE AREA (CONT.)

T_c (CONT.)

$T_c = T_1 + T_2 + T_3 = 27.9$ MIN.

CURVE NUMBER

1.56 AC 2ND GROWTH OVER TYPE C SOIL. CN = 81.

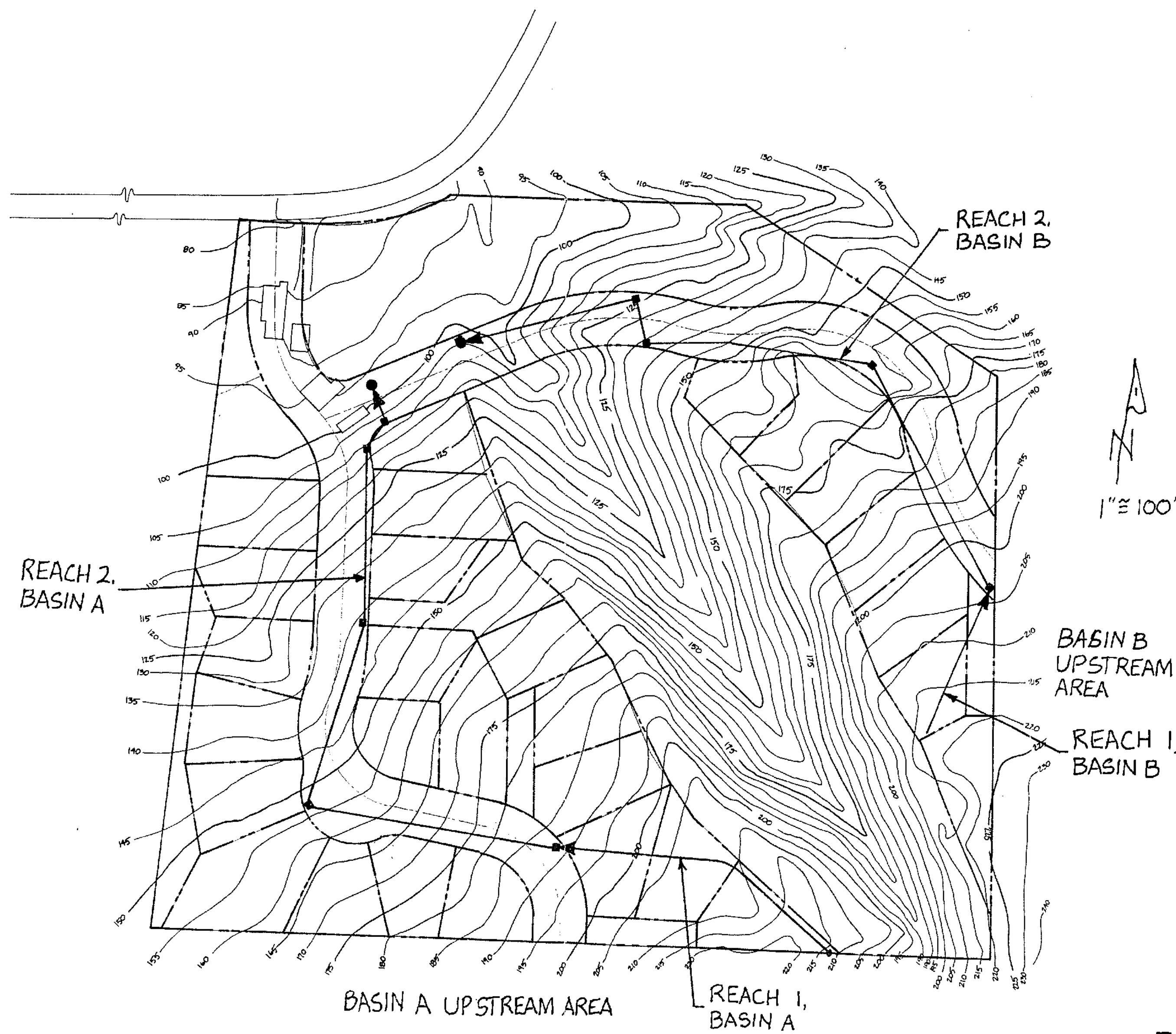

FIG POST-DEV. COND'NS

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POST-DEVELOPMENT CONDITIONS

DEVELOPMENT AREA A

ON-SITE AREA

T_c

REACH 1

150 LF SHEET FLOW ACROSS LAWNS
$\Delta EL = 20$ FT

$L = 150$ $\qquad P_2 = 2.10$
$S = 0.1333$ $\qquad n_s = 0.15$

$$T_1 = \frac{(0.42)\left[(0.15)(150)\right]^{0.8}}{(2.10)^{0.5}(0.1333)^{0.4}} = 7.8 \text{ MIN}$$

REACH 2

550 LF OF PIPE FLOW

ASSUME V = 10 FT/SEC

$$T_2 = \frac{550 \text{ LF}}{(60)(10)} = 0.9 \text{ MIN}$$

CURVE NUMBER $\qquad T_c = 7.8 + 0.9 = 8.7$

3.5 DU/GA RESIDENTIAL DEVELOPMENT = 38% IMPERVIOUS

(5.16 AC TOTAL ON-SITE)(0.38) = 1.96 AC IMPERVIOUS
∴ 3.20 AC PERVIOUS

IMPERVIOUS AREA CN = 98
PERVIOUS AREA CN = 86 LANDSCAPING OVER TYPE C SOIL

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POST-DEVELOPED CONDITIONS (CONT)

DEVELOPMENT AREA B (CONT.)

ON-SITE AREA

Tc

REACH 1

150 LF SHEET FLOW OVER LANDSCAPING
$\Delta EL = 10$ FT

$L = 150$ FT $P_2 = 2.10$
$S = 0.0667$ $n_s = 0.15$ (TABLE 3.5.2C, KCSWDM)

$$T_1 = \frac{(0.42)[(0.15)(150)]^{0.8}}{(2.10)^{0.5}(0.0667)^{0.4}} = 10.3 \text{ MIN}$$

REACH 2

600 LF PIPE FLOW

ASSUME V = 10 FT/SEC

$$T_2 = \frac{600 \text{ FT}}{(60)(10)} = 1.0 \text{ MIN}$$

$$T_c = T_1 + T_2 = 11.3 \text{ MIN}$$

CURVE NUMBER

3.5 DU/AC → 38% IMPERVIOUS

(1.56 AC)(0.38) = 0.59 ACRES IMPERVIOUS
∴ 0.97 ACRES PERVIOUS

IMPERVIOUS AREA CN = 98
PERVIOUS AREA CN = 86 LANDSCAPING OVER TYPE C.

As-Built Detention Pipe Calculations

Hydrologic Analysis
93073

STAGE STORAGE TABLE

UNDERGROUND PIPE ID No. pipe (DETENTION TANK)
Description: p1
Diameter: 8.00 ft. Length: 160.00 ft.
Slope...: 0.0000 ft/ft

STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-
94.50	0.0000	0.0000	96.60	1684	0.0387	98.70	1855	0.0426	100.80	4583	0.1052
94.60	19.011	0.0004	96.70	1798	0.0413	98.80	1962	0.0450	100.90	4738	0.1088
94.70	53.562	0.0012	96.80	1913	0.0439	98.90	2068	0.0475	101.00	4896	0.1124
94.80	98.018	0.0023	96.90	2029	0.0466	99.00	2179	0.0500	101.10	5057	0.1161
94.90	150.34	0.0035	97.00	2147	0.0493	99.10	2292	0.0526	101.20	5219	0.1198
95.00	209.28	0.0048	97.10	2267	0.0520	99.20	2407	0.0553	101.30	5384	0.1236
95.10	274.05	0.0063	97.20	2387	0.0548	99.30	2525	0.0580	101.40	5552	0.1274
95.20	343.97	0.0079	97.30	2509	0.0576	99.40	2645	0.0607	101.50	5722	0.1313
95.30	418.57	0.0096	97.40	2631	0.0604	99.50	2768	0.0635	101.60	5894	0.1353
95.40	497.44	0.0114	97.50	2755	0.0632	99.60	2894	0.0664	101.70	6070	0.1393
95.50	580.26	0.0133	97.60	2879	0.0661	99.70	3021	0.0694	101.80	6249	0.1434
95.60	666.65	0.0153	97.70	3004	0.0690	99.80	3152	0.0723	101.90	6431	0.1476
95.70	756.46	0.0174	97.80	3130	0.0718	99.90	3284	0.0754	102.00	6618	0.1519
95.80	849.43	0.0195	97.90	3256	0.0748	100.00	3419	0.0785	102.10	6810	0.1563
95.90	945.26	0.0217	98.00	3383	0.0777	100.10	3557	0.0816	102.20	7009	0.1609
96.00	1044	0.0240	98.10	3510	0.0806	100.20	3696	0.0849	102.30	7220	0.1657
96.10	1145	0.0263	98.20	3637	0.0835	100.30	3838	0.0881	102.40	7453	0.1711
96.20	1249	0.0287	98.30	3766	0.0865	100.40	3982	0.0914	102.50	7837	0.1799
96.30	1354	0.0311	98.40	3892	0.0893	100.50	4129	0.0948	102.50	8042	0.1846
96.40	1462	0.0336	98.50	4021	0.0923	100.60	4278	0.0982			
96.50	1572	0.0361	98.60	1755	0.0403	100.70	4429	0.1017			

Hydrologic Analysis
93073

STAGE DISCHARGE TABLE

MULTIPLE ORIFICE ID No. or1 (FROP TEE)
Description:
Outlet Elev: 94.50
Elev: 92.50 ft Orifice Diameter: 2.9297 in. USE 2 7/8"
Elev: 101.30 ft Orifice 2 Diameter: 4.7227 in. USE 4 3/4"

(ft)	---cfs-- -------	(ft)	---cfs-- -------	(ft)	---cfs-- -------	(ft)	---cfs-- -------
94.50	0.0000	96.90	0.3608	99.30	0.5103	101.70	1.0078
94.60	0.0737	97.00	0.3683	99.40	0.5156	101.80	1.0573
94.70	0.1042	97.10	0.3756	99.50	0.5208	101.90	1.1024
94.80	0.1276	97.20	0.3827	99.60	0.5260	102.00	1.1443
94.90	0.1473	97.30	0.3897	99.70	0.5311	102.10	1.1835
95.00	0.1647	97.40	0.3966	99.80	0.5362	102.20	1.2205
95.10	0.1804	97.50	0.4034	99.90	0.5413	102.30	1.2558
95.20	0.1949	97.60	0.4101	100.00	0.5462	102.40	1.2895
95.30	0.2083	97.70	0.4167	100.10	0.5512	102.50	1.3218
95.40	0.2210	97.80	0.4231	100.20	0.5561	102.60	1.3530
95.50	0.2329	97.90	0.4295	100.30	0.5609	102.70	1.3831
95.60	0.2443	98.00	0.4358	100.40	0.5658	102.80	1.4123
95.70	0.2551	98.10	0.4419	100.50	0.5705	102.90	1.4407
95.80	0.2656	98.20	0.4480	100.60	0.5753	103.00	1.4682
95.90	0.2756	98.30	0.4540	100.70	0.5800	103.10	1.4951
96.00	0.2853	98.40	0.4600	100.80	0.5846	103.20	1.5213
96.10	0.2946	98.50	0.4658	100.90	0.5892	103.30	1.5469
96.20	0.3037	98.60	0.4716	101.00	0.5938	103.40	1.5720
96.30	0.3125	98.70	0.4773	101.10	0.5984	103.50	1.5965
96.40	0.3211	98.80	0.4830	101.20	0.6029	103.60	1.6205
96.50	0.3294	98.90	0.4886	101.30	0.6074	103.70	1.6441
96.60	0.3375	99.00	0.4941	101.40	0.8032	103.80	1.6673
96.70	0.3455	99.10	0.4996	101.50	0.8869	103.90	1.6901
96.80	0.3532	99.20	0.5050	101.60	0.9521	104.00	1.7124

Hydrologic Analysis
93073

LEVEL POOL TABLE SUMMARY

<--------DESCRIPTION--------->	MATCH (cfs)	INFLOW (cfs)	-STO- --id-	-DIS- --id-	<-PEAK-> <-STAGE>	STORAGE id	STORAGE VOL (cf)
2yr, 24 hr storm	0.60	2.10	pipe	or1	101.22	7	5260.03
10yr, 24 hr storm	1.33	3.34	pipe	or1	102.46	8	7688.06

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FOR: CHERRY VALLEY VISTA HYDROLOGIC ANALYSIS		JOB NO. 91027
PREPARED BY: HAD	DATE: 4/14/94	PAGE OF
CHECKED BY:	SCALE:	

RISER OVERFLOW CAPACITY

$Q_{100} = 4.96$ CFS (HYDROGRAPH 6)

