Surface and Stormwater Comprehensive Plan

City of Bellingham

August 20, 2020

Certificate of Engineer

The report and data contained in this report for the City of Bellingham Surface and Stormwater Comprehensive Plan and Rate Study Plan were prepared under the supervision and direction of the undersigned, whose seal, as a professional engineer licensed to practice as such, is affixed below.

(Signature along with sealed stamp to be provided with Final Drainage Report)

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Acknowledgements

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City of Bellingham

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Abbreviations

µg	microgram(s)
AACE	Association for the Advancement of Cost Engineering
ac	acre(s)
ac-ft	acre-foot/feet
AKART	all known, available, and reasonable methods of prevention, control,
ANSI	American National Standards Institute
AWWA	American Water Works Association
B-IBI	benthic index of biotic integrity
BMC	Bellingham Municipal Code
BMP	best management practice
B-IBI	benthic index of biotic integrity
BTV	Bellingham Television
CCI	Construction Cost Index
CCTV	closed-circuit television
CESCL	Certified Erosion and Sediment Control Lead
CIG	Climate Impacts Group
CIP	Capital Improvement Plan
City	City of Bellingham
CMMS	computerized maintenance management system
CMP	corrugated metal pipe
CN	curve number
County	Whatcom County
CPI	Consumer Price Index
CSR	customer service request
DCD	Department of Community Development
DIP	ductile iron pipe
DSCR	debt service coverage ratio
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
EV	Environmental
ft	foot/feet
ft^2	square foot/feet
ft/ft	foot/feet horizontal:foot/feet vertical
FTE	full-time equivalent
FY	fiscal year
GASB	Governmental Accounting Standards Board
GHG	greenhouse gas
GIS	Geographic Information System
GSI	green stormwater infrastructure
Habitat Restoration	2015 *Bellingham Habitat Restoration Technical Assessment*
HDR	HDR Engineering, Inc.
HPC	high pulse count
HPR	high pulse range
HSPF	Hydrological Simulation Program-Fortran

Abbreviations

I-5	Interstate 5
ID	identifier
IDDE	illicit discharge detection and elimination
IMPLND	impervious land
IPCC	Intergovernmental Panel on Climate Change
JARPA	Joint Aquatic Resources Permit Application
L	liter(s)
lb	pound(s)
LU	Land Use
Lf	linear foot/feet
LID	low-impact development
MEP	maximum extent practicable
MFR	multifamily residential
MHI	median household income
mL	milliliter(s)
M&O	Maintenance and Operations
MOU	memorandum of understanding
MPN	most probable number
MS4	municipal separate storm sewer system
NA	not applicable
ND	not detected
NFIP	National Flood Insurance Program
NO_2+NO_3	nitrogen dioxide plus nitrate
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NSQD	National Stormwater Quality Database
OHP	overhead power
O&M	operation and maintenance
PERLND	pervious land
Phase II Permit	Western Washington Phase II Municipal Stormwater Permit
PI	Priority Index
PIC	Pollution Identification and Correction Program
PM	preventive maintenance
Prioritization	2010 *City of Bellingham Culvert Improvement Prioritization: Phase I*
PURC	Pavement and Utility Rating Committee
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
QC	quality control
RCP	reinforced concrete pipe
RCW	Revised Code of Washington
ROW	right-of-way
SAM	Stormwater Action Monitoring
SDC	system development charge

Abbreviations

SF	South Fork
SFR	single-family residential
SLR	sea level rise
SMAP	Stormwater Management Action Plan/planning
SOP	standard operating procedure
SSWCP	Surface and Stormwater Comprehensive Plan
SSWU	Surface and Stormwater Utility
State	Washington State
SWMM	Storm Water Management Model
SWMMWW	*Stormwater Management Manual for Western Washington*
SWMP	Stormwater Management Program
SWPPP	Stormwater Pollution Prevention Plan
TMDL	total maximum daily load
TQ Mean	fraction of time that stream flow exceeds the daily mean
TSS	total suspended sediment
USGS	United States Geological Survey
USMP	Urban Streams Monitoring Program
UW	University of Washington
WSDOT	Washington State Department of Transportation
VIT	vitrified clay pipe
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WSDOT	Washington State Department of Transportation
WWHM	Western Washington Hydrology Model
WWHM3	Western Washington Hydrology Model 3

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1 Introduction

When rain falls in forested or undeveloped areas, some of the rainfall is absorbed by trees and plants, and most of it seeps or infiltrates into the ground. In developed or urban areas, the impervious surfaces (hard surfaces including roofs, driveways, sidewalks, roadways, and turf fields) do not allow the rain to infiltrate. Instead, the rain becomes stormwater runoff as it travels across hard or impervious surfaces, often picking up sediment and pollutants along the way. Stormwater flows across impervious surfaces and into catch basins or other stormwater system infrastructure through an underground network of pipes and then into natural waterways. Managing surface flows and stormwater in Bellingham is the responsibility of the City of Bellingham's Public Works Department (City) Surface and Stormwater Utility (SSWU).

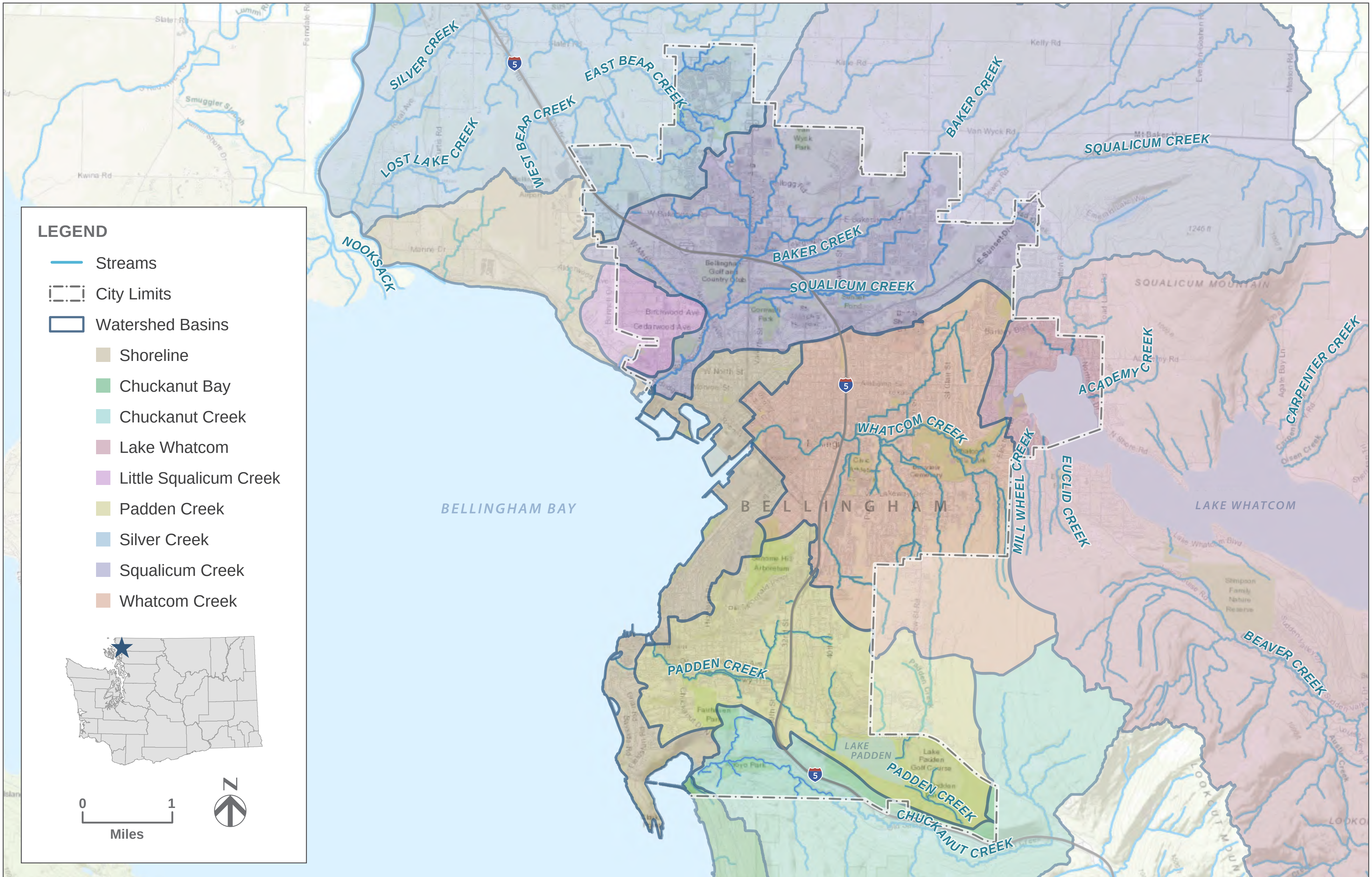
Lake Whatcom

The SSWU's core responsibilities are as follows:

- Protect aquatic resources
- Respond to flooding and erosion damages
- Reduce flood risk
- Reduce the discharge of pollutants
- Improve fish habitat

The City's SSWU operates to reduce water pollution being discharged into nearby wetlands, ponds, streams, creeks, lakes, and surrounding water bodies, like Bellingham Bay and Chuckanut Bay. Lake Whatcom is the drinking water source for more than 120,000 Bellingham residents, so clean stormwater runoff that discharges to it is one of the City's priorities. The City has implemented various programs to improve water quality such as the Lake Whatcom Management Program, Bellingham Water Quality Improvement Plans, Habitat Restoration Plans, and waterfront restoration programs.