AVAILABLE HEAD

103.25	(CB 5&6 RIM)
102.50	(OVERFLOW)
0.75 FT	

TRY RISER

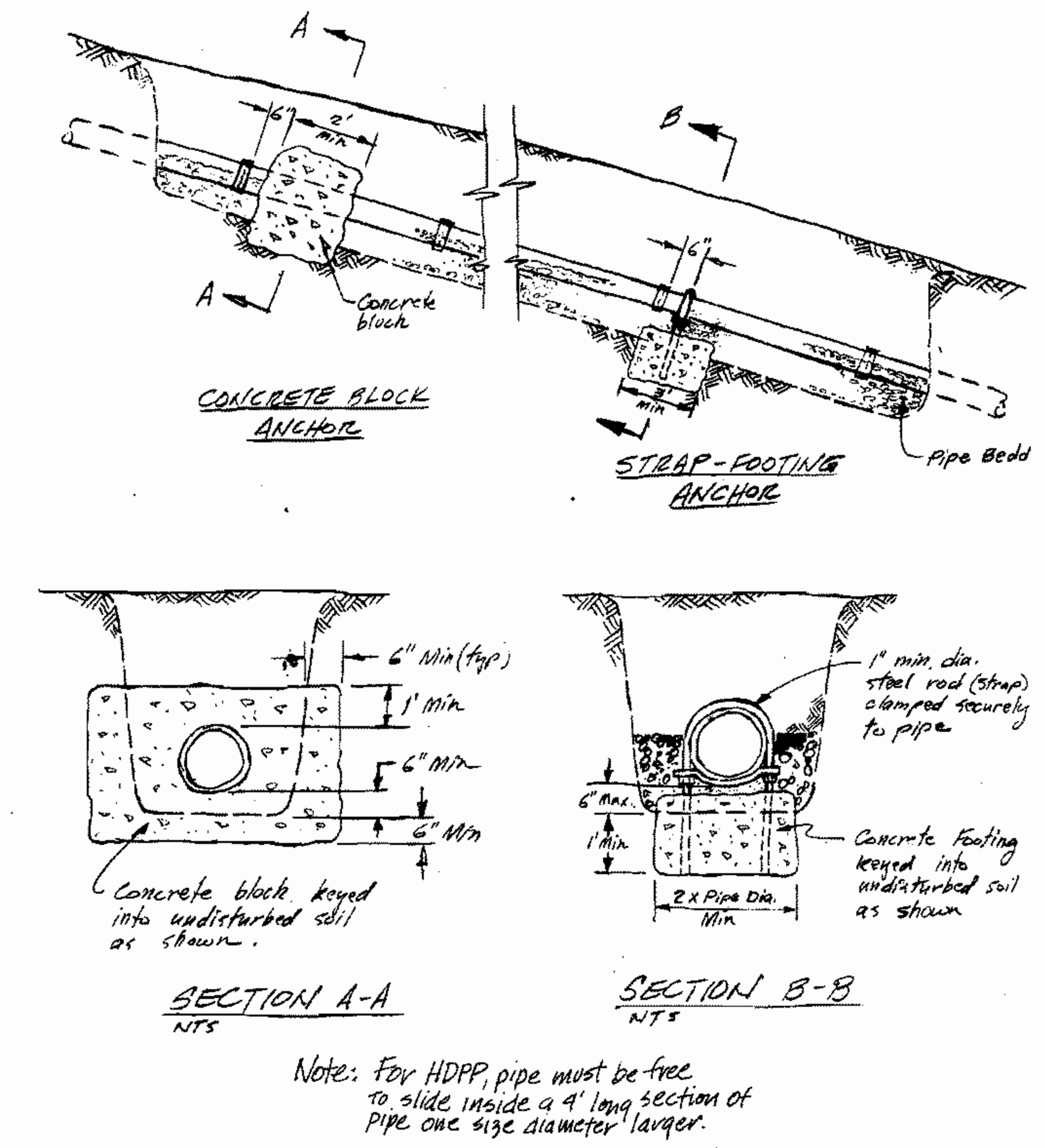
✓ WIER FLOW $Q = 9.739\,DH^{3/2}$

$= (9.739)(1.5)(0.75)^{3/2} = 9.5$ cfs

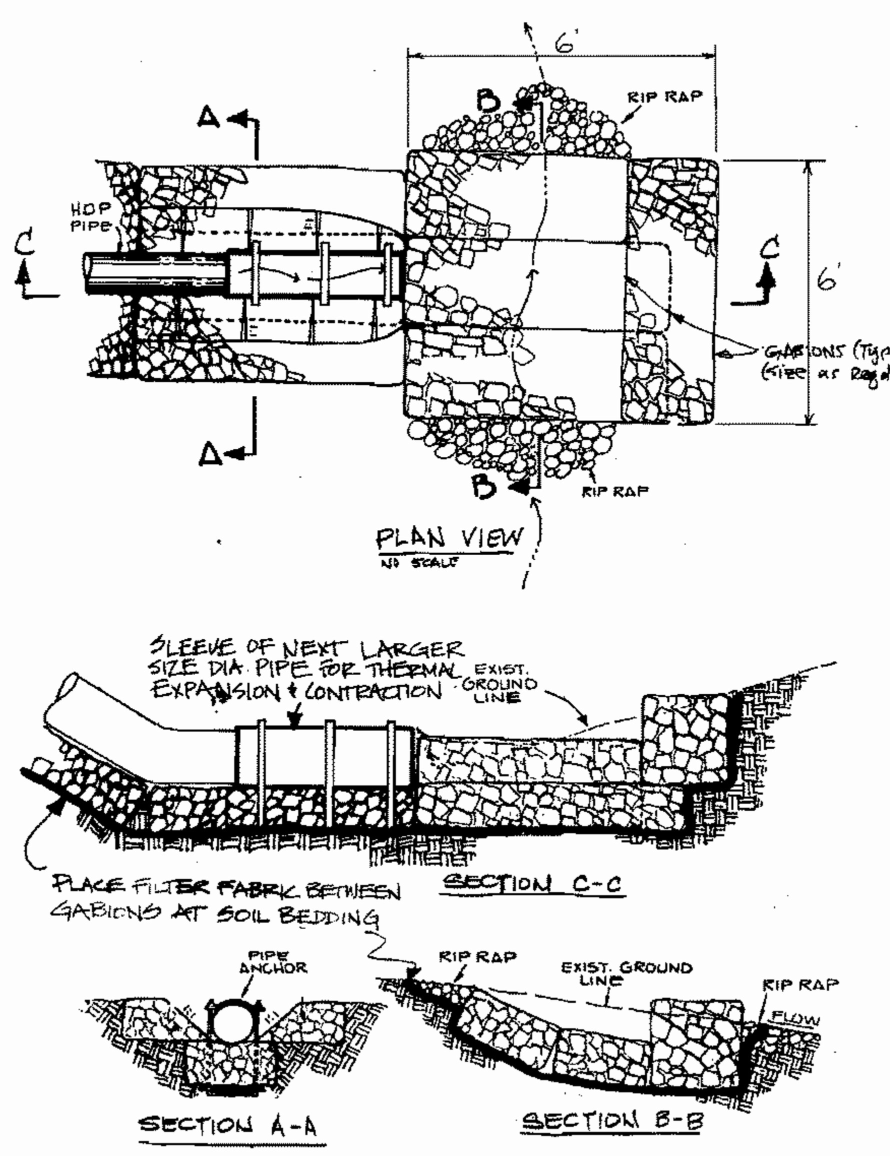
✓ ORIFICE FLOW $Q = 3.782\,D^2H^{1/2}$

$= (3.782)(1.5)^2(0.75)^{0.5} = 7.4$ cfs ← OK

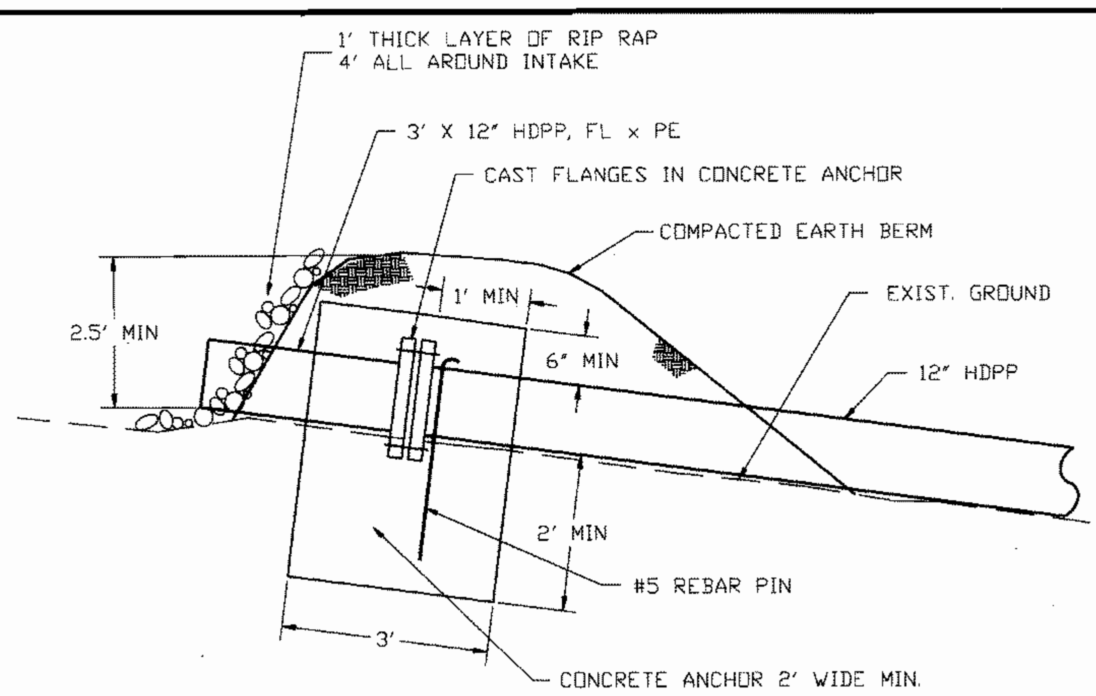
∴ USE 18"Ø RISER



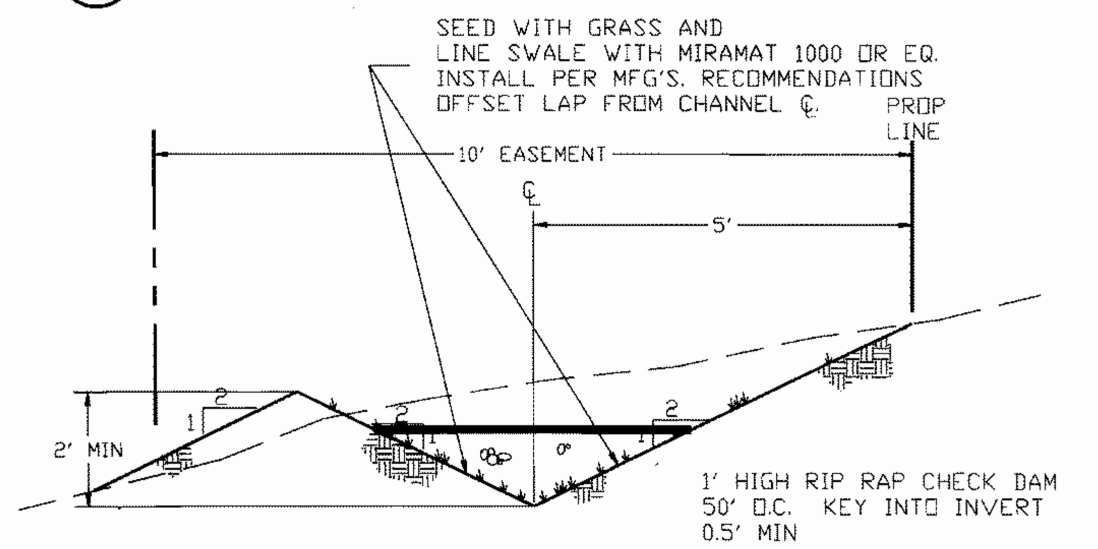
① PIPE ANCHORS



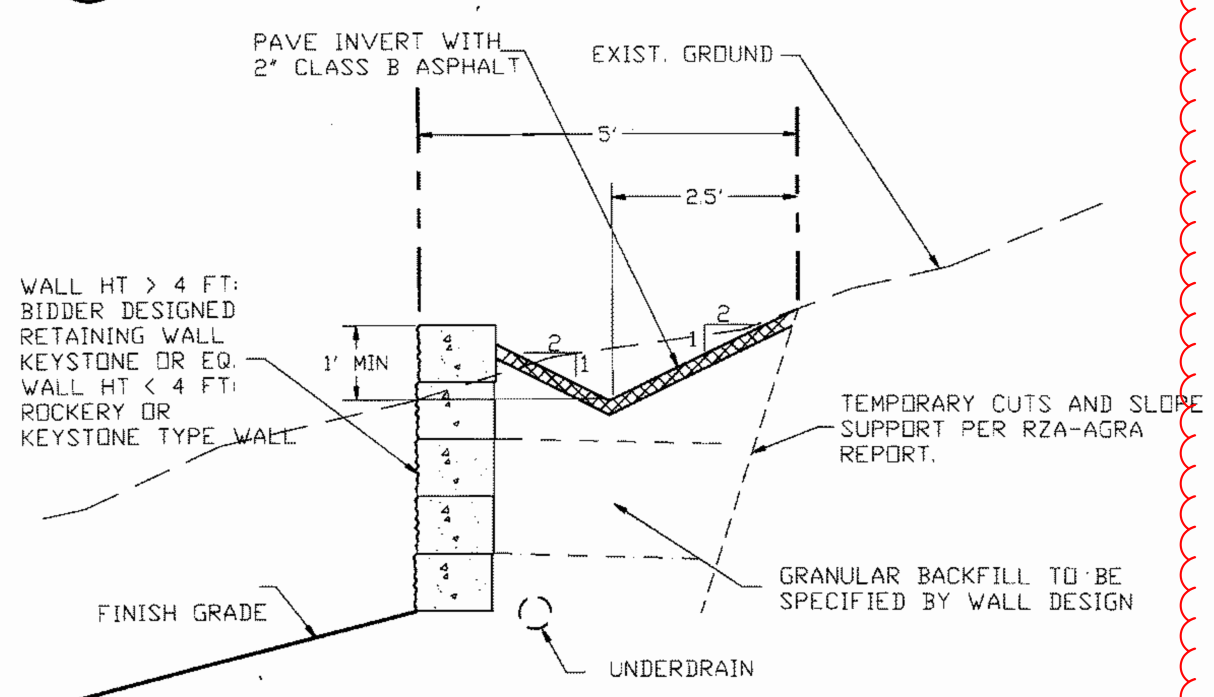
② GABION OUTFALL FOR HDPP



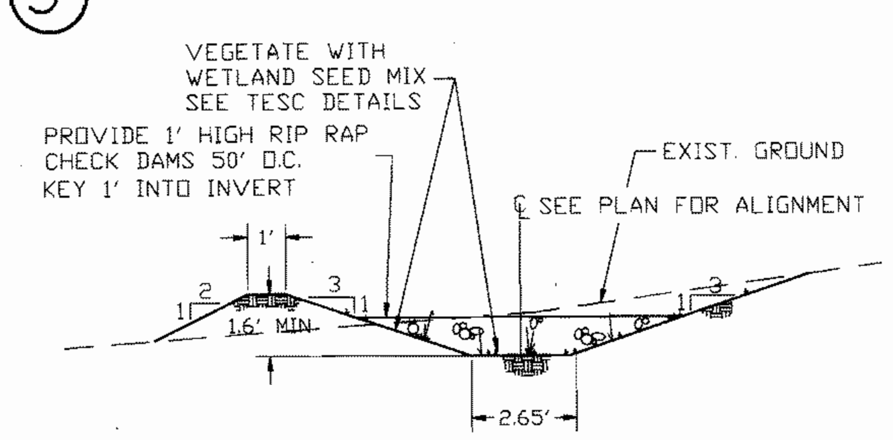
③ FIXED ANCHOR FOR HDPP INTAKE



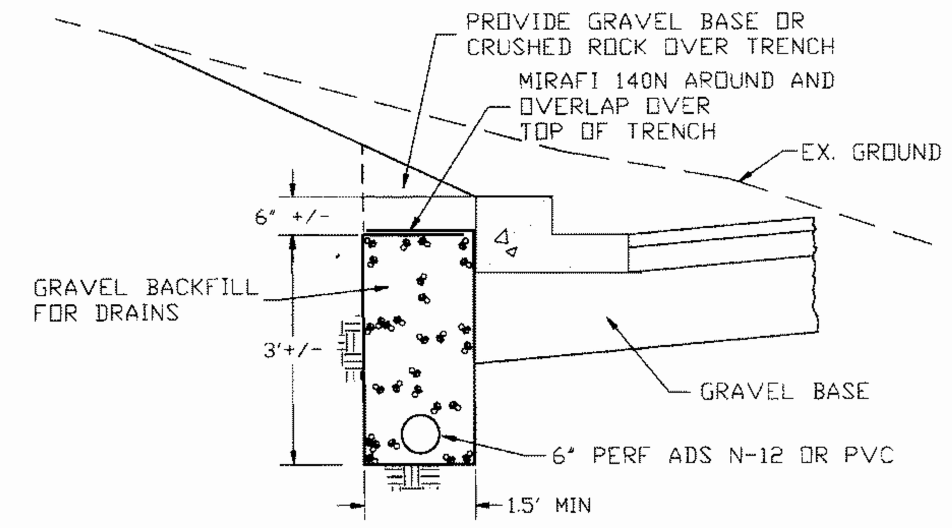
④ INTERCEPTOR SWALE



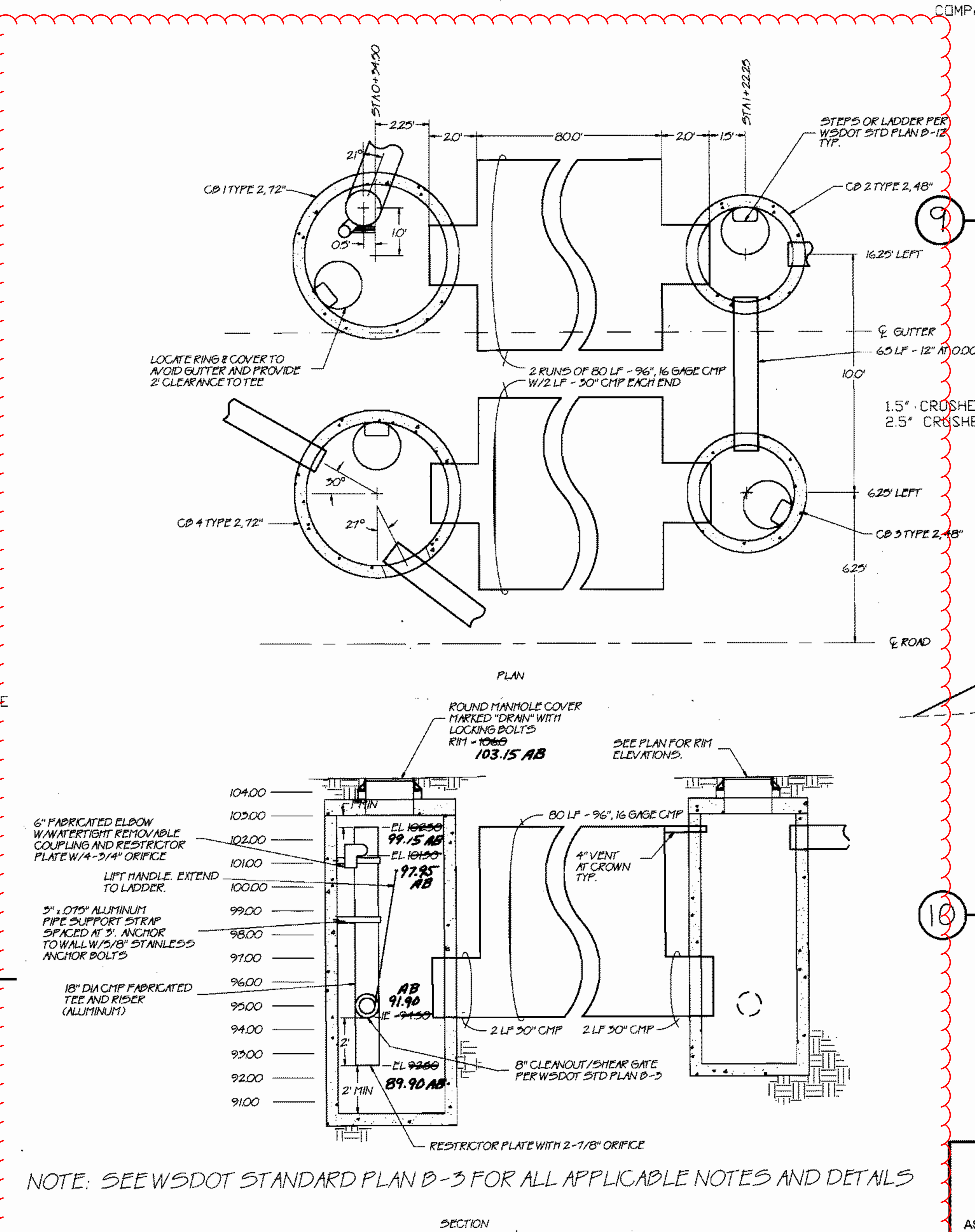
⑤ INTERCEPTOR SWALE (ON WALL)



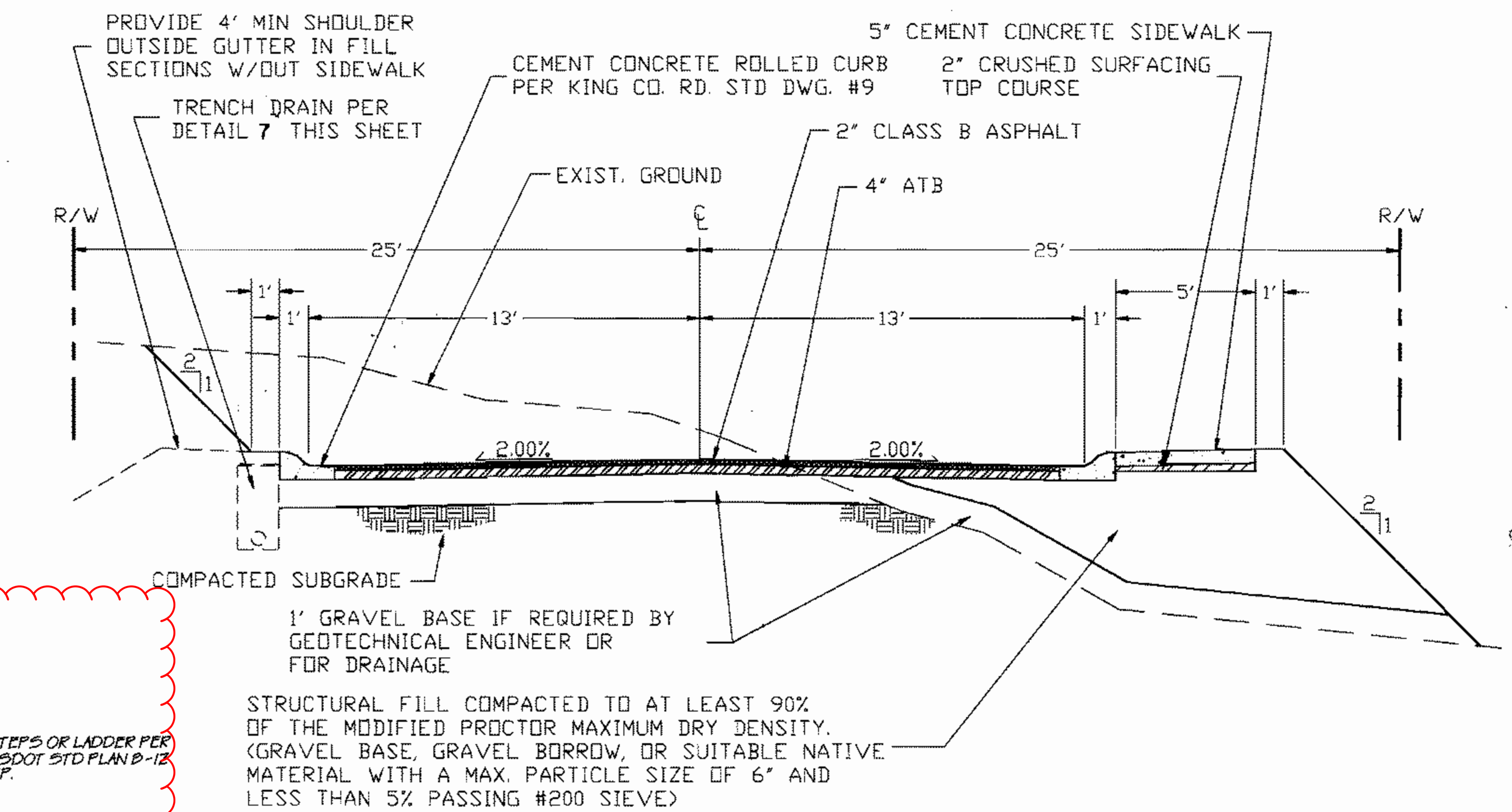
⑥ BIOSWALE SECTION



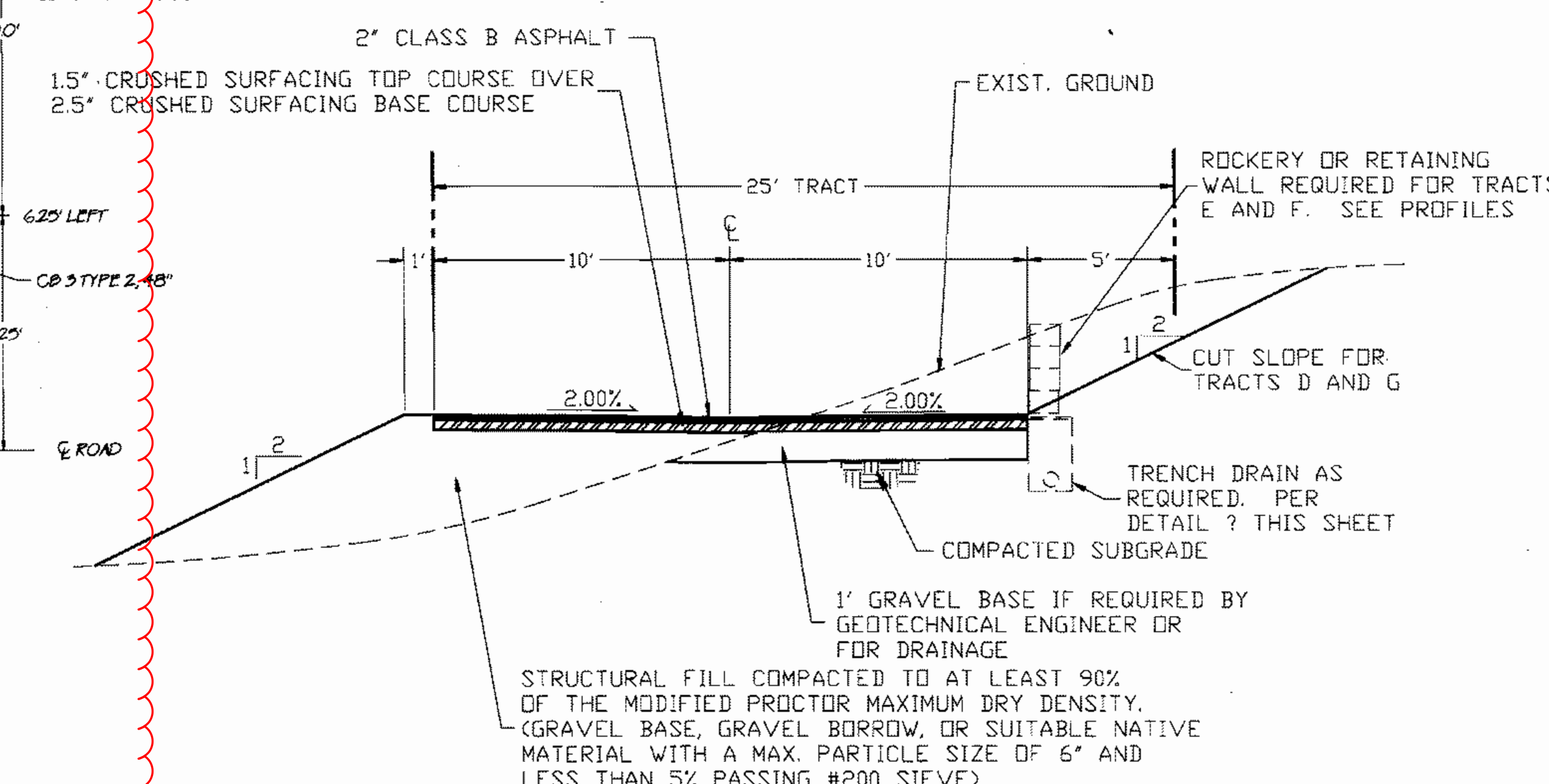
⑦ TRENCH DRAIN DETAIL



⑧ DETENTION SYSTEM



⑨ TYPICAL ROADWAY SECTION



⑩ TYPICAL ACCESS TRACT SECTION

HAMMOND, COLLIER & WADE - LIVINGSTONE ASSOCIATES, INC.
PE 6/7/94
PEER REVIEW

AS BUILT

AS BUILT DATA REFLECTED HEREON WAS PROVIDED BY AGENCY INSPECTOR, AND/OR CONTRACTOR, AND/OR DEVELOPER'S SURVEYOR.

G.R. (BOB) PARROTT, P.E. 10-9-96

3924 - 204th Street S.W. • Lynnwood, WA 98036 • (206) 778-0987

APPROVED FOR CONSTRUCTION

CITY ENGINEER/PUBLIC WORK DIR. 6/2/94

UTILITIES SUPERINTENDENT 6/2/94

CITY OF DUVALL, WA 98019

NO.	DATE	REVISION	BY
2	05/02/94	REVISED PER CITY COMMENTS	KRE
1	4/18/94	REVISED PER CITY COMMENTS	HMD

HAROLD M. DUNCANSON — STATE OF WASHINGTON — 29647 — REGISTERED PROFESSIONAL ENGINEER — EXPIRES 7/3/95

Urban Design INC.
Environmental Planning, Civil Engineering, Landscape Design & Project Management Services
611 MARKET STREET, SUITE 3 KIRKLAND, WA 98033 (206) 822-4886
311 SOUTH LEHUA STREET KAHULUI, MAUI, HI 96732 (808) 871-5701

CHERRY VALLEY VISTA

SCALE: | APPROVED BY | DRAWN BY HMD
DATE: 2-8-94

GRADING, DRAINAGE & PAVING DETAILS

91027

DRAWING NUMBER C6

BASIN AREAS

EXISTING PERVIOUS AREA (PER T.I.R.) = 4.17 AC

EXISTING IMPERVIOUS AREA (PER T.I.R.) = 2.55 AC

N

1"=120'
0 120
Scale Feet

SMW	Design
AAM	Drawn
2017-10-24	Date
374-001-16	Project No.

SDA
Civil Engineering
Project Management
Planning
1724 W. Marine View Drive, Suite 140; Everett, Washington 98201
Office: 425.486.6533 Fax: 425.486.6593 www.sdaengineers.com

DUVALL WATERSHED PLAN
CHERRY VALLEY VISTA

DRAINAGE BASIN

Sheet: 5

Nov 27, 2017 – 3:55PM Last Saved By: SWelch

R:\Projects\374 (ESA)\001-16 (Duvall Watershed Plan)\Dwg\figures\Fig05.dwg 11x17

WWHM2012

PROJECT REPORT

Existing CVV Pond

General Model Information

Project Name:	Cherry Valley Vista_12_4_17_EX
Site Name:	Cherry Valley Vista
Site Address:	10/18/17
City:	SMW
Report Date:	5/4/2018
Gage:	Seatac
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	1.00
Version:	2014/09/12

POC Thresholds

Low Flow Threshold for POC1:	50 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year

Landuse Basin Data
Predeveloped Land Use

Area A&B

Bypass:	No
GroundWater:	No
Pervious Land Use	Acres
C, Forest, Mod	6.72
Pervious Total	6.72
Impervious Land Use	Acres
Impervious Total	0
Basin Total	6.72

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Area A

Bypass:	No
GroundWater:	No
Pervious Land Use	Acres
C, Lawn, Mod	3.2
Pervious Total	3.2
Impervious Land Use	Acres
ROADS MOD	1.96
Impervious Total	1.96
Basin Total	5.16

Element Flows To:

Surface	Interflow	Groundwater
Tank 1	Tank 1	

Area B

Bypass:	No
GroundWater:	No
Pervious Land Use	Acres
C, Lawn, Mod	0.97
Pervious Total	0.97
Impervious Land Use	Acres
ROADS MOD	0.59
Impervious Total	0.59
Basin Total	1.56

Element Flows To:

Surface	Interflow	Groundwater
Tank 2	Tank 2	

Routing Elements
Predeveloped Routing

Mitigated Routing

Tank 2

Dimensions
Depth: 8 ft.
Tank Type: Circular
Diameter: 8 ft.
Length: 80 ft.
Discharge Structure
Riser Height: 7.25 ft.
Riser Diameter: 18 in.
Orifice 1 Diameter: 2.875 in. Elevation:0 ft.
Orifice 2 Diameter: 4.75 in. Elevation:6.05 ft.
Element Flows To:
Outlet 1 Outlet 2

Tank Hydraulic Table

Stage(ft)	**Area(ac)**	**Volume(ac-ft)**	**Discharge(cfs)**	**Infilt(cfs)**
91.900	0.000	0.000	0.000	0.000
91.989	0.003	0.000	0.064	0.000
92.078	0.004	0.000	0.091	0.000
92.167	0.005	0.000	0.112	0.000
92.256	0.006	0.001	0.129	0.000
92.344	0.006	0.002	0.144	0.000
92.433	0.007	0.002	0.158	0.000
92.522	0.007	0.003	0.171	0.000
92.611	0.008	0.004	0.183	0.000
92.700	0.008	0.004	0.194	0.000
92.789	0.009	0.005	0.204	0.000
92.878	0.009	0.006	0.214	0.000
92.967	0.010	0.007	0.224	0.000
93.056	0.010	0.008	0.233	0.000
93.144	0.010	0.009	0.242	0.000
93.233	0.011	0.010	0.250	0.000
93.322	0.011	0.011	0.258	0.000
93.411	0.011	0.012	0.266	0.000
93.500	0.011	0.013	0.274	0.000
93.589	0.012	0.014	0.282	0.000
93.678	0.012	0.015	0.289	0.000
93.767	0.012	0.016	0.296	0.000
93.856	0.012	0.017	0.303	0.000
93.944	0.012	0.018	0.310	0.000
94.033	0.013	0.019	0.317	0.000
94.122	0.013	0.020	0.323	0.000
94.211	0.013	0.022	0.330	0.000
94.300	0.013	0.023	0.336	0.000
94.389	0.013	0.024	0.342	0.000
94.478	0.013	0.025	0.348	0.000
94.567	0.013	0.026	0.354	0.000
94.656	0.014	0.028	0.360	0.000
94.744	0.014	0.029	0.366	0.000
94.833	0.014	0.030	0.371	0.000
94.922	0.014	0.031	0.377	0.000
95.011	0.014	0.033	0.382	0.000
95.100	0.014	0.034	0.388	0.000