The Bellingham Municipal Code (BMC) includes stormwater mitigation requirements for new development and redeveloping properties within city limits designated by the City of Bellingham's Western Washington Phase II Municipal Stormwater Permit (Phase II Permit) to help meet State of Washington (State) water quality standards in the receiving water bodies. For the City, stormwater collected by the City's storm drainage networks discharges to Chuckanut Creek, Padden Creek, Whatcom Creek, Squalicum Creek and its tributaries (Baker Creek and Spring Creek), Little Squalicum Creek, East Bear Creek, Lake Whatcom, Lake Padden, Bellingham Bay, and Chuckanut Bay, as shown in Figure 1-1.



PROJECT VICIVITY

FIGURE 1-1

City of Bellingham

Surface and Stormwater Comprehensive Plan

UPDATED 8/20/2020

1.1 Purpose and Authority

The City's SSWU is responsible for operation of the City's storm drainage system under the regulatory framework of the Phase II Permit. The City carries out this responsibility in part by having a comprehensive Stormwater Management Program (SWMP) that establishes policy and service level standards, and a Capital Improvement Plan (CIP) designed to meet the goals and objectives of the SSWU. The purpose of this update to the Surface and Stormwater Comprehensive Plan (SSWCP) is to provide goals, policies, guidance, and planned program activities that will help the City meet regulatory requirements and create funding mechanisms to support a CIP, development permit reviews, and maintenance requirements for the SSWU for the years 2020 to 2026. The recommendations set forth in this SSWCP will be the basis of SSWU rates for the planning horizon.

In summary, this SSWCP:

- Describes the City's organizational approach to managing stormwater
- Evaluates the proposed CIP that supports the City's overall stormwater management goals
- Evaluates the role and management programs instituted to carry out regulatory requirements stipulated in the City's Phase II Permit
- Provides retrofit planning recommendations to address water quality concerns in areas developed prior to the use of stormwater regulations
- Recommends capital improvement projects for improving water quality, aquatic habitat, flood reduction, and infrastructure renewal
- Provides the basis for conducting an SSWU rate study
- Serves as a guide to future users to help mitigate water quality impacts

The SSWCP is organized into the following 10 chapters:

- **Chapter 1: Introduction**.
- **Chapter 2: Background,** describes the city's population growth, its history, and the sub-watersheds that are the focus of this update.
- **Chapter 3, Hydrology,** is an analysis of the City's stream flow monitoring program and a summary of past hydrologic modeling that established design flows throughout the city. The predicted design flows could be a starting point for CIP design. Chapter 3 also describes the 2020 review of past models.
- **Chapter 4, Climate Change Considerations for Stormwater Planning**, is an assessment of predicted effects on stormwater planning based on sea level rise (SLR) and changing precipitation patterns. The chapter relies on information published by the University of Washington (UW) Climate Impacts Group (CIG).
- **Chapter 5, Stormwater Condition Assessment Program**, describes the City's ongoing asset management program, culminating with program recommendations. The

recommendations are based on analysis of the City's asset inventory, a condition assessment strategy, and conditions-based maintenance and funding recommendations that are factored into the rate study.

- **Chapter 6, Stormwater Management Program Evaluation**, describes an evaluation of the City's activities to meet the 2019–2024 Phase II Permit requirements and identified SMWP gaps and opportunities. Chapter 6 presents the findings from this analysis, involving a step-by-step review of the City's SWMP as detailed in its Stormwater Annual Plan to the Washington State Department of Ecology (Ecology). The comprehensive gap analysis was based on current levels of service compared to SWMP requirements stipulated by the Phase II Permit.
- **Chapter 7, Stormwater System Analysis**, describes the analyses conducted to identify system deficiencies that the capital improvement plan would address. Chapter 7 breaks down the various system analyses that were part of the SSWCP update. The city was evaluated for stormwater retrofit opportunities, prioritizing of fish passage barriers, and a hydraulic analysis of the City's conveyance pipelines discharging directly to Bellingham Bay.
- **Chapter 8, Capital Improvement Plan**, is the proposed 2020 CIP, developed by identifying City drainage issues brought forward by City staff, projects identified by the retrofit analysis, fish passage barriers identified in the 2010 *City of Bellingham Culvert Improvement Prioritization: Phase I Final Report* (Prioritization Report) (City 2010), capacity-limiting conveyance pipes from the 2007 Stormwater Comprehensive Plan, and system modeling. Projects were identified and ranked through the City's CIP process. This process of project identification helps support appropriate funding levels for a CIP. Adjustments in project selection and scope are anticipated throughout the life of a CIP implementation; therefore, the identification of actual projects found in this SSWCP is done solely to assist in developing a CIP funding level of service.
- **Chapter 9, Recommended Stormwater Management Program and Implementation**, summarizes the findings of the SSWCP and its individual sections along with recommendations for CIP funding, staffing levels, and recommended utility rates.
- **Chapter 10, Financial Program Review**, examines the financial aspects of the stormwater program, looking specifically at the cost of service relating to the different CIP levels, evaluation of permit fees, integrating additional staffing to support the program and meeting the needs of the Phase II Permit, while also looking at affordability needs of the city and its residents. A comprehensive financial program provides a detailed account of methods to fund the CIP and demonstrate that the utility operates in a financially sustainable manner over the course of the planning period.

1.2 Organization and Staffing

The City of Bellingham's SSWU was created in 1990 to address the issues of stormwater pollution. Under the auspices of the federal National Pollutant Discharge Elimination System (NPDES) for stormwater, the SSWU is charged with working toward improvement of water quality in stormwater runoff prior to its discharge to receiving waters. An organizational chart of the SSWU is shown in Figure 1-2.

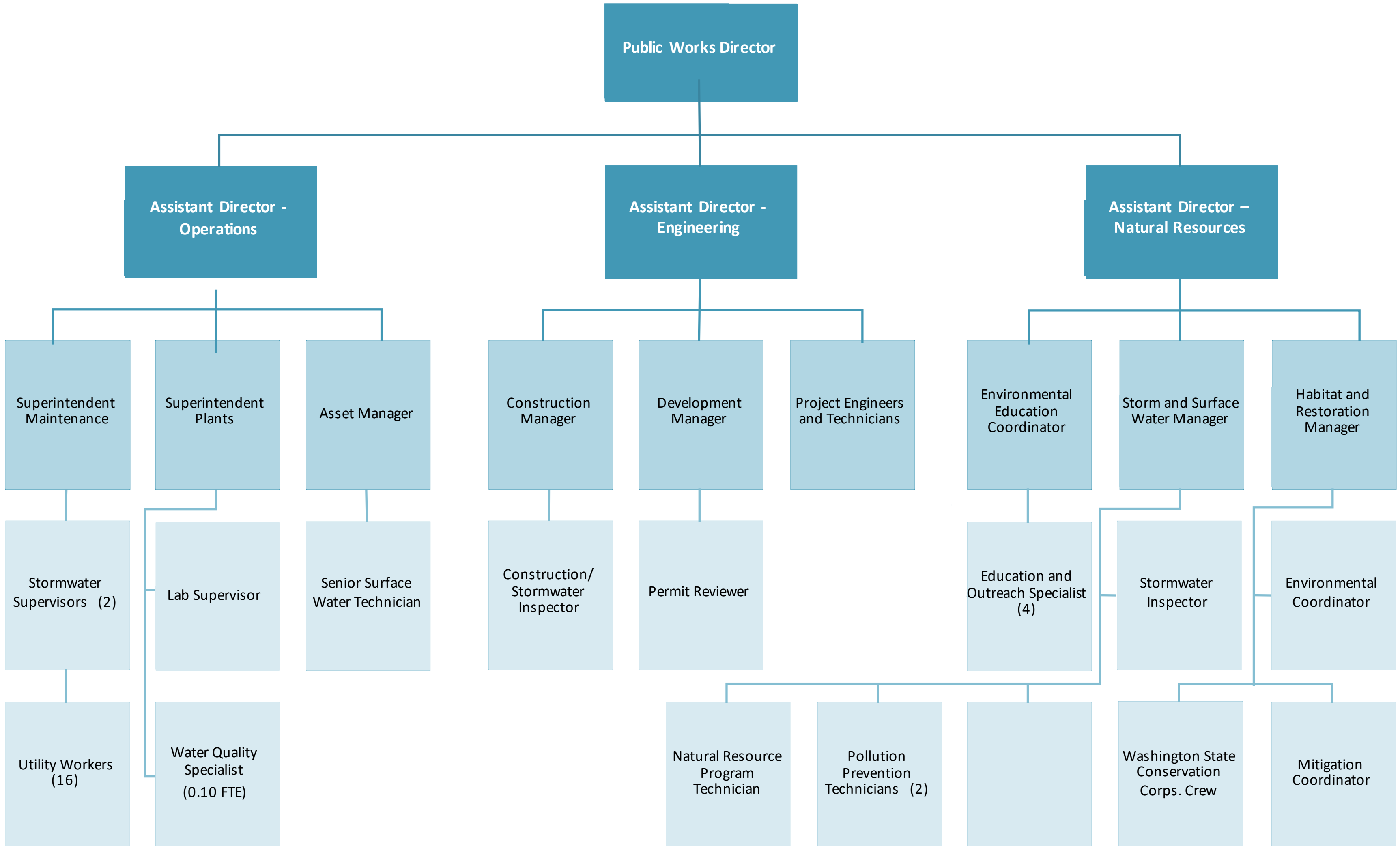


Figure 1-2. Bellingham SSWU organization chart

1.3 Regulatory Drivers

The U.S. Environmental Protection Agency (EPA) identifies stormwater runoff as a nonpoint source of pollution (Ecology 2018a) and has, since passage of the federal Clean Water Act, enacted regulations to offset the impacts of polluted stormwater runoff on the environment.