95.189	0.014	0.035	0.393	0.000
95.278	0.014	0.037	0.399	0.000
95.367	0.014	0.038	0.404	0.000
95.456	0.014	0.039	0.409	0.000
95.544	0.014	0.040	0.414	0.000
95.633	0.014	0.042	0.419	0.000
95.722	0.014	0.043	0.424	0.000
95.811	0.014	0.044	0.429	0.000
95.900	0.014	0.046	0.434	0.000
95.989	0.014	0.047	0.439	0.000
96.078	0.014	0.048	0.443	0.000
96.167	0.014	0.050	0.448	0.000
96.256	0.014	0.051	0.453	0.000
96.344	0.014	0.052	0.457	0.000
96.433	0.014	0.054	0.462	0.000
96.522	0.014	0.055	0.466	0.000
96.611	0.014	0.056	0.471	0.000
96.700	0.014	0.057	0.475	0.000
96.789	0.014	0.059	0.480	0.000
96.878	0.014	0.060	0.484	0.000
96.967	0.014	0.061	0.488	0.000
97.056	0.014	0.062	0.492	0.000
97.144	0.014	0.064	0.497	0.000
97.233	0.013	0.065	0.501	0.000
97.322	0.013	0.066	0.505	0.000
97.411	0.013	0.067	0.509	0.000
97.500	0.013	0.069	0.513	0.000
97.589	0.013	0.070	0.517	0.000
97.678	0.013	0.071	0.521	0.000
97.767	0.013	0.072	0.525	0.000
97.856	0.012	0.073	0.529	0.000
97.944	0.012	0.074	0.533	0.000
98.033	0.012	0.075	0.708	0.000
98.122	0.012	0.077	0.787	0.000
98.211	0.012	0.078	0.848	0.000
98.300	0.011	0.079	0.899	0.000
98.389	0.011	0.080	0.945	0.000
98.478	0.011	0.081	0.987	0.000
98.567	0.011	0.082	1.025	0.000
98.656	0.010	0.083	1.062	0.000
98.744	0.010	0.084	1.096	0.000
98.833	0.010	0.085	1.128	0.000
98.922	0.009	0.085	1.159	0.000
99.011	0.009	0.086	1.189	0.000
99.1	0.008	0.087	1.218	0.000
99.188	0.008	0.088	1.357	0.000
99.277	0.007	0.089	1.939	0.000
99.366	0.007	0.089	2.771	0.000
99.455	0.006	0.090	3.791	0.000
99.544	0.006	0.090	4.967	0.000
99.633	0.005	0.091	6.281	0.000
99.722	0.004	0.091	7.719	0.000
99.811	0.003	0.092	9.271	0.000
99.9	0.000	0.092	10.93	0.000
99.988	0.000	0.000	12.68	0.000

Tank 1

Dimensions
Depth: 8 ft.
Tank Type: Circular
Diameter: 8 ft.
Length: 80 ft.
Discharge Structure
Riser Height: 7.25 ft.
Riser Diameter: 18 in.
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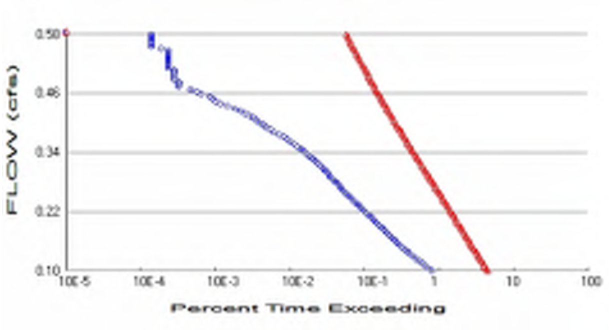
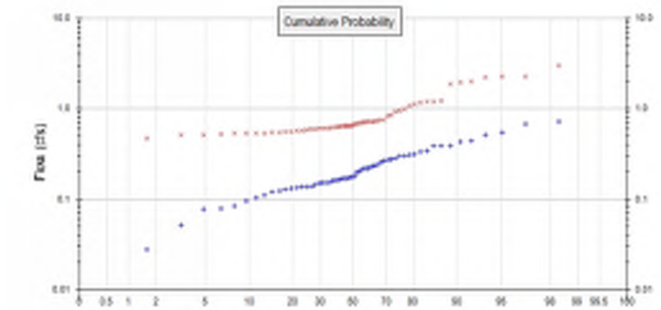
92.256	0.006	0.001	0.129	0.000
92.344	0.006	0.002	0.144	0.000
92.433	0.007	0.002	0.158	0.000
92.522	0.007	0.003	0.171	0.000
92.611	0.008	0.004	0.183	0.000
92.700	0.008	0.004	0.194	0.000
92.789	0.009	0.005	0.204	0.000
92.878	0.009	0.006	0.214	0.000
92.967	0.010	0.007	0.224	0.000
93.056	0.010	0.008	0.233	0.000
93.144	0.010	0.009	0.242	0.000
93.233	0.011	0.010	0.250	0.000
93.322	0.011	0.011	0.258	0.000
93.411	0.011	0.012	0.266	0.000
93.500	0.011	0.013	0.274	0.000
93.589	0.012	0.014	0.282	0.000
93.678	0.012	0.015	0.289	0.000
93.767	0.012	0.016	0.296	0.000
93.856	0.012	0.017	0.303	0.000
93.944	0.012	0.018	0.310	0.000
94.033	0.013	0.019	0.317	0.000
94.122	0.013	0.020	0.323	0.000
94.211	0.013	0.022	0.330	0.000
94.300	0.013	0.023	0.336	0.000
94.389	0.013	0.024	0.342	0.000
94.478	0.013	0.025	0.348	0.000
94.567	0.013	0.026	0.354	0.000
94.656	0.014	0.028	0.360	0.000
94.744	0.014	0.029	0.366	0.000
94.833	0.014	0.030	0.371	0.000
94.922	0.014	0.031	0.377	0.000
95.011	0.014	0.033	0.382	0.000
95.100	0.014	0.034	0.388	0.000
95.189	0.014	0.035	0.393	0.000
95.278	0.014	0.037	0.399	0.000

95.367	0.014	0.038	0.404	0.000
95.456	0.014	0.039	0.409	0.000
95.544	0.014	0.040	0.414	0.000
95.633	0.014	0.042	0.419	0.000
95.722	0.014	0.043	0.424	0.000
95.811	0.014	0.044	0.429	0.000
95.900	0.014	0.046	0.434	0.000
95.989	0.014	0.047	0.439	0.000
96.078	0.014	0.048	0.443	0.000
96.167	0.014	0.050	0.448	0.000
96.256	0.014	0.051	0.453	0.000
96.344	0.014	0.052	0.457	0.000
96.433	0.014	0.054	0.462	0.000
96.522	0.014	0.055	0.466	0.000
96.611	0.014	0.056	0.471	0.000
96.700	0.014	0.057	0.475	0.000
96.789	0.014	0.059	0.480	0.000
96.878	0.014	0.060	0.484	0.000
96.967	0.014	0.061	0.488	0.000
97.056	0.014	0.062	0.492	0.000
97.144	0.014	0.064	0.497	0.000
97.233	0.013	0.065	0.501	0.000
97.322	0.013	0.066	0.505	0.000
97.411	0.013	0.067	0.509	0.000
97.500	0.013	0.069	0.513	0.000
97.589	0.013	0.070	0.517	0.000
97.678	0.013	0.071	0.521	0.000
97.767	0.013	0.072	0.525	0.000
97.856	0.012	0.073	0.529	0.000
97.944	0.012	0.074	0.533	0.000
98.033	0.012	0.075	0.708	0.000
98.122	0.012	0.077	0.787	0.000
98.211	0.012	0.078	0.848	0.000
98.300	0.011	0.079	0.899	0.000
98.389	0.011	0.080	0.945	0.000
98.478	0.011	0.081	0.987	0.000
98.567	0.011	0.082	1.025	0.000
98.656	0.010	0.083	1.062	0.000
98.744	0.010	0.084	1.096	0.000
98.833	0.010	0.085	1.128	0.000
98.922	0.009	0.085	1.159	0.000
99.011	0.009	0.086	1.189	0.000
99.1	0.008	0.087	1.218	0.000
99.188	0.008	0.088	1.357	0.000
99.277	0.007	0.089	1.939	0.000
99.366	0.007	0.089	2.771	0.000
99.455	0.006	0.090	3.791	0.000
99.544	0.006	0.090	4.967	0.000
99.633	0.005	0.091	6.281	0.000
99.722	0.004	0.091	7.719	0.000
99.811	0.003	0.092	9.271	0.000
99.9	0.000	0.092	10.93	0.000
99.988	0.000	0.000	12.68	0.000

Analysis Results
POC 1





+ Predeveloped   x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 6.72
Total Impervious Area: 0

Mitigated Landuse Totals for POC #1
Total Pervious Area: 4.17
Total Impervious Area: 2.55

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.200089
5 year	0.327864
10 year	0.410021
25 year	0.50775
50 year	0.575443
100 year	0.638672

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.739306
5 year	1.108046
10 year	1.412178
25 year	1.87424
50 year	2.281437
100 year	2.748457

Annual Peaks
Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	0.230	0.830
1950	0.273	1.214
1951	0.437	0.751
1952	0.137	0.535
1953	0.111	0.537
1954	0.170	0.572
1955	0.272	0.679
1956	0.219	0.610
1957	0.177	0.743
1958	0.196	0.549

1959	0.168	0.515
1960	0.302	0.705
1961	0.166	0.640
1962	0.103	0.515
1963	0.142	0.622
1964	0.201	0.640
1965	0.134	0.667
1966	0.128	0.573
1967	0.307	0.857
1968	0.173	0.702
1969	0.168	0.628
1970	0.135	0.592
1971	0.153	0.649
1972	0.332	1.183
1973	0.147	0.531
1974	0.163	0.614
1975	0.227	0.737
1976	0.162	0.583
1977	0.024	0.536
1978	0.137	0.723
1979	0.083	0.648
1980	0.391	0.922
1981	0.123	0.683
1982	0.253	1.946
1983	0.217	0.722
1984	0.131	0.541
1985	0.077	0.652
1986	0.343	1.078
1987	0.303	0.996
1988	0.119	0.526
1989	0.079	0.561
1990	0.725	2.998
1991	0.384	2.257
1992	0.157	0.603
1993	0.153	0.474
1994	0.051	0.467
1995	0.220	0.590
1996	0.507	1.195
1997	0.392	0.942
1998	0.096	0.612
1999	0.429	1.867
2000	0.153	0.713
2001	0.027	0.561
2002	0.177	1.117
2003	0.264	0.635
2004	0.282	2.259
2005	0.209	0.724
2006	0.235	0.608
2007	0.548	1.996
2008	0.668	2.215
2009	0.311	1.198

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.7246	2.9978
2	0.6675	2.2590
3	0.5476	2.2571

4	0.5074	2.2149
5	0.4372	1.9961
6	0.4294	1.9460
7	0.3916	1.8671
8	0.3907	1.2142
9	0.3843	1.1979
10	0.3429	1.1947
11	0.3319	1.1829
12	0.3112	1.1168
13	0.3072	1.0782
14	0.3026	0.9963
15	0.3016	0.9417
16	0.2821	0.9223
17	0.2733	0.8571
18	0.2719	0.8300
19	0.2640	0.7507
20	0.2534	0.7429
21	0.2355	0.7371
22	0.2303	0.7236
23	0.2270	0.7232
24	0.2195	0.7221
25	0.2191	0.7131
26	0.2167	0.7047
27	0.2093	0.7023
28	0.2010	0.6830
29	0.1963	0.6789
30	0.1768	0.6674
31	0.1768	0.6516
32	0.1729	0.6490
33	0.1702	0.6484
34	0.1684	0.6402
35	0.1683	0.6398
36	0.1659	0.6348
37	0.1630	0.6283
38	0.1622	0.6222
39	0.1569	0.6141
40	0.1532	0.6123
41	0.1525	0.6100
42	0.1525	0.6076
43	0.1471	0.6030
44	0.1417	0.5920
45	0.1372	0.5898
46	0.1370	0.5833
47	0.1351	0.5726
48	0.1336	0.5722
49	0.1305	0.5614
50	0.1284	0.5607
51	0.1227	0.5490
52	0.1195	0.5410
53	0.1109	0.5367
54	0.1032	0.5355
55	0.0958	0.5348
56	0.0829	0.5312
57	0.0791	0.5259
58	0.0775	0.5152
59	0.0514	0.5150
60	0.0274	0.4736
61	0.0238	0.4668

Duration Flows

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.1000	17090	97020	567	Fail
0.1048	15736	92999	590	Fail
0.1096	14232	88314	620	Fail
0.1145	12897	84144	652	Fail
0.1193	11625	80208	689	Fail
0.1241	10525	76444	726	Fail
0.1289	9721	73513	756	Fail
0.1337	8859	69984	789	Fail
0.1385	8104	66669	822	Fail
0.1433	7381	63482	860	Fail
0.1481	6740	60573	898	Fail
0.1529	6278	58306	928	Fail
0.1577	5790	55611	960	Fail
0.1625	5347	52980	990	Fail
0.1673	4941	50585	1023	Fail
0.1721	4571	48275	1056	Fail
0.1769	4295	46521	1083	Fail
0.1817	3980	44425	1116	Fail
0.1865	3672	42435	1155	Fail
0.1913	3401	40468	1189	Fail
0.1961	3133	38650	1233	Fail
0.2009	2954	37174	1258	Fail
0.2057	2733	35463	1297	Fail
0.2105	2507	33816	1348	Fail
0.2153	2329	32233	1383	Fail
0.2201	2136	30693	1436	Fail
0.2249	2004	29538	1473	Fail
0.2297	1843	28105	1524	Fail
0.2345	1717	26779	1559	Fail
0.2393	1583	25538	1613	Fail
0.2441	1443	24319	1685	Fail
0.2489	1346	23399	1738	Fail
0.2537	1245	22287	1790	Fail
0.2585	1157	21267	1838	Fail
0.2633	1087	20249	1862	Fail
0.2681	1021	19321	1892	Fail
0.2729	964	18604	1929	Fail
0.2777	895	17712	1978	Fail
0.2825	833	16833	2020	Fail
0.2873	765	16035	2096	Fail
0.2921	725	15327	2114	Fail
0.2969	683	14696	2151	Fail
0.3017	633	14005	2212	Fail
0.3065	593	13317	2245	Fail
0.3113	555	12694	2287	Fail
0.3161	506	12100	2391	Fail
0.3209	475	11627	2447	Fail
0.3257	431	11067	2567	Fail
0.3305	389	10543	2710	Fail
0.3353	358	10066	2811	Fail
0.3401	328	9576	2919	Fail
0.3449	304	9236	3038	Fail
0.3497	273	8810	3227	Fail
0.3546	245	8382	3421	Fail

0.3594	219	8006	3655	Fail
0.3642	198	7640	3858	Fail
0.3690	179	7375	4120	Fail
0.3738	155	7043	4543	Fail
0.3786	132	6735	5102	Fail
0.3834	119	6372	5354	Fail
0.3882	104	6062	5828	Fail
0.3930	96	5850	6093	Fail
0.3978	85	5595	6582	Fail
0.4026	77	5360	6961	Fail
0.4074	69	5123	7424	Fail
0.4122	61	4877	7995	Fail
0.4170	54	4716	8733	Fail
0.4218	47	4502	9578	Fail
0.4266	39	4312	11056	Fail
0.4314	31	4107	13248	Fail
0.4362	25	3942	15767	Fail
0.4410	22	3818	17354	Fail
0.4458	20	3645	18225	Fail
0.4506	18	3469	19272	Fail
0.4554	14	3315	23678	Fail
0.4602	12	3172	26433	Fail
0.4650	10	3063	30629	Fail
0.4698	7	2954	42200	Fail
0.4746	7	2830	40428	Fail
0.4794	7	2699	38557	Fail
0.4842	6	2607	43450	Fail
0.4890	6	2500	41666	Fail
0.4938	6	2415	40250	Fail
0.4986	6	2336	38933	Fail
0.5034	6	2248	37466	Fail
0.5082	5	2158	43160	Fail
0.5130	5	2065	41300	Fail
0.5178	5	1985	39700	Fail
0.5226	5	1895	37900	Fail
0.5274	5	1827	36540	Fail
0.5322	5	1748	34960	Fail
0.5370	5	1677	33540	Fail
0.5418	5	1628	32560	Fail
0.5466	4	1546	38650	Fail
0.5514	3	1479	49300	Fail
0.5562	3	1422	47400	Fail
0.5610	3	1383	46100	Fail
0.5658	3	1340	44666	Fail
0.5706	3	1290	43000	Fail
0.5754	3	1232	41066	Fail

The development has an increase in flow durations from 1/2 Predeveloped 2 year flow to the 2 year flow or more than a 10% increase from the 2 year to the 50 year flow.
The development has an increase in flow durations for more than 50% of the flows for the range of the duration analysis.

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0.1801 acre-feet
On-line facility target flow:	0.0912 cfs.
Adjusted for 15 min:	0.0912 cfs.
Off-line facility target flow:	0.0602 cfs.
Adjusted for 15 min:	0.0602 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Tank 2 POC	☐	155.71			☐	0.00			
Tank 1 POC	☐	515.73			☐	0.00			
Total Volume Infiltrated		671.44	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50-yr									Duration Analysis Result = Failed

Model Default Modifications

Total of 0 changes have been made.

PERLND Changes

No PERLND changes have been made.

IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic

Mitigated Schematic

Disclaimer

Legal Notice

Clear Creek Solutions, Inc.
6200 Capitol Blvd. Ste F
Olympia, WA. 98501
Toll Free 1(866)943-0304
Local (360)943-0304

www.clearcreeksolutions.com

WWHM2012

PROJECT REPORT

Modification Option 1: Deeper Combined Flow Control and Water Quality Facility

General Model Information

Project Name:	Cherry Valley Vista_12_4_17_proppond_walls2
Site Name:	Cherry Valley Vista
Site Address:	10/18/17
City:	SMW
Report Date:	5/4/2018
Gage:	Seatac
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	1.00
Version:	2014/09/12

POC Thresholds

Low Flow Threshold for POC1:	50 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year

Landuse Basin Data
Predeveloped Land Use

Area A&B

Bypass:	No
GroundWater:	No
Pervious Land Use	Acres
C, Forest, Mod	6.72
Pervious Total	6.72
Impervious Land Use	Acres
Impervious Total	0
Basin Total	6.72

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Area A

Bypass:	No
GroundWater:	No
Pervious Land Use	Acres
C, Lawn, Mod	3.2
Pervious Total	3.2
Impervious Land Use	Acres
ROADS MOD	1.96
Impervious Total	1.96
Basin Total	5.16

Element Flows To:

Surface	Interflow	Groundwater
Tank 1	Tank 1	

Area B

Bypass:	No	
GroundWater:	No	
Pervious Land Use	Acres	
C, Lawn, Mod	0.97	
Pervious Total	0.97	
Impervious Land Use	Acres	
ROADS MOD	0.59	
Impervious Total	0.59	
Basin Total	1.56	

Element Flows To:

Surface	Interflow	Groundwater
Tank 2	Tank 2	

Routing Elements
Predeveloped Routing

Mitigated Routing

Tank 2

Dimensions
Depth: 8 ft.
Tank Type: Circular
Diameter: 8 ft.
Length: 80 ft.
Discharge Structure
Riser Height: 7.25 ft.
Riser Diameter: 18 in.
Orifice 1 Diameter: 2.875 in. Elevation:0 ft.
Orifice 2 Diameter: 4.75 in. Elevation:6.05 ft.
Element Flows To:
Outlet 1 Outlet 2
Trapezoidal Pond 1

Tank Hydraulic Table

Stage(ft)	Area(ac)	Volume(ac-ft)	Discharge(cfs)	Infilt(cfs)
91.900	0.000	0.000	0.000	0.000
91.989	0.003	0.000	0.064	0.000
92.078	0.004	0.000	0.091	0.000
92.167	0.005	0.000	0.112	0.000
92.256	0.006	0.001	0.129	0.000
92.344	0.006	0.002	0.144	0.000
92.433	0.007	0.002	0.158	0.000
92.522	0.007	0.003	0.171	0.000
92.611	0.008	0.004	0.183	0.000
92.700	0.008	0.004	0.194	0.000
92.789	0.009	0.005	0.204	0.000
92.878	0.009	0.006	0.214	0.000
92.967	0.010	0.007	0.224	0.000
93.056	0.010	0.008	0.233	0.000
93.144	0.010	0.009	0.242	0.000
93.233	0.011	0.010	0.250	0.000
93.322	0.011	0.011	0.258	0.000
93.411	0.011	0.012	0.266	0.000
93.500	0.011	0.013	0.274	0.000
93.589	0.012	0.014	0.282	0.000
93.678	0.012	0.015	0.289	0.000
93.767	0.012	0.016	0.296	0.000
93.856	0.012	0.017	0.303	0.000
93.944	0.012	0.018	0.310	0.000
94.033	0.013	0.019	0.317	0.000
94.122	0.013	0.020	0.323	0.000
94.211	0.013	0.022	0.330	0.000
94.300	0.013	0.023	0.336	0.000
94.389	0.013	0.024	0.342	0.000
94.478	0.013	0.025	0.348	0.000
94.567	0.013	0.026	0.354	0.000
94.656	0.014	0.028	0.360	0.000
94.744	0.014	0.029	0.366	0.000
94.833	0.014	0.030	0.371	0.000
94.922	0.014	0.031	0.377	0.000
95.011	0.014	0.033	0.382	0.000
95.100	0.014	0.034	0.388	0.000

95.189	0.014	0.035	0.393	0.000
95.278	0.014	0.037	0.399	0.000
95.367	0.014	0.038	0.404	0.000
95.456	0.014	0.039	0.409	0.000
95.544	0.014	0.040	0.414	0.000
95.633	0.014	0.042	0.419	0.000
95.722	0.014	0.043	0.424	0.000
95.811	0.014	0.044	0.429	0.000
95.900	0.014	0.046	0.434	0.000
95.989	0.014	0.047	0.439	0.000
96.078	0.014	0.048	0.443	0.000
96.167	0.014	0.050	0.448	0.000
96.256	0.014	0.051	0.453	0.000
96.344	0.014	0.052	0.457	0.000
96.433	0.014	0.054	0.462	0.000
96.522	0.014	0.055	0.466	0.000
96.611	0.014	0.056	0.471	0.000
96.700	0.014	0.057	0.475	0.000
96.789	0.014	0.059	0.480	0.000
96.878	0.014	0.060	0.484	0.000
96.967	0.014	0.061	0.488	0.000
97.056	0.014	0.062	0.492	0.000
97.144	0.014	0.064	0.497	0.000
97.233	0.013	0.065	0.501	0.000
97.322	0.013	0.066	0.505	0.000
97.411	0.013	0.067	0.509	0.000
97.500	0.013	0.069	0.513	0.000
97.589	0.013	0.070	0.517	0.000
97.678	0.013	0.071	0.521	0.000
97.767	0.013	0.072	0.525	0.000
97.856	0.012	0.073	0.529	0.000
97.944	0.012	0.074	0.533	0.000
98.033	0.012	0.075	0.708	0.000
98.122	0.012	0.077	0.787	0.000
98.211	0.012	0.078	0.848	0.000
98.300	0.011	0.079	0.899	0.000
98.389	0.011	0.080	0.945	0.000
98.478	0.011	0.081	0.987	0.000
98.567	0.011	0.082	1.025	0.000
98.656	0.010	0.083	1.062	0.000
98.744	0.010	0.084	1.096	0.000
98.833	0.010	0.085	1.128	0.000
98.922	0.009	0.085	1.159	0.000
99.011	0.009	0.086	1.189	0.000
99.1	0.008	0.087	1.218	0.000
99.188	0.008	0.088	1.357	0.000
99.277	0.007	0.089	1.939	0.000
99.366	0.007	0.089	2.771	0.000
99.455	0.006	0.090	3.791	0.000
99.544	0.006	0.090	4.967	0.000
99.633	0.005	0.091	6.281	0.000
99.722	0.004	0.091	7.719	0.000
99.811	0.003	0.092	9.271	0.000
99.9	0.000	0.092	10.93	0.000
99.988	0.000	0.000	12.68	0.000

Trapezoidal Pond 1

Bottom Length: 159.00 ft.
Bottom Width: 90.00 ft.
Depth: 5.75 ft.
Volume at riser head: 1.5741 acre-ft.
Side slope 1: 0 To 1
Side slope 2: 0 To 1
Side slope 3: 0 To 1
Side slope 4: 0 To 1
Discharge Structure
Riser Height: 4.75 ft.
Riser Diameter: 12 in.
Orifice 1 Diameter: 1.5 in. Elevation:0 ft.
Orifice 2 Diameter: 2.425 in. Elevation:3.2 ft.
Orifice 3 Diameter: 2.125 in. Elevation:4 ft.
Element Flows To:
Outlet 1 Outlet 2

Pond Hydraulic Table

Stage(ft)	Area(ac)	Volume(ac-ft)	Discharge(cfs)	Infilt(cfs)
0.0000	0.328	0.000	0.000	0.000
0.0639	0.328	0.021	0.014	0.000
0.1278	0.328	0.042	0.021	0.000
0.1917	0.328	0.063	0.025	0.000
0.2556	0.328	0.084	0.029	0.000
0.3194	0.328	0.104	0.033	0.000
0.3833	0.328	0.125	0.036	0.000
0.4472	0.328	0.146	0.039	0.000
0.5111	0.328	0.167	0.042	0.000
0.5750	0.328	0.188	0.044	0.000
0.6389	0.328	0.209	0.047	0.000
0.7028	0.328	0.230	0.049	0.000
0.7667	0.328	0.251	0.051	0.000
0.8306	0.328	0.272	0.053	0.000
0.8944	0.328	0.293	0.055	0.000
0.9583	0.328	0.314	0.057	0.000
1.0222	0.328	0.335	0.059	0.000
1.0861	0.328	0.356	0.061	0.000
1.1500	0.328	0.377	0.063	0.000
1.2139	0.328	0.398	0.065	0.000
1.2778	0.328	0.419	0.066	0.000
1.3417	0.328	0.440	0.068	0.000
1.4056	0.328	0.461	0.070	0.000
1.4694	0.328	0.482	0.071	0.000
1.5333	0.328	0.503	0.073	0.000
1.5972	0.328	0.524	0.074	0.000
1.6611	0.328	0.545	0.076	0.000
1.7250	0.328	0.566	0.077	0.000
1.7889	0.328	0.587	0.079	0.000
1.8528	0.328	0.608	0.080	0.000
1.9167	0.328	0.629	0.081	0.000
1.9806	0.328	0.650	0.083	0.000
2.0444	0.328	0.671	0.084	0.000
2.1083	0.328	0.692	0.085	0.000
2.1722	0.328	0.713	0.087	0.000

2.2361	0.328	0.734	0.088	0.000
2.3000	0.328	0.755	0.089	0.000
2.3639	0.328	0.776	0.090	0.000
2.4278	0.328	0.797	0.092	0.000
2.4917	0.328	0.818	0.093	0.000
2.5556	0.328	0.839	0.094	0.000
2.6194	0.328	0.860	0.095	0.000
2.6833	0.328	0.881	0.096	0.000
2.7472	0.328	0.902	0.097	0.000
2.8111	0.328	0.923	0.099	0.000
2.8750	0.328	0.944	0.100	0.000
2.9389	0.328	0.965	0.101	0.000
3.0028	0.328	0.986	0.102	0.000
3.0667	0.328	1.007	0.103	0.000
3.1306	0.328	1.028	0.104	0.000
3.1944	0.328	1.049	0.105	0.000
3.2583	0.328	1.070	0.144	0.000
3.3222	0.328	1.091	0.161	0.000
3.3861	0.328	1.112	0.175	0.000
3.4500	0.328	1.133	0.187	0.000
3.5139	0.328	1.154	0.197	0.000
3.5778	0.328	1.175	0.206	0.000
3.6417	0.328	1.196	0.215	0.000
3.7056	0.328	1.217	0.223	0.000
3.7694	0.328	1.238	0.231	0.000
3.8333	0.328	1.259	0.238	0.000
3.8972	0.328	1.280	0.245	0.000
3.9611	0.328	1.301	0.252	0.000
4.0250	0.328	1.322	0.277	0.000
4.0889	0.328	1.343	0.300	0.000
4.1528	0.328	1.364	0.317	0.000
4.2167	0.328	1.385	0.332	0.000
4.2806	0.328	1.406	0.345	0.000
4.3444	0.328	1.427	0.358	0.000
4.4083	0.328	1.448	0.369	0.000
4.4722	0.328	1.469	0.380	0.000
4.5361	0.328	1.490	0.391	0.000
4.6000	0.328	1.511	0.401	0.000
4.6639	0.328	1.532	0.411	0.000
4.7278	0.328	1.553	0.420	0.000
4.7917	0.328	1.574	0.512	0.000
4.8556	0.328	1.595	0.772	0.000
4.9194	0.328	1.616	1.126	0.000
4.9833	0.328	1.637	1.553	0.000
5.0472	0.328	1.658	2.042	0.000
5.1111	0.328	1.679	2.585	0.000
5.1750	0.328	1.700	3.178	0.000
5.2389	0.328	1.721	3.816	0.000
5.3028	0.328	1.742	4.498	0.000
5.3667	0.328	1.763	5.219	0.000
5.4306	0.328	1.784	5.978	0.000
5.4944	0.328	1.805	6.773	0.000
5.5583	0.328	1.826	7.602	0.000
5.6222	0.328	1.847	8.464	0.000
5.6861	0.328	1.868	9.359	0.000
5.7500	0.328	1.888	10.28	0.000

Tank 1

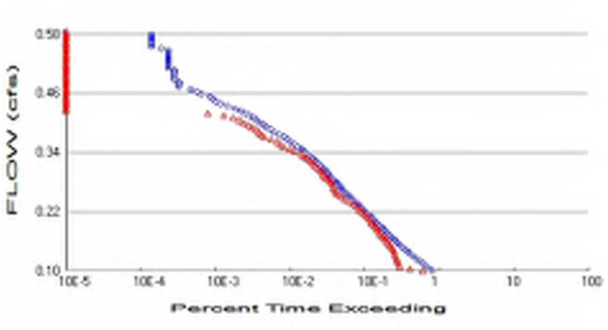
Dimensions
Depth: 8 ft.
Tank Type: Circular
Diameter: 8 ft.
Length: 80 ft.
Discharge Structure
Riser Height: 7.25 ft.
Riser Diameter: 18 in.
Orifice 1 Diameter: 2.875 in. Elevation:0 ft.
Orifice 2 Diameter: 4.75 in. Elevation:6.05 ft.
Element Flows To:
Outlet 1 Outlet 2
Trapezoidal Pond 1

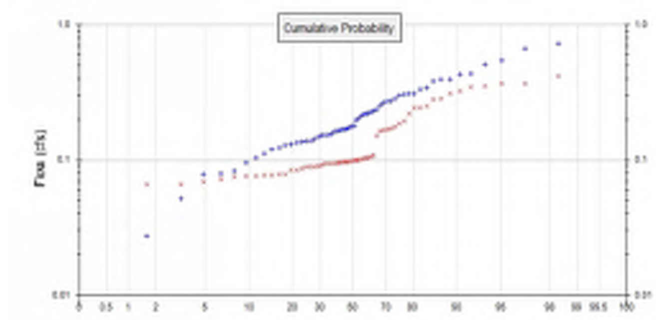
Tank Hydraulic Table

Stage(ft)	Area(ac)	Volume(ac-ft)	Discharge(cfs)	Infilt(cfs)
91.900	0.000	0.000	0.000	0.000
91.989	0.003	0.000	0.064	0.000
92.078	0.004	0.000	0.091	0.000
92.167	0.005	0.000	0.112	0.000
92.256	0.006	0.001	0.129	0.000
92.344	0.006	0.002	0.144	0.000
92.433	0.007	0.002	0.158	0.000
92.522	0.007	0.003	0.171	0.000
92.611	0.008	0.004	0.183	0.000
92.700	0.008	0.004	0.194	0.000
92.789	0.009	0.005	0.204	0.000
92.878	0.009	0.006	0.214	0.000
92.967	0.010	0.007	0.224	0.000
93.056	0.010	0.008	0.233	0.000
93.144	0.010	0.009	0.242	0.000
93.233	0.011	0.010	0.250	0.000
93.322	0.011	0.011	0.258	0.000
93.411	0.011	0.012	0.266	0.000
93.500	0.011	0.013	0.274	0.000
93.589	0.012	0.014	0.282	0.000
93.678	0.012	0.015	0.289	0.000
93.767	0.012	0.016	0.296	0.000
93.856	0.012	0.017	0.303	0.000
93.944	0.012	0.018	0.310	0.000
94.033	0.013	0.019	0.317	0.000
94.122	0.013	0.020	0.323	0.000
94.211	0.013	0.022	0.330	0.000
94.300	0.013	0.023	0.336	0.000
94.389	0.013	0.024	0.342	0.000
94.478	0.013	0.025	0.348	0.000
94.567	0.013	0.026	0.354	0.000
94.656	0.014	0.028	0.360	0.000
94.744	0.014	0.029	0.366	0.000
94.833	0.014	0.030	0.371	0.000
94.922	0.014	0.031	0.377	0.000
95.011	0.014	0.033	0.382	0.000
95.100	0.014	0.034	0.388	0.000
95.189	0.014	0.035	0.393	0.000
95.278	0.014	0.037	0.399	0.000