1.3.1 Western Washington Phase II Municipal Stormwater Permit

With jurisdictional authority to regulate stormwater runoff discharging from municipal stormwater systems to the waters of the United States, EPA has delegated authority to Ecology to implement the rules and regulations for managing stormwater in Washington State. To that end, Ecology regulates stormwater discharges from municipalities via the Municipal Stormwater Permit, divided into Phase I for large municipalities or Phase II for small municipalities, and between eastern Washington and western Washington. The City of Bellingham is a Phase II jurisdiction and operates its SSWU according to the standards and conditions in the Phase II Permit. The Phase II Permit requires the City to enforce the quantity and quality of stormwater runoff discharging from the City's municipal separate storm sewer system (MS4) to the "waters of the state." Integral Phase II Permit elements include the following:

- **S5.C.1, Stormwater Planning:** Efforts to assist the development of policies and strategies that protect receiving water bodies. The Phase II Permit requires future long-term planning efforts to include updates for the incorporation of low-impact development (LID) principles and best management practices (BMPs) requirements, stormwater management action planning (SMAP), and receiving-water prioritization. (Note: SMAP is used in this document as an acronym for both stormwater management action planning and Stormwater Action Plan, depending on context.)
- **S5.C.2, Public Education and Outreach:** Efforts to raise awareness of the contributions of pollutants to the environment from stormwater runoff and measure behavior changes by the public to reduce or eliminate harmful stormwater impacts. The Phase II Permit requires permittees to foster stewardship opportunities in the community to address stormwater runoff impacts.
- **S5.C.3, Public Involvement and Participation:** Efforts to foster public involvement and participation of SWMP and SMAP discussions through avenues such as advisory councils, public hearings, watershed committees, rate structure discussions, and similar activities.
- **S5.C.4, MS4 Mapping and Documentation:** Continued and new mapping and documentation of the MS4.
- **S5.C.5, Illicit Discharge Detection and Elimination:** Development of an ongoing program to prevent, detect, characterize, trace, record, and eliminate illicit connections and illicit discharges related to MS4.
- **S5.C.6, Controlling Runoff from New Development, Redevelopment and Construction Sites:** Implementation of a program to reduce stormwater runoff pollutants to regulated

levels relevant to new development, redevelopment, and construction site activities, inclusive of public and private projects.

- **S5.C.7, Operation and Maintenance:** Implementation of a program to reduce detrimental stormwater impacts through the development of maintenance standards; continued maintenance of stormwater facilities; and practices, policies, and procedures to reduce stormwater impacts. Further, activities shall include continued training of employees on best operation and maintenance (O&M) practices, and implementation of a Stormwater Pollution Prevention Plan (SWPPP) at heavy maintenance or storage yards owned and operated by the utility.
- **S5.C.8, Source Control Program for Existing Development:** Development of a program to prevent and reduce pollutants in runoff from areas that discharge to the MS4.

1.3.2 City of Bellingham Municipal Code

The BMC provides comprehensive regulatory coverage for development within the city. The following municipal codes have direct references to the SSWU. Below is a brief summary of each.

The following list summarizes sections from BMC title 15, chapter 16:

- **15.16.005: Intent.** This section establishes intent and purposes for having an SSWU by promoting a comprehensive approach to surface water and stormwater problems, controlling surface water and stormwater runoff, and enhancing environmental protection and that SSWU rates are necessary to accomplish these intentions.
- **15.16.010: Definitions.** This section provides technical definitions that are critical to owning and operating an SSWU.
- **15.16.020: Utility charges imposed.** This section includes a declaration to charge SSWU rates.
- **15.16.030: Storm and surface water service rates.** The SSWU rate schedule is listed in this section.
- **15.16.040: Exemption, credits and adjustments.** This section provides information to ratepayers on exemptions, credits, and adjustments.
- **15.16.050: Deposit and use of utility charges.** This section codifies how charges received will be used.
- **15.16.060: Impervious surface area or rate adjustments.** This section provides BMC provisions for ratepayers seeking to have the impervious area adjusted.
- **15.16.070: Billing and collection.** This section codifies how billing and fee collection will be implemented.
- **15.16.080: Severability.** This section states that, "in the event any provision of this chapter or its application to any person, entity or circumstance is held invalid, the remainder of this chapter or the application of the provision to other persons, entities or circumstances shall not be affected."

The following list summarizes sections from BMC Chapter 15.40 Drainage:

- **15.40.010: Purpose – Liability for damages.** This section declares the City's intention for operating the SSWU "to assist the city and its residents in the correction of existing storm drainage and surface water runoff."
- **15.40.020: Administration by public works department.** This section codifies that the SSWU is administered by the Public Works Department.
- **15.40.140: Dedication of drainage facilities to the city – Contract.** This section provides criteria and standards for drainage facilities to be dedicated to the public system.
- **15.40.170: Nuisances declared – Abatement.** This section codifies definitions of drainage nuisances and provides the City with authority to address the nuisances as to protect the public drainage system.

BMC Chapter 15.42 covers findings of fact, regulations, and infractions. This chapter effectively provides the regulatory framework for implementing the conditions of the Phase II Permit.

- **15.42.010: Findings of fact – Need and purpose.** This section codifies that stormwater runoff contains pollution and needs to be managed and regulated.
- **15.42.020: Definitions.** This section contains the specific definitions necessary for interpreting the SSWU code and development standards.
- **15.42.030: General provisions.** This section codifies that this chapter does not repeal, abrogate, or impair any existing regulations, easements, covenants, or deed restrictions. However, where this chapter imposes greater restrictions, the provisions of this chapter shall prevail.
- **15.42.040: Regulated activities.** This section describes the types of activities that are regulated; for example, land-clearing activities.
- **15.42.050: General requirements.** This section includes language for adoption of the Surface and Stormwater Comprehensive Plan and codifies the use of BMPs to control stormwater runoff and prevent pollution from entering receiving waters; identifies and prohibits illicit discharges; lists the restrictions on application of fertilizers, mulches, and soil amendments containing phosphorus; and lists requirements for retail stores selling such materials.
- **15.42.060: Approval standards.** This section contains the specific stormwater development regulations for new and/or redeveloping properties within city limits. It also describes the specific minimum requirements and development standards for areas within the city draining to Lake Whatcom.
- **15.42.070: Maintenance, inspection and enforcement.** This section codifies requirements for maintenance of stormwater facilities, what standards are applied, inspection, and enforcement.
- **15.42.080: Administration.** This section includes the fee schedule for approving development permits.

- **15.42.090: Variances and appeals.** This section includes criteria for requesting and granting variances from the regulations including Right of Appeal.
- **15.42.100: Infractions – Penalty.** This section codifies the authority of the City to issue penalties in the event that there are violations of this code.
- **15.42.110: Misdemeanors – Penalty.** This section codifies the authority of the City to issue penalties in the event that there are violations of this code.
- **15.42.120: Severability.** This section states: "If any provision of this chapter or its application to any person, entity, or circumstance is held invalid, the remainder of this chapter or the application of the provision to other persons, entities, or circumstances shall not be affected."

BMC Chapter 17.76, Construction in Floodplains sets forth regulations for development in floodplains meeting the standards of the National Flood Insurance Program (NFIP), a federal program that provides flood insurance to property owners in participating communities. In exchange for providing flood insurance, participating communities must manage and implement minimum standards for properties that develop in the floodplain.

1.3.3 Applicable Policies

The purpose of the City's citywide Comprehensive Plan is to provide a comprehensive statement of City goals and policies to focus, direct, and coordinate the efforts of the departments within the City government. It is a basic source of reference for officials as they consider enactment of ordinances or regulations affecting the community's physical and economic development. The Comprehensive Plan has several elements, each with a goal and several policies that are designed to help achieve the goals. The excerpts below are a partial list of goals that apply to the SWMP.

The following are land use goals of the state-mandated and citywide Comprehensive Plan (Land Use [LU] and Environmental [EV] chapters):

- **Goal LU-5:** Support the Growth Management Act's goal to encourage growth in urban areas.
- **Goal LU-7:** Protect and restore our community's natural resources (land, water, and air) through proactive environmental stewardship.
- **Goal EV-2:** Limit development in the Lake Whatcom watershed.
- **Goal EV-4:** Limit urban sprawl and promote sustainable land use planning.