95.367	0.014	0.038	0.404	0.000
95.456	0.014	0.039	0.409	0.000
95.544	0.014	0.040	0.414	0.000
95.633	0.014	0.042	0.419	0.000
95.722	0.014	0.043	0.424	0.000
95.811	0.014	0.044	0.429	0.000
95.900	0.014	0.046	0.434	0.000
95.989	0.014	0.047	0.439	0.000
96.078	0.014	0.048	0.443	0.000
96.167	0.014	0.050	0.448	0.000
96.256	0.014	0.051	0.453	0.000
96.344	0.014	0.052	0.457	0.000
96.433	0.014	0.054	0.462	0.000
96.522	0.014	0.055	0.466	0.000
96.611	0.014	0.056	0.471	0.000
96.700	0.014	0.057	0.475	0.000
96.789	0.014	0.059	0.480	0.000
96.878	0.014	0.060	0.484	0.000
96.967	0.014	0.061	0.488	0.000
97.056	0.014	0.062	0.492	0.000
97.144	0.014	0.064	0.497	0.000
97.233	0.013	0.065	0.501	0.000
97.322	0.013	0.066	0.505	0.000
97.411	0.013	0.067	0.509	0.000
97.500	0.013	0.069	0.513	0.000
97.589	0.013	0.070	0.517	0.000
97.678	0.013	0.071	0.521	0.000
97.767	0.013	0.072	0.525	0.000
97.856	0.012	0.073	0.529	0.000
97.944	0.012	0.074	0.533	0.000
98.033	0.012	0.075	0.708	0.000
98.122	0.012	0.077	0.787	0.000
98.211	0.012	0.078	0.848	0.000
98.300	0.011	0.079	0.899	0.000
98.389	0.011	0.080	0.945	0.000
98.478	0.011	0.081	0.987	0.000
98.567	0.011	0.082	1.025	0.000
98.656	0.010	0.083	1.062	0.000
98.744	0.010	0.084	1.096	0.000
98.833	0.010	0.085	1.128	0.000
98.922	0.009	0.085	1.159	0.000
99.011	0.009	0.086	1.189	0.000
99.1	0.008	0.087	1.218	0.000
99.188	0.008	0.088	1.357	0.000
99.277	0.007	0.089	1.939	0.000
99.366	0.007	0.089	2.771	0.000
99.455	0.006	0.090	3.791	0.000
99.544	0.006	0.090	4.967	0.000
99.633	0.005	0.091	6.281	0.000
99.722	0.004	0.091	7.719	0.000
99.811	0.003	0.092	9.271	0.000
99.9	0.000	0.092	10.93	0.000
99.988	0.000	0.000	12.68	0.000

Analysis Results
POC 1





\+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 6.72
Total Impervious Area: 0

Mitigated Landuse Totals for POC #1
Total Pervious Area: 4.17
Total Impervious Area: 2.55

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.200089
5 year	0.327864
10 year	0.410021
25 year	0.50775
50 year	0.575443
100 year	0.638672

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.117859
5 year	0.191429
10 year	0.254662
25 year	0.354005
50 year	0.444127
100 year	0.549869

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	0.230	0.084
1950	0.273	0.109
1951	0.437	0.365
1952	0.137	0.074
1953	0.111	0.091
1954	0.170	0.096
1955	0.272	0.093
1956	0.219	0.186
1957	0.177	0.094
1958	0.196	0.100

1959	0.168	0.083
1960	0.302	0.280
1961	0.166	0.104
1962	0.103	0.071
1963	0.142	0.096
1964	0.201	0.097
1965	0.134	0.169
1966	0.128	0.089
1967	0.307	0.101
1968	0.173	0.090
1969	0.168	0.089
1970	0.135	0.094
1971	0.153	0.097
1972	0.332	0.249
1973	0.147	0.166
1974	0.163	0.100
1975	0.227	0.088
1976	0.162	0.095
1977	0.024	0.066
1978	0.137	0.102
1979	0.083	0.068
1980	0.391	0.285
1981	0.123	0.094
1982	0.253	0.193
1983	0.217	0.100
1984	0.131	0.077
1985	0.077	0.078
1986	0.343	0.150
1987	0.303	0.221
1988	0.119	0.078
1989	0.079	0.076
1990	0.725	0.324
1991	0.384	0.242
1992	0.157	0.105
1993	0.153	0.077
1994	0.051	0.065
1995	0.220	0.104
1996	0.507	0.367
1997	0.392	0.348
1998	0.096	0.076
1999	0.429	0.243
2000	0.153	0.097
2001	0.027	0.056
2002	0.177	0.174
2003	0.264	0.087
2004	0.282	0.310
2005	0.209	0.096
2006	0.235	0.168
2007	0.548	0.419
2008	0.668	0.349
2009	0.311	0.164

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.7246	0.4186
2	0.6675	0.3665
3	0.5476	0.3647

4	0.5074	0.3489
5	0.4372	0.3477
6	0.4294	0.3236
7	0.3916	0.3100
8	0.3907	0.2848
9	0.3843	0.2804
10	0.3429	0.2486
11	0.3319	0.2434
12	0.3112	0.2421
13	0.3072	0.2206
14	0.3026	0.1933
15	0.3016	0.1856
16	0.2821	0.1744
17	0.2733	0.1694
18	0.2719	0.1682
19	0.2640	0.1661
20	0.2534	0.1643
21	0.2355	0.1498
22	0.2303	0.1087
23	0.2270	0.1052
24	0.2195	0.1042
25	0.2191	0.1042
26	0.2167	0.1018
27	0.2093	0.1010
28	0.2010	0.0999
29	0.1963	0.0998
30	0.1768	0.0996
31	0.1768	0.0975
32	0.1729	0.0972
33	0.1702	0.0972
34	0.1684	0.0964
35	0.1683	0.0962
36	0.1659	0.0957
37	0.1630	0.0950
38	0.1622	0.0941
39	0.1569	0.0938
40	0.1532	0.0937
41	0.1525	0.0933
42	0.1525	0.0910
43	0.1471	0.0904
44	0.1417	0.0889
45	0.1372	0.0888
46	0.1370	0.0881
47	0.1351	0.0868
48	0.1336	0.0836
49	0.1305	0.0832
50	0.1284	0.0776
51	0.1227	0.0776
52	0.1195	0.0771
53	0.1109	0.0770
54	0.1032	0.0756
55	0.0958	0.0755
56	0.0829	0.0744
57	0.0791	0.0714
58	0.0775	0.0683
59	0.0514	0.0657
60	0.0274	0.0654
61	0.0238	0.0559

Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.1000	17090	12801	74	Pass
0.1048	15736	8641	54	Pass
0.1096	14232	6310	44	Pass
0.1145	12897	6087	47	Pass
0.1193	11625	5897	50	Pass
0.1241	10525	5736	54	Pass
0.1289	9721	5602	57	Pass
0.1337	8859	5443	61	Pass
0.1385	8104	5292	65	Pass
0.1433	7381	5144	69	Pass
0.1481	6740	4862	72	Pass
0.1529	6278	4639	73	Pass
0.1577	5790	4353	75	Pass
0.1625	5347	4081	76	Pass
0.1673	4941	3790	76	Pass
0.1721	4571	3553	77	Pass
0.1769	4295	3397	79	Pass
0.1817	3980	3213	80	Pass
0.1865	3672	3033	82	Pass
0.1913	3401	2851	83	Pass
0.1961	3133	2680	85	Pass
0.2009	2954	2532	85	Pass
0.2057	2733	2389	87	Pass
0.2105	2507	2257	90	Pass
0.2153	2329	2094	89	Pass
0.2201	2136	1910	89	Pass
0.2249	2004	1806	90	Pass
0.2297	1843	1663	90	Pass
0.2345	1717	1503	87	Pass
0.2393	1583	1340	84	Pass
0.2441	1443	1153	79	Pass
0.2489	1346	1031	76	Pass
0.2537	1245	924	74	Pass
0.2585	1157	890	76	Pass
0.2633	1087	860	79	Pass
0.2681	1021	826	80	Pass
0.2729	964	797	82	Pass
0.2777	895	760	84	Pass
0.2825	833	710	85	Pass
0.2873	765	653	85	Pass
0.2921	725	613	84	Pass
0.2969	683	580	84	Pass
0.3017	633	548	86	Pass
0.3065	593	507	85	Pass
0.3113	555	459	82	Pass
0.3161	506	429	84	Pass
0.3209	475	396	83	Pass
0.3257	431	355	82	Pass
0.3305	389	325	83	Pass
0.3353	358	297	82	Pass
0.3401	328	244	74	Pass
0.3449	304	215	70	Pass
0.3497	273	176	64	Pass

0.3546	245	161	65	Pass
0.3594	219	144	65	Pass
0.3642	198	119	60	Pass
0.3690	179	97	54	Pass
0.3738	155	88	56	Pass
0.3786	132	81	61	Pass
0.3834	119	75	63	Pass
0.3882	104	66	63	Pass
0.3930	96	60	62	Pass
0.3978	85	52	61	Pass
0.4026	77	45	58	Pass
0.4074	69	37	53	Pass
0.4122	61	28	45	Pass
0.4170	54	17	31	Pass
0.4218	47	0	0	Pass
0.4266	39	0	0	Pass
0.4314	31	0	0	Pass
0.4362	25	0	0	Pass
0.4410	22	0	0	Pass
0.4458	20	0	0	Pass
0.4506	18	0	0	Pass
0.4554	14	0	0	Pass
0.4602	12	0	0	Pass
0.4650	10	0	0	Pass
0.4698	7	0	0	Pass
0.4746	7	0	0	Pass
0.4794	7	0	0	Pass
0.4842	6	0	0	Pass
0.4890	6	0	0	Pass
0.4938	6	0	0	Pass
0.4986	6	0	0	Pass
0.5034	6	0	0	Pass
0.5082	5	0	0	Pass
0.5130	5	0	0	Pass
0.5178	5	0	0	Pass
0.5226	5	0	0	Pass
0.5274	5	0	0	Pass
0.5322	5	0	0	Pass
0.5370	5	0	0	Pass
0.5418	5	0	0	Pass
0.5466	4	0	0	Pass
0.5514	3	0	0	Pass
0.5562	3	0	0	Pass
0.5610	3	0	0	Pass
0.5658	3	0	0	Pass
0.5706	3	0	0	Pass
0.5754	3	0	0	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0.1801 acre-feet
On-line facility target flow:	0.0912 cfs.
Adjusted for 15 min:	0.0912 cfs.
Off-line facility target flow:	0.0602 cfs.
Adjusted for 15 min:	0.0602 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Trapezoidal Pond 1 POC	☐	671.38			☐	0.00			
Tank 2	☐	155.71			☐	0.00			
Tank 1	☐	515.73			☐	0.00			
Total Volume Infiltrated		1342.82	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50-yr									Duration Analysis Result = Failed

Model Default Modifications

Total of 0 changes have been made.

PERLND Changes

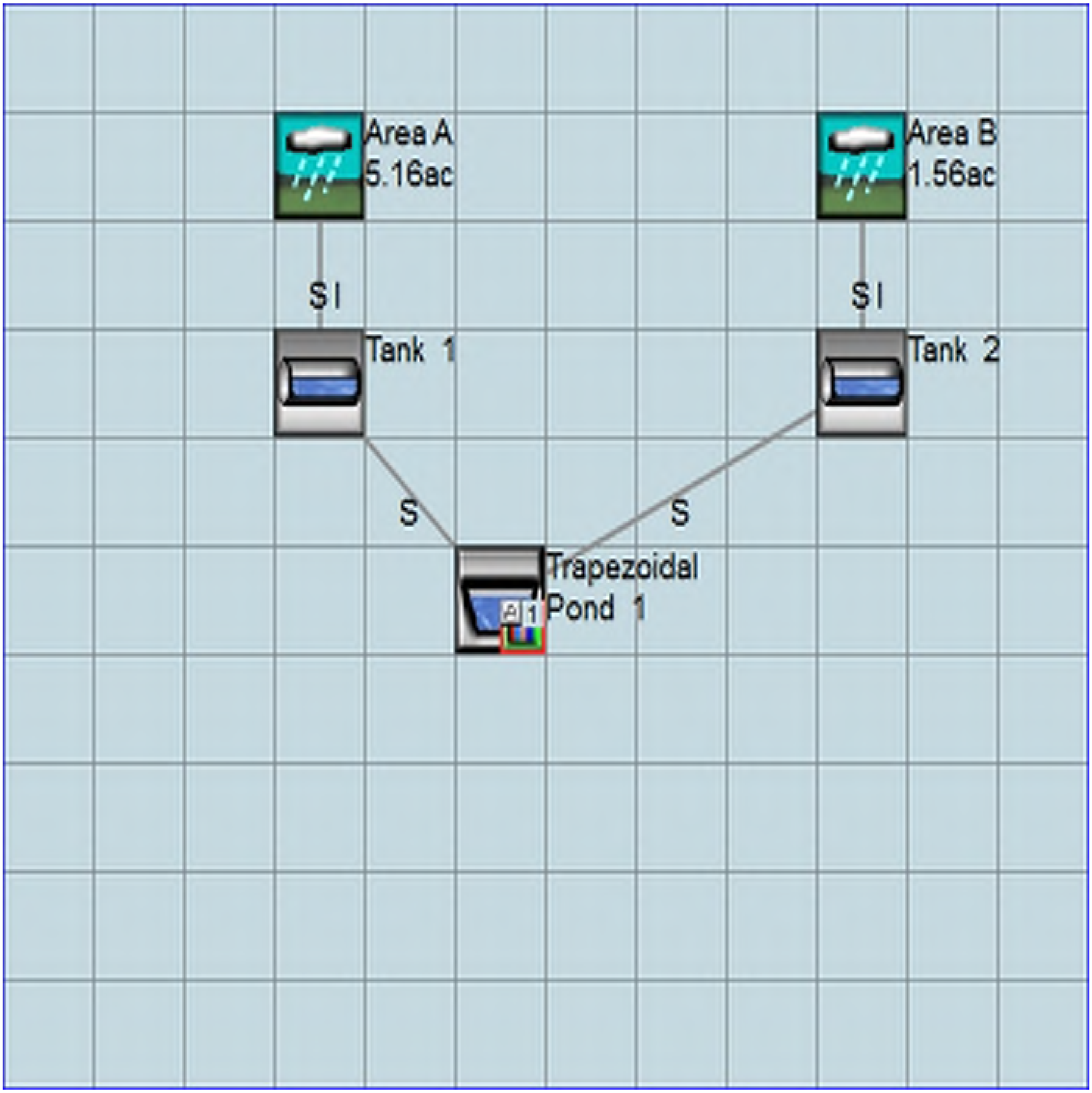
No PERLND changes have been made.

IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic

Mitigated Schematic



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Local (360)943-0304

www.clearcreeksolutions.com

WWHM2012

PROJECT REPORT

Modification Option 2: Proposed Combined Flow Control and Water Quality Facility - Maximize Footprint and Walls

General Model Information

Project Name:	Cherry Valley Vista_05_04_18_prop
Site Name:	Cherry Valley Vista
Site Address:	10/18/17
City:	SMW
Report Date:	5/4/2018
Gage:	Seatac
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	1.00
Version:	2014/09/12

POC Thresholds

Low Flow Threshold for POC1:	50 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year

Landuse Basin Data

Predeveloped Land Use

Area A&B

Bypass:	No
GroundWater:	No
Pervious Land Use	Acres
C, Forest, Mod	6.72
Pervious Total	6.72
Impervious Land Use	Acres
Impervious Total	0
Basin Total	6.72

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Area A

Bypass:	No
GroundWater:	No
Pervious Land Use	Acres
C, Lawn, Mod	3.2
Pervious Total	3.2
Impervious Land Use	Acres
ROADS MOD	1.96
Impervious Total	1.96
Basin Total	5.16

Element Flows To:

Surface	Interflow	Groundwater
Tank 1	Tank 1	

Area B

Bypass:	No	
GroundWater:	No	
Pervious Land Use	Acres	
C, Lawn, Mod	0.97	
Pervious Total	0.97	
Impervious Land Use	Acres	
ROADS MOD	0.59	
Impervious Total	0.59	
Basin Total	1.56	

Element Flows To:

Surface	Interflow	Groundwater
Tank 2	Tank 2	

Routing Elements
Predeveloped Routing

Mitigated Routing

Tank 2

Dimensions
Depth: 8 ft.
Tank Type: Circular
Diameter: 8 ft.
Length: 80 ft.
Discharge Structure
Riser Height: 7.25 ft.
Riser Diameter: 18 in.
Orifice 1 Diameter: 2.875 in. Elevation:0 ft.
Orifice 2 Diameter: 4.75 in. Elevation:6.05 ft.
Element Flows To:
Outlet 1 Outlet 2
Trapezoidal Pond 1

Tank Hydraulic Table

Stage(ft)	**Area(ac)**	**Volume(ac-ft)**	**Discharge(cfs)**	**Infilt(cfs)**
91.900	0.000	0.000	0.000	0.000
91.989	0.003	0.000	0.064	0.000
92.078	0.004	0.000	0.091	0.000
92.167	0.005	0.000	0.112	0.000
92.256	0.006	0.001	0.129	0.000
92.344	0.006	0.002	0.144	0.000
92.433	0.007	0.002	0.158	0.000
92.522	0.007	0.003	0.171	0.000
92.611	0.008	0.004	0.183	0.000
92.700	0.008	0.004	0.194	0.000
92.789	0.009	0.005	0.204	0.000
92.878	0.009	0.006	0.214	0.000
92.967	0.010	0.007	0.224	0.000
93.056	0.010	0.008	0.233	0.000
93.144	0.010	0.009	0.242	0.000
93.233	0.011	0.010	0.250	0.000
93.322	0.011	0.011	0.258	0.000
93.411	0.011	0.012	0.266	0.000
93.500	0.011	0.013	0.274	0.000
93.589	0.012	0.014	0.282	0.000
93.678	0.012	0.015	0.289	0.000
93.767	0.012	0.016	0.296	0.000
93.856	0.012	0.017	0.303	0.000
93.944	0.012	0.018	0.310	0.000
94.033	0.013	0.019	0.317	0.000
94.122	0.013	0.020	0.323	0.000
94.211	0.013	0.022	0.330	0.000
94.300	0.013	0.023	0.336	0.000
94.389	0.013	0.024	0.342	0.000
94.478	0.013	0.025	0.348	0.000
94.567	0.013	0.026	0.354	0.000
94.656	0.014	0.028	0.360	0.000
94.744	0.014	0.029	0.366	0.000
94.833	0.014	0.030	0.371	0.000
94.922	0.014	0.031	0.377	0.000
95.011	0.014	0.033	0.382	0.000
95.100	0.014	0.034	0.388	0.000

95.189	0.014	0.035	0.393	0.000
95.278	0.014	0.037	0.399	0.000
95.367	0.014	0.038	0.404	0.000
95.456	0.014	0.039	0.409	0.000
95.544	0.014	0.040	0.414	0.000
95.633	0.014	0.042	0.419	0.000
95.722	0.014	0.043	0.424	0.000
95.811	0.014	0.044	0.429	0.000
95.900	0.014	0.046	0.434	0.000
95.989	0.014	0.047	0.439	0.000
96.078	0.014	0.048	0.443	0.000
96.167	0.014	0.050	0.448	0.000
96.256	0.014	0.051	0.453	0.000
96.344	0.014	0.052	0.457	0.000
96.433	0.014	0.054	0.462	0.000
96.522	0.014	0.055	0.466	0.000
96.611	0.014	0.056	0.471	0.000
96.700	0.014	0.057	0.475	0.000
96.789	0.014	0.059	0.480	0.000
96.878	0.014	0.060	0.484	0.000
96.967	0.014	0.061	0.488	0.000
97.056	0.014	0.062	0.492	0.000
97.144	0.014	0.064	0.497	0.000
97.233	0.013	0.065	0.501	0.000
97.322	0.013	0.066	0.505	0.000
97.411	0.013	0.067	0.509	0.000
97.500	0.013	0.069	0.513	0.000
97.589	0.013	0.070	0.517	0.000
97.678	0.013	0.071	0.521	0.000
97.767	0.013	0.072	0.525	0.000
97.856	0.012	0.073	0.529	0.000
97.944	0.012	0.074	0.533	0.000
98.033	0.012	0.075	0.708	0.000
98.122	0.012	0.077	0.787	0.000
98.211	0.012	0.078	0.848	0.000
98.300	0.011	0.079	0.899	0.000
98.389	0.011	0.080	0.945	0.000
98.478	0.011	0.081	0.987	0.000
98.567	0.011	0.082	1.025	0.000
98.656	0.010	0.083	1.062	0.000
98.744	0.010	0.084	1.096	0.000
98.833	0.010	0.085	1.128	0.000
98.922	0.009	0.085	1.159	0.000
99.011	0.009	0.086	1.189	0.000
99.1	0.008	0.087	1.218	0.000
99.188	0.008	0.088	1.357	0.000
99.277	0.007	0.089	1.939	0.000
99.366	0.007	0.089	2.771	0.000
99.455	0.006	0.090	3.791	0.000
99.544	0.006	0.090	4.967	0.000
99.633	0.005	0.091	6.281	0.000
99.722	0.004	0.091	7.719	0.000
99.811	0.003	0.092	9.271	0.000
99.9	0.000	0.092	10.93	0.000
99.988	0.000	0.000	12.68	0.000

Trapezoidal Pond 1

Bottom Length:	100.00 ft.
Bottom Width:	78.00 ft.
Depth:	5.75 ft.
Volume at riser head:	0.8580 acre-ft.
Side slope 1:	0 To 1
Side slope 2:	0 To 1
Side slope 3:	0 To 1
Side slope 4:	0 To 1
Discharge Structure	
Riser Height:	4.75 ft.
Riser Diameter:	12 in.
Orifice 1 Diameter:	1.5 in. Elevation:0 ft.
Orifice 2 Diameter:	2.425 in. Elevation:3.2 ft.
Orifice 3 Diameter:	2.125 in. Elevation:4 ft.
Element Flows To:	

Outlet 1 Outlet 2

Pond Hydraulic Table

Stage(ft)	**Area(ac)**	**Volume(ac-ft)**	**Discharge(cfs)**	**Infilt(cfs)**
0.0000	0.179	0.000	0.000	0.000
0.0639	0.179	0.011	0.014	0.000
0.1278	0.179	0.022	0.021	0.000
0.1917	0.179	0.034	0.025	0.000
0.2556	0.179	0.045	0.029	0.000
0.3194	0.179	0.057	0.033	0.000
0.3833	0.179	0.068	0.036	0.000
0.4472	0.179	0.080	0.039	0.000
0.5111	0.179	0.091	0.042	0.000
0.5750	0.179	0.103	0.044	0.000
0.6389	0.179	0.114	0.047	0.000
0.7028	0.179	0.125	0.049	0.000
0.7667	0.179	0.137	0.051	0.000
0.8306	0.179	0.148	0.053	0.000
0.8944	0.179	0.160	0.055	0.000
0.9583	0.179	0.171	0.057	0.000
1.0222	0.179	0.183	0.059	0.000
1.0861	0.179	0.194	0.061	0.000
1.1500	0.179	0.205	0.063	0.000
1.2139	0.179	0.217	0.065	0.000
1.2778	0.179	0.228	0.066	0.000
1.3417	0.179	0.240	0.068	0.000
1.4056	0.179	0.251	0.070	0.000
1.4694	0.179	0.263	0.071	0.000
1.5333	0.179	0.274	0.073	0.000
1.5972	0.179	0.286	0.074	0.000
1.6611	0.179	0.297	0.076	0.000
1.7250	0.179	0.308	0.077	0.000
1.7889	0.179	0.320	0.079	0.000
1.8528	0.179	0.331	0.080	0.000
1.9167	0.179	0.343	0.081	0.000
1.9806	0.179	0.354	0.083	0.000
2.0444	0.179	0.366	0.084	0.000
2.1083	0.179	0.377	0.085	0.000
2.1722	0.179	0.389	0.087	0.000

2.2361	0.179	0.400	0.088	0.000
2.3000	0.179	0.411	0.089	0.000
2.3639	0.179	0.423	0.090	0.000
2.4278	0.179	0.434	0.092	0.000
2.4917	0.179	0.446	0.093	0.000
2.5556	0.179	0.457	0.094	0.000
2.6194	0.179	0.469	0.095	0.000
2.6833	0.179	0.480	0.096	0.000
2.7472	0.179	0.491	0.097	0.000
2.8111	0.179	0.503	0.099	0.000
2.8750	0.179	0.514	0.100	0.000
2.9389	0.179	0.526	0.101	0.000
3.0028	0.179	0.537	0.102	0.000
3.0667	0.179	0.549	0.103	0.000
3.1306	0.179	0.560	0.104	0.000
3.1944	0.179	0.572	0.105	0.000
3.2583	0.179	0.583	0.144	0.000
3.3222	0.179	0.594	0.161	0.000
3.3861	0.179	0.606	0.175	0.000
3.4500	0.179	0.617	0.187	0.000
3.5139	0.179	0.629	0.197	0.000
3.5778	0.179	0.640	0.206	0.000
3.6417	0.179	0.652	0.215	0.000
3.7056	0.179	0.663	0.223	0.000
3.7694	0.179	0.675	0.231	0.000
3.8333	0.179	0.686	0.238	0.000
3.8972	0.179	0.697	0.245	0.000
3.9611	0.179	0.709	0.252	0.000
4.0250	0.179	0.720	0.277	0.000
4.0889	0.179	0.732	0.300	0.000
4.1528	0.179	0.743	0.317	0.000
4.2167	0.179	0.755	0.332	0.000
4.2806	0.179	0.766	0.345	0.000
4.3444	0.179	0.777	0.358	0.000
4.4083	0.179	0.789	0.369	0.000
4.4722	0.179	0.800	0.380	0.000
4.5361	0.179	0.812	0.391	0.000
4.6000	0.179	0.823	0.401	0.000
4.6639	0.179	0.835	0.411	0.000
4.7278	0.179	0.846	0.420	0.000
4.7917	0.179	0.858	0.512	0.000
4.8556	0.179	0.869	0.772	0.000
4.9194	0.179	0.880	1.126	0.000
4.9833	0.179	0.892	1.553	0.000
5.0472	0.179	0.903	2.042	0.000
5.1111	0.179	0.915	2.585	0.000
5.1750	0.179	0.926	3.178	0.000
5.2389	0.179	0.938	3.816	0.000
5.3028	0.179	0.949	4.498	0.000
5.3667	0.179	0.961	5.219	0.000
5.4306	0.179	0.972	5.978	0.000
5.4944	0.179	0.983	6.773	0.000
5.5583	0.179	0.995	7.602	0.000
5.6222	0.179	1.006	8.464	0.000
5.6861	0.179	1.018	9.359	0.000
5.7500	0.179	1.029	10.28	0.000

Tank 1

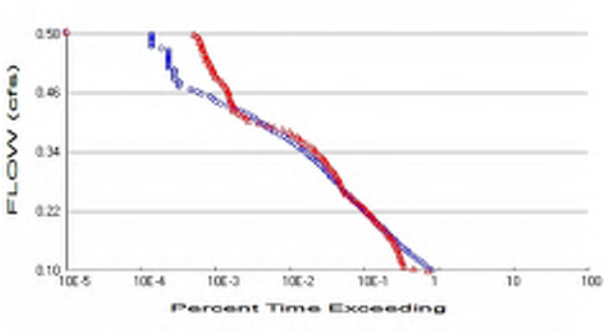
Dimensions
Depth: 8 ft.
Tank Type: Circular
Diameter: 8 ft.
Length: 80 ft.
Discharge Structure
Riser Height: 7.25 ft.
Riser Diameter: 18 in.
Orifice 1 Diameter: 2.875 in. Elevation:0 ft.
Orifice 2 Diameter: 4.75 in. Elevation:6.05 ft.
Element Flows To:
Outlet 1 Outlet 2
Trapezoidal Pond 1

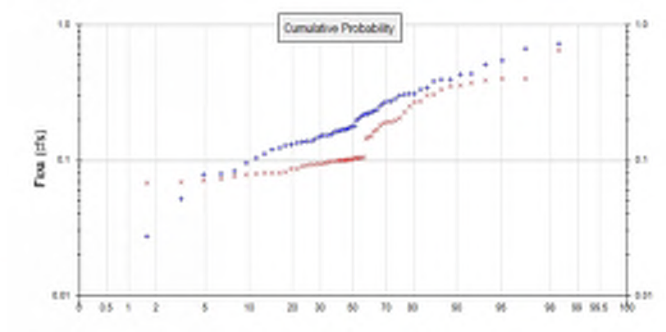
Tank Hydraulic Table

Stage(ft)	Area(ac)	Volume(ac-ft)	Discharge(cfs)	Infilt(cfs)
91.900	0.000	0.000	0.000	0.000
91.989	0.003	0.000	0.064	0.000
92.078	0.004	0.000	0.091	0.000
92.167	0.005	0.000	0.112	0.000
92.256	0.006	0.001	0.129	0.000
92.344	0.006	0.002	0.144	0.000
92.433	0.007	0.002	0.158	0.000
92.522	0.007	0.003	0.171	0.000
92.611	0.008	0.004	0.183	0.000
92.700	0.008	0.004	0.194	0.000
92.789	0.009	0.005	0.204	0.000
92.878	0.009	0.006	0.214	0.000
92.967	0.010	0.007	0.224	0.000
93.056	0.010	0.008	0.233	0.000
93.144	0.010	0.009	0.242	0.000
93.233	0.011	0.010	0.250	0.000
93.322	0.011	0.011	0.258	0.000
93.411	0.011	0.012	0.266	0.000
93.500	0.011	0.013	0.274	0.000
93.589	0.012	0.014	0.282	0.000
93.678	0.012	0.015	0.289	0.000
93.767	0.012	0.016	0.296	0.000
93.856	0.012	0.017	0.303	0.000
93.944	0.012	0.018	0.310	0.000
94.033	0.013	0.019	0.317	0.000
94.122	0.013	0.020	0.323	0.000
94.211	0.013	0.022	0.330	0.000
94.300	0.013	0.023	0.336	0.000
94.389	0.013	0.024	0.342	0.000
94.478	0.013	0.025	0.348	0.000
94.567	0.013	0.026	0.354	0.000
94.656	0.014	0.028	0.360	0.000
94.744	0.014	0.029	0.366	0.000
94.833	0.014	0.030	0.371	0.000
94.922	0.014	0.031	0.377	0.000
95.011	0.014	0.033	0.382	0.000
95.100	0.014	0.034	0.388	0.000
95.189	0.014	0.035	0.393	0.000
95.278	0.014	0.037	0.399	0.000

95.367	0.014	0.038	0.404	0.000
95.456	0.014	0.039	0.409	0.000
95.544	0.014	0.040	0.414	0.000
95.633	0.014	0.042	0.419	0.000
95.722	0.014	0.043	0.424	0.000
95.811	0.014	0.044	0.429	0.000
95.900	0.014	0.046	0.434	0.000
95.989	0.014	0.047	0.439	0.000
96.078	0.014	0.048	0.443	0.000
96.167	0.014	0.050	0.448	0.000
96.256	0.014	0.051	0.453	0.000
96.344	0.014	0.052	0.457	0.000
96.433	0.014	0.054	0.462	0.000
96.522	0.014	0.055	0.466	0.000
96.611	0.014	0.056	0.471	0.000
96.700	0.014	0.057	0.475	0.000
96.789	0.014	0.059	0.480	0.000
96.878	0.014	0.060	0.484	0.000
96.967	0.014	0.061	0.488	0.000
97.056	0.014	0.062	0.492	0.000
97.144	0.014	0.064	0.497	0.000
97.233	0.013	0.065	0.501	0.000
97.322	0.013	0.066	0.505	0.000
97.411	0.013	0.067	0.509	0.000
97.500	0.013	0.069	0.513	0.000
97.589	0.013	0.070	0.517	0.000
97.678	0.013	0.071	0.521	0.000
97.767	0.013	0.072	0.525	0.000
97.856	0.012	0.073	0.529	0.000
97.944	0.012	0.074	0.533	0.000
98.033	0.012	0.075	0.708	0.000
98.122	0.012	0.077	0.787	0.000
98.211	0.012	0.078	0.848	0.000
98.300	0.011	0.079	0.899	0.000
98.389	0.011	0.080	0.945	0.000
98.478	0.011	0.081	0.987	0.000
98.567	0.011	0.082	1.025	0.000
98.656	0.010	0.083	1.062	0.000
98.744	0.010	0.084	1.096	0.000
98.833	0.010	0.085	1.128	0.000
98.922	0.009	0.085	1.159	0.000
99.011	0.009	0.086	1.189	0.000
99.1	0.008	0.087	1.218	0.000
99.188	0.008	0.088	1.357	0.000
99.277	0.007	0.089	1.939	0.000
99.366	0.007	0.089	2.771	0.000
99.455	0.006	0.090	3.791	0.000
99.544	0.006	0.090	4.967	0.000
99.633	0.005	0.091	6.281	0.000
99.722	0.004	0.091	7.719	0.000
99.811	0.003	0.092	9.271	0.000
99.9	0.000	0.092	10.93	0.000
99.988	0.000	0.000	12.68	0.000