The following are surface water and stormwater goals of the Comprehensive Plan:

- **Goal LU-8:** Protect and improve Lake Whatcom and its watershed to ensure a long-term, sustainable supply of water.
- **Goal EV-1:** Protect and improve drinking water sources.
- **Goal EV-5:** Protect and improve the health of lakes, stream, and the Salish Sea.
- **Goal EV-6:** Conserve and maintain natural resources, including the urban forest.

State stormwater policies from the Washington Administrative Code (WAC) that apply to water quality standards are provided below:

- **WAC 173-200:** Water Quality Standards for Groundwaters of the State of Washington
- **WAC 173-201A:** Water Quality Standards for Surface Waters of the State of Washington
- **WAC 173-204:** Sediment Management Standards

1.4 Goals and Objectives

The goals and objectives of this Plan update are as follows:

- Analyze the existing drainage system to identify capacity deficiencies as compared to the City's policies and service level standards
- Identify existing drainage problems
- Evaluate the City's SWMP to aid in maintaining compliance with the City's Phase II Permit through the development of a gap analysis of the City's efforts in complying with the Phase II Permit conditions
- Develop a CIP
- Establish an equitable stormwater utility fee structure consistent with the City's affordability policies that fully supports the City's SWMP and CIP

1.5 Plan Development Methodology

This 2020 updated SSWCP describes the built and natural systems used in the conveyance of surface water and stormwater flows. It references how urban growth and development impact the hydrology of the area. The SSWCP includes analysis of the City's asset management programs and its activities for Phase II Permit compliance, identifies stormwater retrofit opportunities, and makes recommendations for staffing and capital resources needed to meet the City's objectives. These recommendations were then used as the funding basis of a stormwater utility rate study (Chapter 10).

1.5.1 Existing Data Review

As part of the SSWCP update, a variety of information was collected, reviewed, and analyzed. Sources of information included interviews with City staff and review of the City's financial policies and current budget, organizational charts, and past SSWCPs and studies, including the City's 1995 Watershed Master Plan and 2007 Stormwater Comprehensive Plan. Critical to the retrofit planning efforts of this SSWCP was the 2015 *Bellingham Habitat Restoration Technical Assessment* (Habitat Restoration Assessment) (ESA 2015). That plan identified areas where stormwater retrofit was recommended to improve water quality in receiving waters.

Conveyance system analyses were dependent on the City's asset management database, which stores critical information on the built infrastructure. Several catch basin invert elevations were measured in the field to facilitate the analysis. Phase II Permit annual reports, O&M activity database information, and the Lake Whatcom Management Plan provided essential information to support the evaluation and recommendations found within.

1.6 Public Involvement Conducted for This Plan

This section will be completed upon completion of the public input process.

2 Background

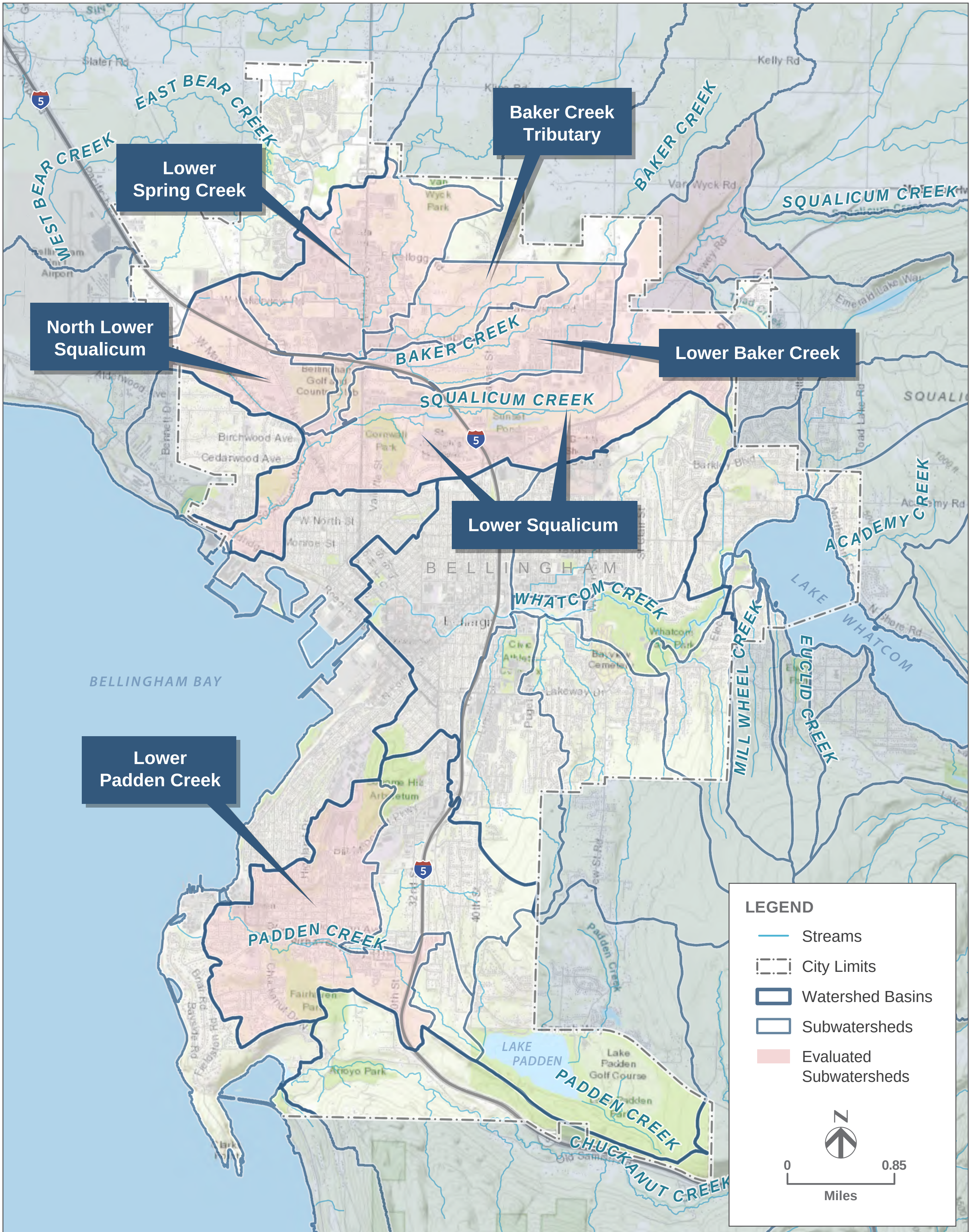
Stormwater runoff represents the portion of rain or melting snow that "runs off" across the land instead of seeping into the ground. The City's stormwater system primarily manages this stormwater runoff, with the exception of groundwater connections per BMC 15.42.020. Stormwater follows topography from high points to low, crossing property boundary lines and even jurisdictional limits. As stormwater flows from one property owner to the next, each owner is responsible for receiving and conveying stormwater across his/her property downstream to the next. Similar to other urban planning challenges, comprehensive plans to manage stormwater runoff seek to provide the City with a forward-looking plan that promotes development without impacting the surrounding environment.

There is a direct relationship between runoff volume and impervious surface area. As natural landscapes are converted to impervious urbanized areas, infiltration of rainfall into the ground diminishes, resulting in more stormwater runoff. The challenge faced by the SSWU is to collect, treat, and convey stormwater runoff to nearby receiving waters safely and cost-effectively while minimizing adverse impacts to waterways, public infrastructure, and private property. The major watersheds in Bellingham where stormwater runoff flows to are (from north to south) Silver Creek, Little Squalicum Creek, Squalicum Creek, Whatcom Creek, Padden Creek, and Chuckanut Creek, plus shoreline areas draining directly to Bellingham Bay (see Figure 2-1).

This chapter provides an overview of the City's watersheds and drainage systems that are the main elements of the SSWU. It includes a history of the city's growth, a summary of the city's built assets—drainage structures, pipes, and detention and water quality facilities—and a summary of two previous SSWCPs.

2.1 Population and Industry Growth

Demands for managing stormwater are directly correlated with population growth and urban development. Bellingham, located within Whatcom County along the shores of Bellingham Bay, is the northernmost large city in Washington State, about 21 miles south of the Canada-United States border. The area was incorporated in 1903 when Bellingham, Fairhaven, Sehome, and Whatcom combined into the City of Bellingham. Since 1996, around the time when the City prepared its first SSWCP, the city's population has grown from around 60,000 residents to 90,655 in 2018 (U.S. Census Bureau 2020). Figure 2-2 below illustrates Bellingham's population growth between 1996 and 2018. It is estimated that the city's current population is about 120,000. Typical of most Puget Sound communities, Bellingham has experienced growth in its population and consequently in land development activity that has resulted in an increase in the amount of impervious surfaces, such as roads, driveways, rooftops, parking lots, and other hard surfaces to accommodate urban development.