Analysis Results
POC 1





+ Predeveloped   x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 6.72
Total Impervious Area: 0

Mitigated Landuse Totals for POC #1
Total Pervious Area: 4.17
Total Impervious Area: 2.55

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.200089
5 year	0.327864
10 year	0.410021
25 year	0.50775
50 year	0.575443
100 year	0.638672

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.129501
5 year	0.218
10 year	0.294507
25 year	0.415041
50 year	0.524511
100 year	0.652961

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	0.230	0.086
1950	0.273	0.163
1951	0.437	0.398
1952	0.137	0.076
1953	0.111	0.094
1954	0.170	0.100
1955	0.272	0.098
1956	0.219	0.205
1957	0.177	0.098
1958	0.196	0.104

1959	0.168	0.086
1960	0.302	0.333
1961	0.166	0.149
1962	0.103	0.073
1963	0.142	0.100
1964	0.201	0.100
1965	0.134	0.191
1966	0.128	0.092
1967	0.307	0.104
1968	0.173	0.093
1969	0.168	0.091
1970	0.135	0.096
1971	0.153	0.101
1972	0.332	0.271
1973	0.147	0.169
1974	0.163	0.103
1975	0.227	0.092
1976	0.162	0.099
1977	0.024	0.068
1978	0.137	0.105
1979	0.083	0.071
1980	0.391	0.304
1981	0.123	0.096
1982	0.253	0.225
1983	0.217	0.104
1984	0.131	0.080
1985	0.077	0.081
1986	0.343	0.180
1987	0.303	0.249
1988	0.119	0.080
1989	0.079	0.079
1990	0.725	0.372
1991	0.384	0.302
1992	0.157	0.149
1993	0.153	0.080
1994	0.051	0.068
1995	0.220	0.144
1996	0.507	0.399
1997	0.392	0.357
1998	0.096	0.079
1999	0.429	0.267
2000	0.153	0.101
2001	0.027	0.059
2002	0.177	0.191
2003	0.264	0.090
2004	0.282	0.353
2005	0.209	0.100
2006	0.235	0.188
2007	0.548	0.646
2008	0.668	0.389
2009	0.311	0.197

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.7246	0.6457
2	0.6675	0.3993
3	0.5476	0.3980

4	0.5074	0.3886
5	0.4372	0.3725
6	0.4294	0.3567
7	0.3916	0.3527
8	0.3907	0.3331
9	0.3843	0.3035
10	0.3429	0.3019
11	0.3319	0.2706
12	0.3112	0.2670
13	0.3072	0.2489
14	0.3026	0.2253
15	0.3016	0.2049
16	0.2821	0.1972
17	0.2733	0.1914
18	0.2719	0.1911
19	0.2640	0.1878
20	0.2534	0.1803
21	0.2355	0.1688
22	0.2303	0.1627
23	0.2270	0.1495
24	0.2195	0.1487
25	0.2191	0.1440
26	0.2167	0.1054
27	0.2093	0.1042
28	0.2010	0.1037
29	0.1963	0.1035
30	0.1768	0.1031
31	0.1768	0.1015
32	0.1729	0.1015
33	0.1702	0.1001
34	0.1684	0.0999
35	0.1683	0.0999
36	0.1659	0.0996
37	0.1630	0.0990
38	0.1622	0.0979
39	0.1569	0.0975
40	0.1532	0.0963
41	0.1525	0.0957
42	0.1525	0.0938
43	0.1471	0.0933
44	0.1417	0.0921
45	0.1372	0.0920
46	0.1370	0.0909
47	0.1351	0.0898
48	0.1336	0.0859
49	0.1305	0.0857
50	0.1284	0.0809
51	0.1227	0.0805
52	0.1195	0.0801
53	0.1109	0.0797
54	0.1032	0.0790
55	0.0958	0.0785
56	0.0829	0.0764
57	0.0791	0.0731
58	0.0775	0.0707
59	0.0514	0.0683
60	0.0274	0.0678
61	0.0238	0.0586

Duration Flows

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.1000	17090	15156	88	Pass
0.1048	15736	9706	61	Pass
0.1096	14232	7199	50	Pass
0.1145	12897	6962	53	Pass
0.1193	11625	6748	58	Pass
0.1241	10525	6560	62	Pass
0.1289	9721	6427	66	Pass
0.1337	8859	6284	70	Pass
0.1385	8104	6130	75	Pass
0.1433	7381	5974	80	Pass
0.1481	6740	5689	84	Pass
0.1529	6278	5486	87	Pass
0.1577	5790	5251	90	Pass
0.1625	5347	5001	93	Pass
0.1673	4941	4669	94	Pass
0.1721	4571	4398	96	Pass
0.1769	4295	4169	97	Pass
0.1817	3980	3861	97	Pass
0.1865	3672	3615	98	Pass
0.1913	3401	3341	98	Pass
0.1961	3133	3125	99	Pass
0.2009	2954	2950	99	Pass
0.2057	2733	2753	100	Pass
0.2105	2507	2603	103	Pass
0.2153	2329	2436	104	Pass
0.2201	2136	2257	105	Pass
0.2249	2004	2122	105	Pass
0.2297	1843	1961	106	Pass
0.2345	1717	1805	105	Pass
0.2393	1583	1648	104	Pass
0.2441	1443	1502	104	Pass
0.2489	1346	1375	102	Pass
0.2537	1245	1218	97	Pass
0.2585	1157	1165	100	Pass
0.2633	1087	1114	102	Pass
0.2681	1021	1067	104	Pass
0.2729	964	1038	107	Pass
0.2777	895	1006	112	Fail
0.2825	833	974	116	Fail
0.2873	765	935	122	Fail
0.2921	725	891	122	Fail
0.2969	683	844	123	Fail
0.3017	633	792	125	Fail
0.3065	593	728	122	Fail
0.3113	555	692	124	Fail
0.3161	506	661	130	Fail
0.3209	475	632	133	Fail
0.3257	431	593	137	Fail
0.3305	389	552	141	Fail
0.3353	358	503	140	Fail
0.3401	328	471	143	Fail
0.3449	304	445	146	Fail
0.3497	273	408	149	Fail
0.3546	245	346	141	Fail

0.3594	219	310	141	Fail
0.3642	198	288	145	Fail
0.3690	179	269	150	Fail
0.3738	155	229	147	Fail
0.3786	132	211	159	Fail
0.3834	119	170	142	Fail
0.3882	104	129	124	Fail
0.3930	96	109	113	Fail
0.3978	85	82	96	Pass
0.4026	77	59	76	Pass
0.4074	69	54	78	Pass
0.4122	61	48	78	Pass
0.4170	54	43	79	Pass
0.4218	47	38	80	Pass
0.4266	39	37	94	Pass
0.4314	31	37	119	Fail
0.4362	25	35	140	Fail
0.4410	22	35	159	Fail
0.4458	20	34	170	Fail
0.4506	18	33	183	Fail
0.4554	14	32	228	Fail
0.4602	12	32	266	Fail
0.4650	10	31	310	Fail
0.4698	7	29	414	Fail
0.4746	7	27	385	Fail
0.4794	7	26	371	Fail
0.4842	6	24	400	Fail
0.4890	6	22	366	Fail
0.4938	6	21	350	Fail
0.4986	6	20	333	Fail
0.5034	6	20	333	Fail
0.5082	5	19	380	Fail
0.5130	5	18	360	Fail
0.5178	5	18	360	Fail
0.5226	5	16	320	Fail
0.5274	5	16	320	Fail
0.5322	5	16	320	Fail
0.5370	5	15	300	Fail
0.5418	5	15	300	Fail
0.5466	4	14	350	Fail
0.5514	3	14	466	Fail
0.5562	3	14	466	Fail
0.5610	3	13	433	Fail
0.5658	3	13	433	Fail
0.5706	3	12	400	Fail
0.5754	3	11	366	Fail

The development has an increase in flow durations from 1/2 Predeveloped 2 year flow to the 2 year flow or more than a 10% increase from the 2 year to the 50 year flow.
The development has an increase in flow durations for more than 50% of the flows for the range of the duration analysis.

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0.1856 acre-feet
On-line facility target flow:	0.0937 cfs.
Adjusted for 15 min:	0.0937 cfs.
Off-line facility target flow:	0.0623 cfs.
Adjusted for 15 min:	0.0623 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Trapezoidal Pond 1 POC	☐	671.44			☐	0.00			
Tank 2	☐	155.71			☐	0.00			
Tank 1	☐	515.73			☐	0.00			
Total Volume Infiltrated		1342.89	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50-yr									Duration Analysis Result = Failed

Model Default Modifications

Total of 0 changes have been made.

PERLND Changes

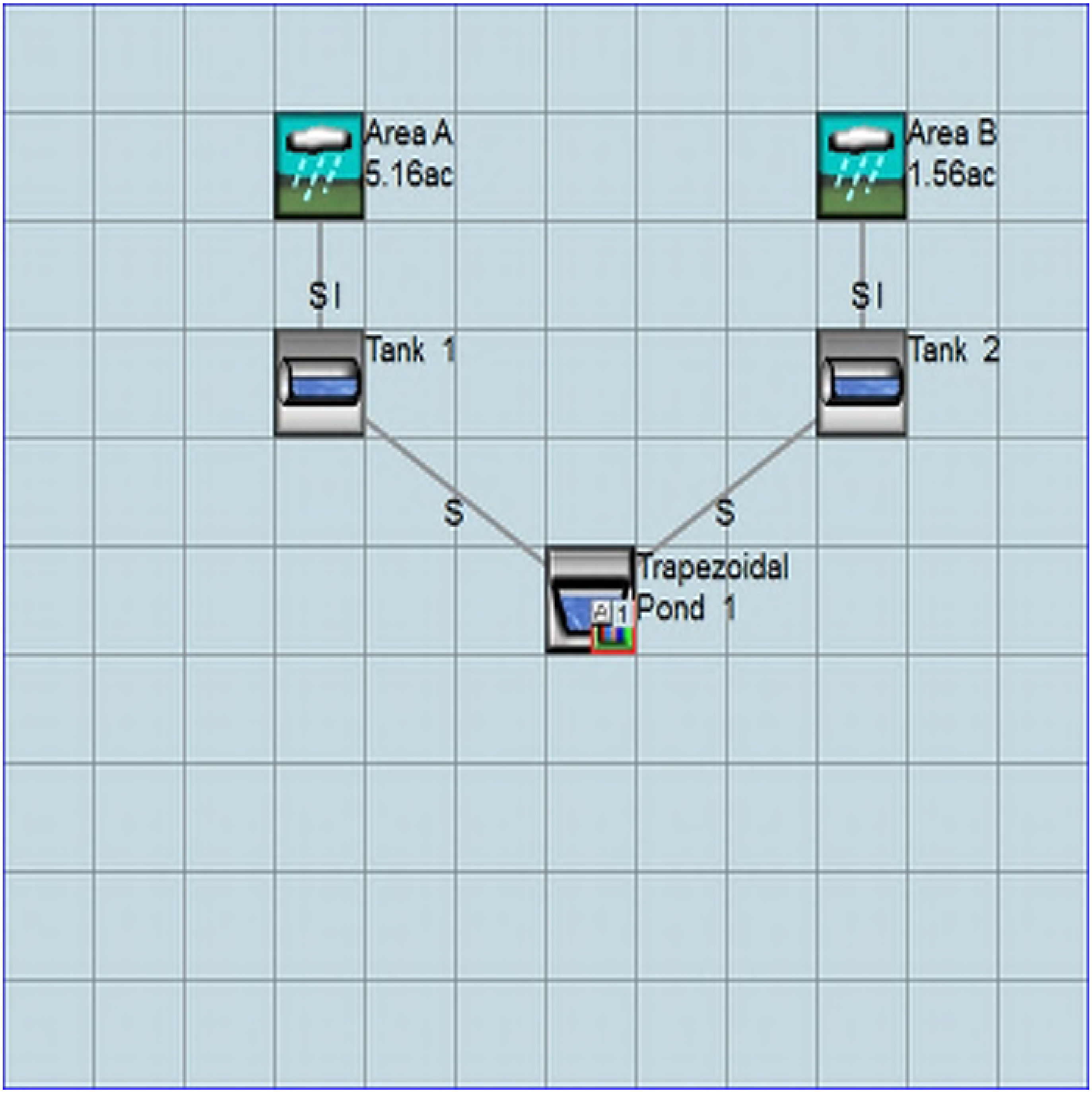
No PERLND changes have been made.

IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic

Mitigated Schematic



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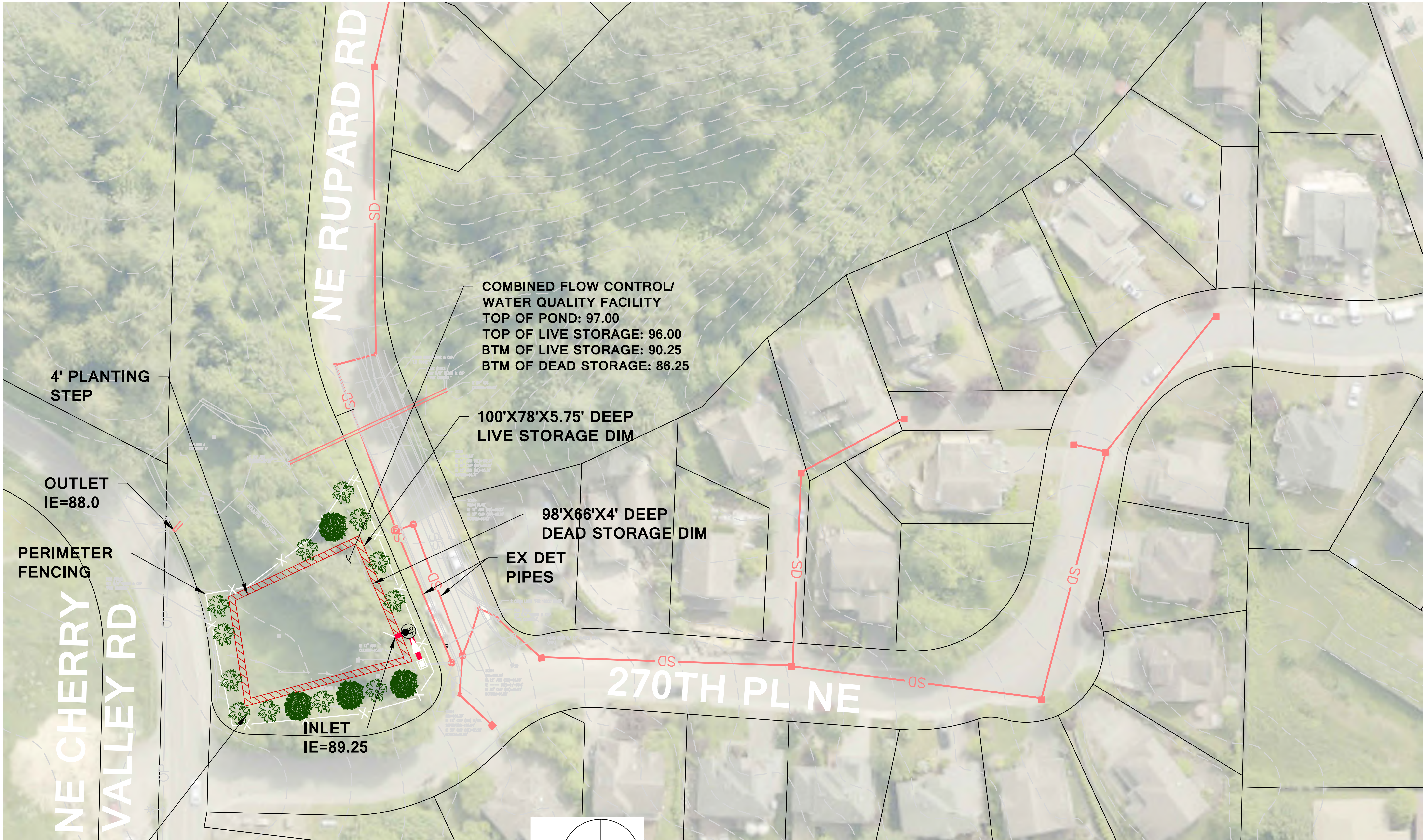

N

1"= 60'

0 60

Scale Feet

SMW	
Design	AAM
Drawn	2017-10-24
Date	374-001-16
Project No.	

S D A
Civil Engineering
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DUVALL WATERSHED PLAN
CHERRY VALLEY VISTA

CONCEPTUAL DESIGN

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May 04, 2018 – 9:27AM Last Saved By: SWelch

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