BELLINGHAM WATERSHEDS

FIGURE 2-1

City of Bellingham

Surface and Stormwater Comprehensive Plan

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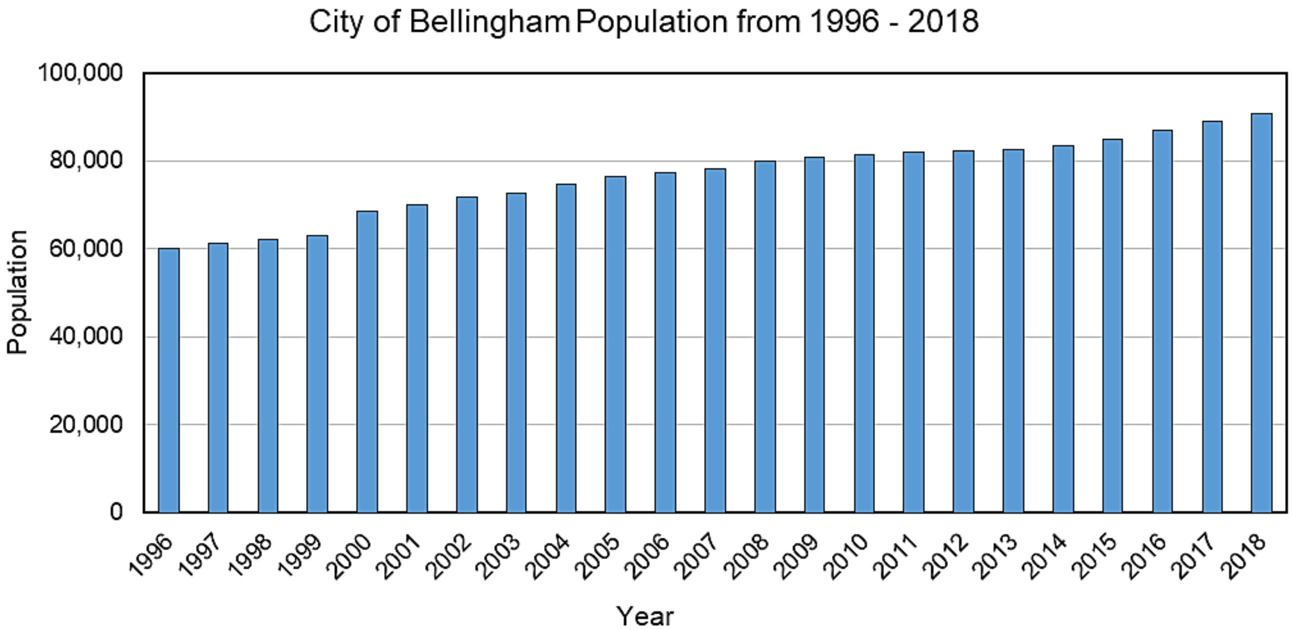


Figure 2-2. U.S. Census Bellingham population, 1996–2018

Bellingham's downtown core has been a hub for commerce and business activities for more than a century. The core industries have centered around the Port of Bellingham, where coal and timber resources were historically exported. Beginning in the early 21st century, with the closure of the Georgia-Pacific pulp mill in 2007, the natural resource export industry yielded to 21st century urban development. As such, the built drainage system in downtown Bellingham has been in place for decades and one component of this 2020 SSWCP update is the evaluation of stormwater system "condition" upgrades in the downtown area, described in detail in Chapter 7. Bellingham's growth in the last half of the 20th century is shown in a series of historical aerial photos from 1943 to 2018 (see Figure 2-3).

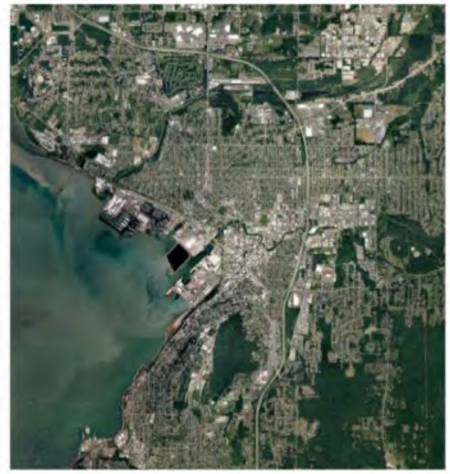
Urban growth in Bellingham, WA

1943

The 1940 census shows that Bellingham's population was 29,000. The Bellingham Bay Coal Company shut down operations in 1955 after a century of extracting and shipping coal from the Squalicum Creek area. Bellingham Bay is fully developed with port operations supporting the natural resources industry. This photographs shows a well-developed urban area with development concentrated in the area west of the present-day I-5 corridor.

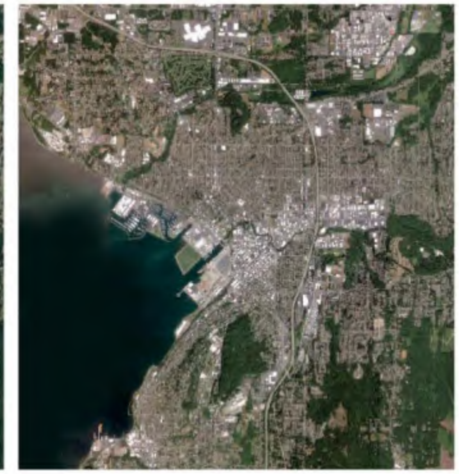
1976

Bellingham's census population in 1980 was 45,800. The primary industry was the operation of the Georgia-Pacific Pulp Mill located in Bellingham Bay. New development can been seen extending east along Lakeway Drive with neighborhood development being concentrated to the northeast. Interstate 5, which opened in 1969, bisects the city. Residential areas are abundant near the downtown core.



1998

Infill and commercial expansion of the business district surrounding Whatcom Creek is evident in this 1998 aerial view. New development outside the city limits is evident in most areas of the city. The large forested areas east of I-5 and south of Lakeway Drive is growing. The 2000 census population was 67,000.



2018

Present-day land cover in Bellingham reflects what has become a typical landscape throughout western Washington. The state's Growth Management Act encourages development to stay in existing population centers which helps keep stormwater impacts from spreading to other undeveloped areas. Bellingham is updating its stormwater management plan in 2020 to facilitate the City's continued growth and management of the utility.

Figure 2-3. Historical aerial images of Bellingham, Washington

2.2 Precipitation

Bellingham receives on average 37.4 inches of rainfall annually as reported at its City Center monitoring location (City 2020a). Seventy-two percent of the average annual precipitation occurs between November and April with the remainder occurring during the relatively dry summer and fall months. Figure 2-4 shows the average monthly rainfall for Bellingham at the City Center monitoring location from 2004 to 2018.

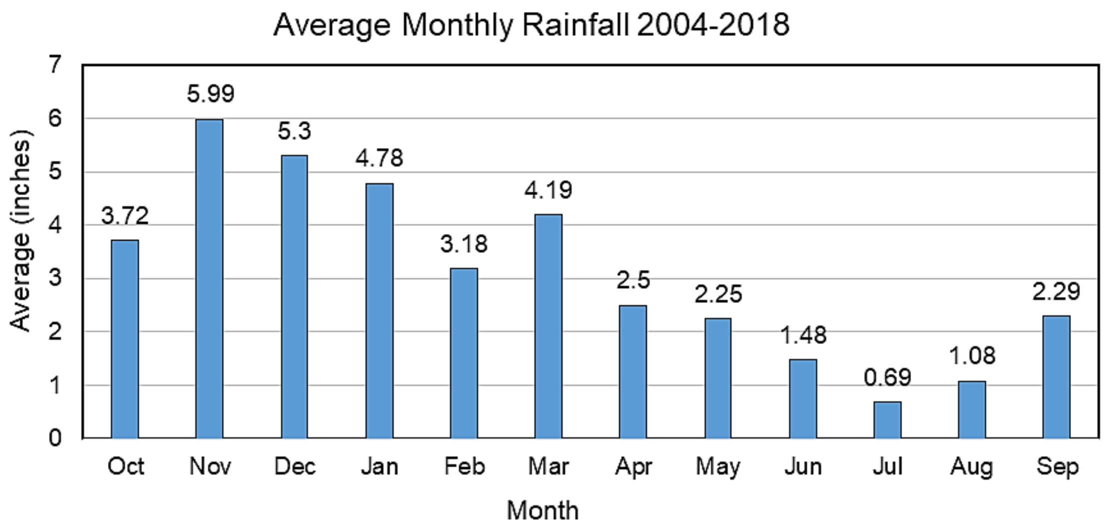


Figure 2-4. City of Bellingham average monthly rainfall, 2004–2018

Source: City 2020b.

The City has in place an Urban Streams Monitoring Program (USMP) that began in 1990 and monitors streams monthly for water quality at 18 sites in 10 streams. The City also collects flow data from four stream gage stations at various locations throughout the city, further explained in Chapter 3, Hydrology.

2.3 Built Stormwater Assets

Built stormwater assets are the man-made components of a drainage system. They consist of drainage structures, pipes, ditches, detention/retention facilities, and water quality facilities that function to collect, treat, and convey stormwater runoff from surfaces toward receiving waters. Built stormwater assets require both short- and long-term maintenance to increase longevity and maintain an appropriate level of service.

As recorded in the City's current records, the City maintains the following assets:

- More than 280 miles of stormwater pipe
- 754 facilities including 6 regional detention ponds
- 168 detention/water quality ponds, vaults, or pipes
- 98 bioswales (linear swales that act like a bioretention device)

- 100 rain gardens and bioretention facilities
- 45 infiltration/dispersion trenches
- 186 sand and media filters
- 10 hydrodynamic pretreatment structures
- 18 sections of permeable pavement (constituting more than 110,860 square feet [ft^2])
- One stormwater treatment wetland
- 16 pollution control and oil/water separator structures
- 12,564 catch basins and 2,326 manholes

The City's stormwater assets are tracked using a Hansen database software program as well as within its Geographic Information System (GIS). The City has recently switched to Cityworks™ asset management software by Azteca. The permitting software used is called TRAKiT™. Asset management software is tightly linked with GIS-centered databases to track maintenance activities and store attribute data such as invert elevations, pipe material, and pipe sizes. The City's Phase II Permit requires the City to maintain records of inspections and maintenance activities, all of which is facilitated by TRAKiT™. The following sections summarize some of the City's built drainage infrastructure.

2.3.1 Storm Drainage Structures

Typically, two types of structures are used in the City's storm drainage network: manholes and catch basins. Manholes are more frequently used in sanitary sewers because they have a channelized section in the bottom to facilitate conveyance through the structure and down to the next pipe segment. Manholes in a stormwater system are used to change the direction of a pipe or change the size of the pipe without collecting additional surface runoff. Catch basins are more commonly used in storm sewer lines to intercept stormwater runoff and come equipped with a sump in the bottom to capture sediment deposits and to facilitate regular maintenance activities. The number of catch basin and manhole structures in the city is shown in Figure 2-5.

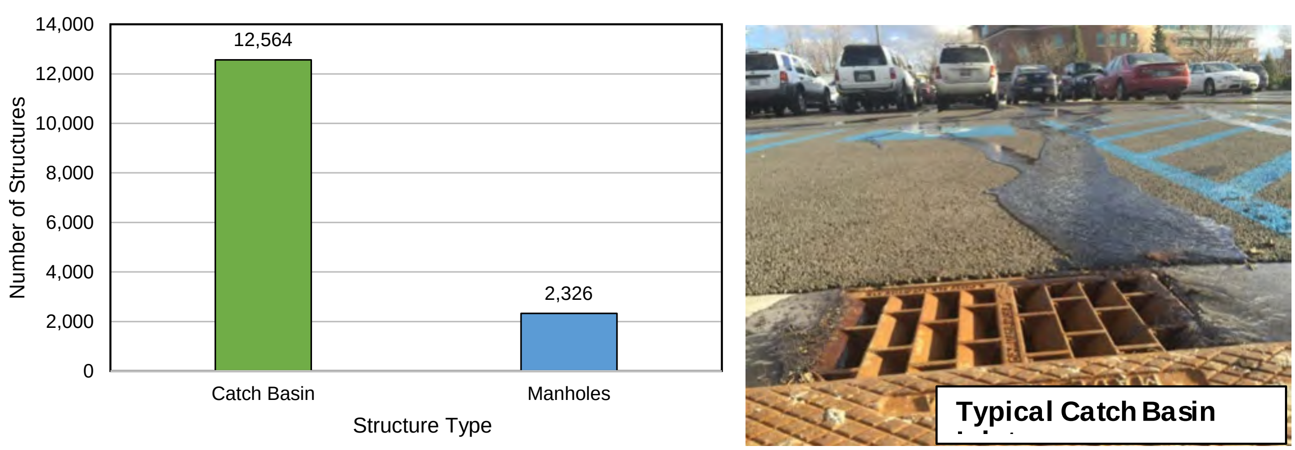


Figure 2-5. Storm drainage structures and photo of catch basin

2.3.2 Storm Drainage Pipe

The City owns about 280 miles of storm drain pipe. A breakout of pipe length by diameter is provided in Figure 2-6. Knowing the length of drain pipe by size and class is helpful for planning asset management renewal and replacement in building a sustainable O&M program.

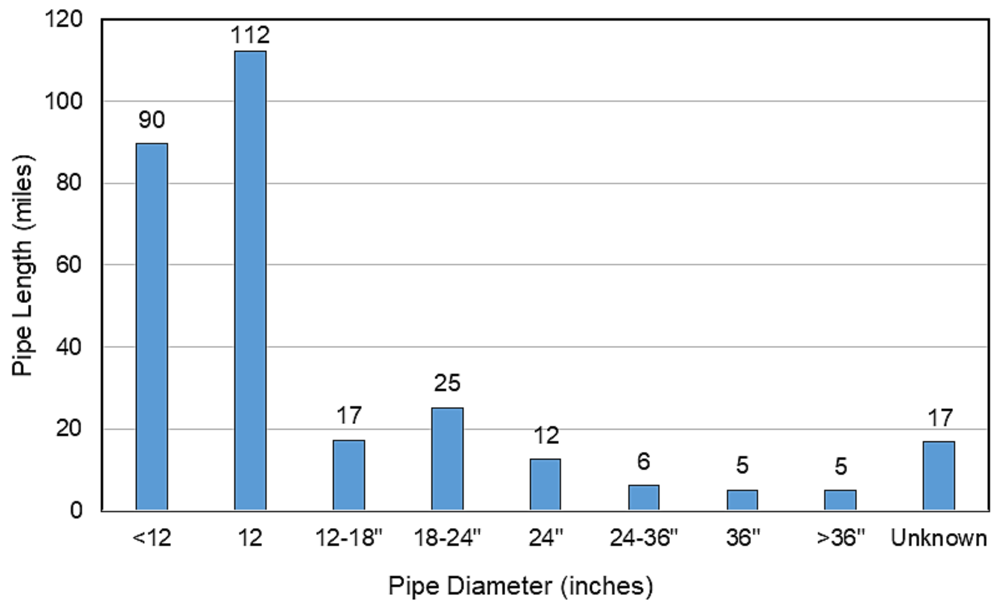


Figure 2-6. Storm drain pipe length by diameter

Collecting information or data on the existing system is an important element of a sustainable stormwater management plan. The City routinely performs data collection on the 280 miles of its piped system. Information is still needed for about 17 miles of pipe to support O&M program elements. Data within these tables reported as "unknown" refer to assets with missing information.

Pipe material is predominantly concrete, with most of the pipes being in place for more than 21 years. Pipe lengths are classified by material in Figure 2-7 and by age in Figure 2-8.

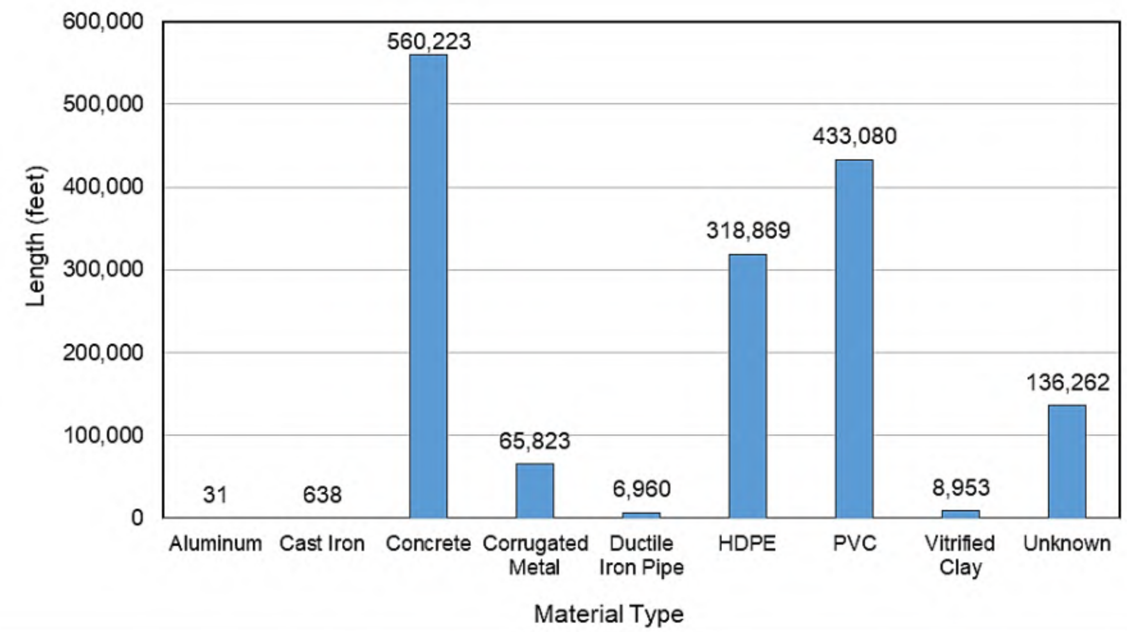


Figure 2-7. Storm drain pipe length by material type

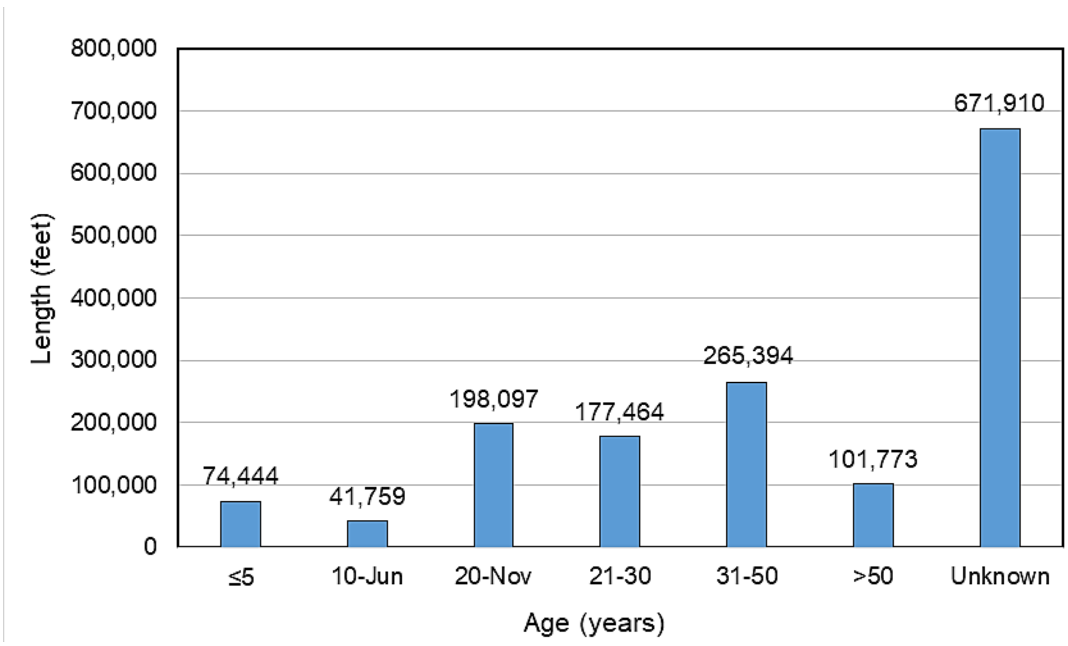


Figure 2-8. Storm drain pipe length by age

2.4 Pollutant Loading

The nature and type of land use is an important factor in stormwater planning because of the range of pollutant concentrations that are typical of urban environments. Stormwater monitoring data from the National Stormwater Quality Database (NSQD) show average concentrations of a range of pollutants in urban runoff from areas of different land uses. The

NSQD contains a large data set from a representative number of municipal stormwater permit holders across the country and provides reliable information for stormwater planners. Much of the data may be used to characterize stormwater produced from specific land uses, such as industrial, commercial, low-density residential, high-density residential, and undeveloped open space. Preliminary statistical analysis of the NSQD found significant differences among land use categories for all pollutants, as shown in Table 2-1.

Table 2-1. National Stormwater Quality Database average pollutant concentrations

Pollutant	Unit	Residential	Commercial	Industrial	Freeways	Open space
Ammonia	mg/L	0.31	0.5	0.5	1.07	0.3
Biochemical oxygen demand	mg/L	9	11.9	9	8	4.2
Cadmium, total	µg/L	0.5	0.9	2	1	0.5
Cadmium, filtered	µg/L	ND	0.3	0.6	0.68	ND
Chemical oxygen demand	mg/L	55	63	60	100	21
Copper, total	µg/L	12	17	22	35	5.3
Copper, filtered	µg/L	7	7.6	8	10.9	ND
Fecal coliform	MPN/100 mL	7,750	4,500	2,500	1,700	3,100
Lead, total	µg/L	12	18	25	25	5
Lead, filtered	µg/L	3	5	5	1.8	ND
Nickel, total	µg/L	5.4	7	16	9	ND
Nickel, filtered	µg/L	2	3	5	4	ND
Nitrogen, NO_2+NO_3	mg/L	0.6	0.6	0.7	0.3	0.6
Nitrogen, total Kjeldahl	mg/L	1.4	1.6	1.4	2	0.6
Phosphorus, total	mg/L	0.3	0.22	0.26	0.25	0.25
Phosphorus, filtered	mg/L	0.17	0.11	0.11	0.2	0.08
Suspended solids, total	mg/L	48	43	77	99	51
Zinc, total	µg/L	73	150	210	200	39
Zinc, filtered	µg/L	33	59	112	51	ND

ND = not detected, or insufficient data to determine a value.
mg/L = milligrams per liter.
µg/L = micrograms per liter.
MPN = most probable number.
NO_2+NO_3 = nitrogen dioxide plus nitrate.

WAC 173-201A sets forth surface water quality standards for marine and fresh waters. WAC surface water quality criteria exist for aquatic life and human health for both chronic and acute exposures with varying numerical standards for the pollutants shown in Table 2-1. The open-space category is a helpful reference to use as a comparison.

Land use in Bellingham is predominantly residential with a downtown business core plus the Fairhaven Urban Village. Like most cities in western Washington, Bellingham is growing with increasing density and increasing impervious areas. An analysis of the city's current land use shows that single-family residential property dominates the land use, but significantly large areas of commercial and industrial land use also exist. Bellingham's overall land use categories are shown in Table 2-2. Information for the sub-watersheds that were the subject of the retrofit analysis (see Chapter 7) are also shown.

Table 2-2. Land use categories for city of Bellingham and studied sub-watershed

Land use	City of Bellingham		Lower Padden Creek		Lower Squalicum Creek		Lower Baker Creek		Lower Spring Creek		Baker Creek tributary	
	Acres	Percent of total	Acres	Percent of total	Acres	Percent of total	Acres	Percent of total	Acres	Percent of total	Acres	Percent of total
Airport operations	1,024	4.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Commercial	1,530	6.4	14	1.1	133	5.5	78	11.2	419	40.9	36	9.2
Industrial	3,779	15.8	0	0.0	726	30.2	294	42.2	115	11.2	8	1.9
Multi-family residential	3,623	15.2	142	11.0	406	16.9	162	23.2	359	35.1	161	40.6
Single-family residential	8,968	37.6	717	55.7	772	32.1	163	23.4	60	5.9	191	48.2
Open space	139	0.6	212	16.5	267	11.1	0	0.0	1	0.1	0	0.0
Mixed use, commercial and residential	1,938	8.1	104	8.0	2	0.1	0	0.0	0	0.0	0	0.0
Institutional	2,851	12.0	99	7.7	96	4.0	0	0.0	69	6.8	0	0.0
Total	**23,854**	**100.0**	**1,289**	**100.0**	**2,402**	**100.0**	**696**	**100.0**	**1,025**	**100.0**	**395**	**100.0**

Calculations based on City of Bellingham GIS data.

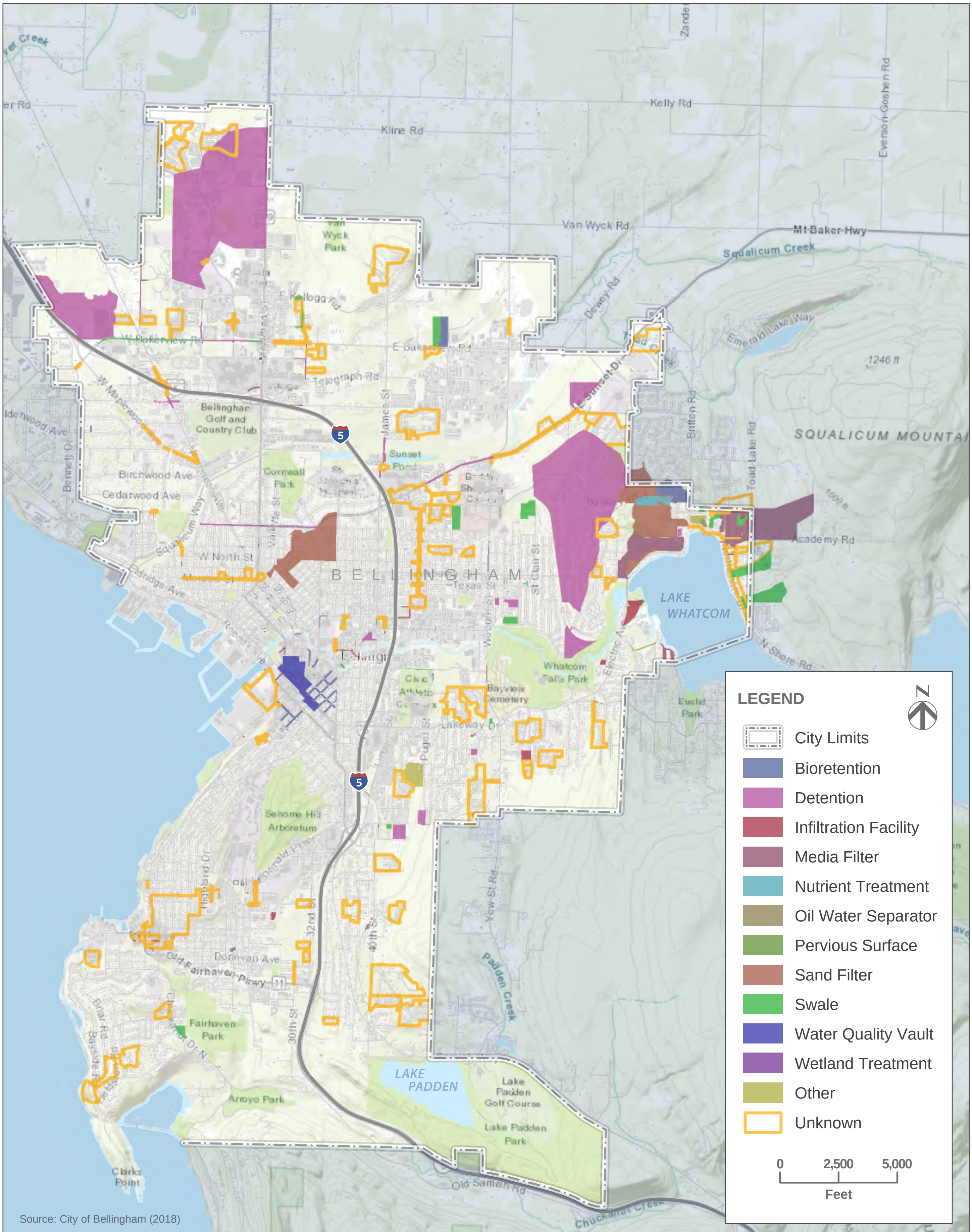
2.5 Water Quality Facilities

Considering the available research and data documenting pollutant concentrations in stormwater runoff, the City has systematically designed and built numerous water quality treatment facilities since the previous SSWCP update. Figure 2-9 shows areas where stormwater runoff is treated. This figure is based on limited records on all projects (both public and private), with some data incomplete on the type of facility (shown as "unknown"), but does provide an indication of a diverse set of water quality strategies throughout the city. Some of the facilities were built by private developers and by the City (transportation projects) in response to stormwater regulations, while others were built as retrofit facilities by the City. Treatment areas and facility types are illustrated in Table 2-3. Water quality treatment types of notable area and size include dams, detention ponds, and sand filters.

Table 2-3. Water quality treatment facilities in the city of Bellingham (GIS data from City)

Treatment facility type	Treatment facility type	Treatment facility type
Bioretention [a]	Nutrient treatment	Sand filter
Dam	Oil/water separator	Unknown
Detention [b]	Other [e]	Water quality vault
Infiltration facility [c]	Permeable surface [f]	Wetland treatment
Media filter [d]	Swale [g]	

a. Includes rain gardens and rock plant filter.
b. Includes detention tanks, vaults, and ponds.
c. Includes infiltration trench and filter and infiltration BMP.
d. Includes Filterra, Modular Wetlands, storm filter, gravel filter.
e. Includes catch basin filter, re-vegetation, energy dissipator, pollution control structure, and groundwater collector.
f. Includes: permeable pavement, pervious concrete.
g. Includes bioswale.



AREAS TREATED BY WATER QUALITY FACILITIES

FIGURE 2-9

City of Bellingham
Surface and Stormwater Comprehensive Plan

UPDATED 8/20/2020

2.6 Characteristics of the Study Area

For purposes of developing a 6-year CIP for the 2020 SSWCP update, stormwater retrofit evaluations were targeted in five sub-watersheds in the city as identified in the Habitat Restoration Assessment (ESA 2015). The five sub-watersheds are identified as top-tier sub-watersheds where improvements have the potential to benefit multiple habitats and functions. Stormwater retrofits are listed as recommended improvements in four of the five sub-watersheds. Stormwater retrofits would benefit the downstream receiving waters. Additionally, conveyance modeling was targeted in the shoreline basin areas. Development of the CIP also used information from past studies and the previous SSWCP. The details of these analyses are located in Chapter 7, Stormwater System Analysis.

The 2020 retrofit analysis leveraged the recommendations in the City's Habitat Restoration Assessment (ESA 2015) to create a stormwater retrofit plan. The Habitat Restoration Assessment (ESA 2015) identified restoration opportunities across the entire city, prioritizing all of the sub-watersheds into one of three categories for restoration opportunity (high-, medium-, and low-priority areas). The objective of the assessment was to focus habitat improvements in areas where restoration efforts would result in significant ecological uplift across multiple habitat groups (i.e., riverine, wetland, forest, and meadow/shrubs and in multiple functions). Among the many strategies identified for improving habitat was stormwater retrofit. The report identified four Tier 1 (high-scoring) sub-watersheds where stormwater retrofit was identified as a means for improving habitat (Table 41). For the purposes of this SSWCP, a fifth sub-watershed was added for inclusion by the City, Lower Squalicum Creek, given its high fish use rating. To that end, the following five sub-watersheds were targeted for the 2020 SSWCP retrofit analysis:

- **2.6.1:** Lower Padden Creek
- **2.6.2:** Lower Squalicum Creek
- **2.6.3:** Lower Baker Creek
- **2.6.4:** Lower Spring Creek
- **2.6.5:** Baker Creek Tributary

In addition to developing a stormwater retrofit plan, the 2020 SSWCP also uses the 2007 Stormwater Comprehensive Plan and hydrologic modeling information to evaluate conveyance capacities of stormwater mainlines that discharge directly to Bellingham Bay. The marine outfall conveyance analyses and the retrofit plan identified CIP projects and programs to renew infrastructure, improve water quality and aquatic habitat, and improve fish passage. The following sections provide a brief summary of the study areas.

2.6.1 Lower Padden Creek Sub-watershed

The Lower Padden Creek sub-watershed is an area of approximately 1,289 acres within the larger Padden Creek watershed (an area of 4,125 acres). Lower Padden Creek is defined as the basin downstream of Lake Padden to the mouth at Bellingham Bay, as illustrated in Figure 2-11. Lower Padden Creek flows 2 stream miles from the outlet of Lake Padden to Bellingham Bay and includes the tributary area of Connelly Creek (ESA 2015). Lake Padden is 160 acres in size

Figure 2-10. Lake Padden outlet structure

and receives stream flow from upper Padden Creek and numerous wade-able, intermittently flowing small streams flowing directly to it. The Lake Padden outlet is controlled by a dam with an overflow weir (Figure 2-10). The weir is maintained by the City, but the dam is not. Seasonal lake levels prevent release of water from the lake to the stream between midsummer and late fall (ESA 2015). The dam, registered by Ecology, was last inspected in November 2018. Ecology gave the dam a "satisfactory" rating with no immediate safety concerns (Ecology 2018b). Land use in the Padden Creek sub-watershed is primarily residential (56 percent) with open space (16 percent) as the next highest land use category. The area-weighted impervious area of lower Padden Creek is 33 percent.

Historically, Padden Creek flowed through an almost half-mile-long conveyance pipe (known as the "Brick Tunnel") beneath the Happy Valley neighborhood and Old Fairhaven Parkway. The stream then entered Fairhaven Park, just south of the Fairhaven commercial district, before finally flowing through substantial commercial and industrial development near the bay. In 2015, the Padden Creek Daylighting project removed the stream from the brick tunnel (ESA 2015). In 2014, the Washington State Department of Transportation (WSDOT) replaced the tunnel crossing east of 20th Street with a fish-passable bridge. The project improved stream and riparian conditions (ESA 2015).

Connelly Creek drains the tributary area north of Old Fairhaven Parkway east of 21st Street, including a portion of I-5 and Samish Way. The lower portion of Connelly Creek is a shrub/grass/deciduous tree-dominated riparian corridor surrounded by residential development. The upstream channel is located in a mature mixed forest vegetation setting. Historically, the Lower Padden Creek floodplain was prone to urban flooding upstream of the 22nd Street tunnel inlet (ESA 2015); however, after the 2015 daylighting project, risk of flooding has been reduced in the Happy Valley Neighborhood.

Padden Creek is listed on the 303(d) list for fecal coliform and dissolved oxygen (Ecology 2008); a total maximum daily load (TMDL) for temperature has been developed for Whatcom, Squalicum, and Padden Creeks collectively (ESA 2015). The 303(d) list, so called because the process is described in Section 303(d) of the Clean Water Act, lists waters in a "polluted water category," as it is functioning below its intended use.

LOWER PADDEN CREEK SUB-WATERSHED

FIGURE 2-11

City of Bellingham

Surface and Stormwater Comprehensive Plan

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A TMDL is the calculation of the maximum amount of a pollutant allowed to enter a water body so that the water body will meet and continue to meet water quality standards for that particular pollutant. A TMDL determines a pollutant reduction target and allocates load reductions necessary to the source(s) of the pollutant.

Lower Padden Creek has documented presence of host salmonids: a relatively small number of Chinook and steelhead salmon, chum salmon, coho salmon, kokanee, and cutthroat trout, and a relatively small number of Chinook (WDFW 2015a, 2015b). Cutthroat spawning habitat is provided by two unnamed tributaries to Lake Padden: a stream at the southeast end of the lake and a stream that flows from Our Lake through the Lake Padden Golf Course to Lake Padden (City 2007). Fish ladders beneath the Chuckanut Drive bridge and at the east end of Fairhaven Park allow anadromous fish to travel upstream.

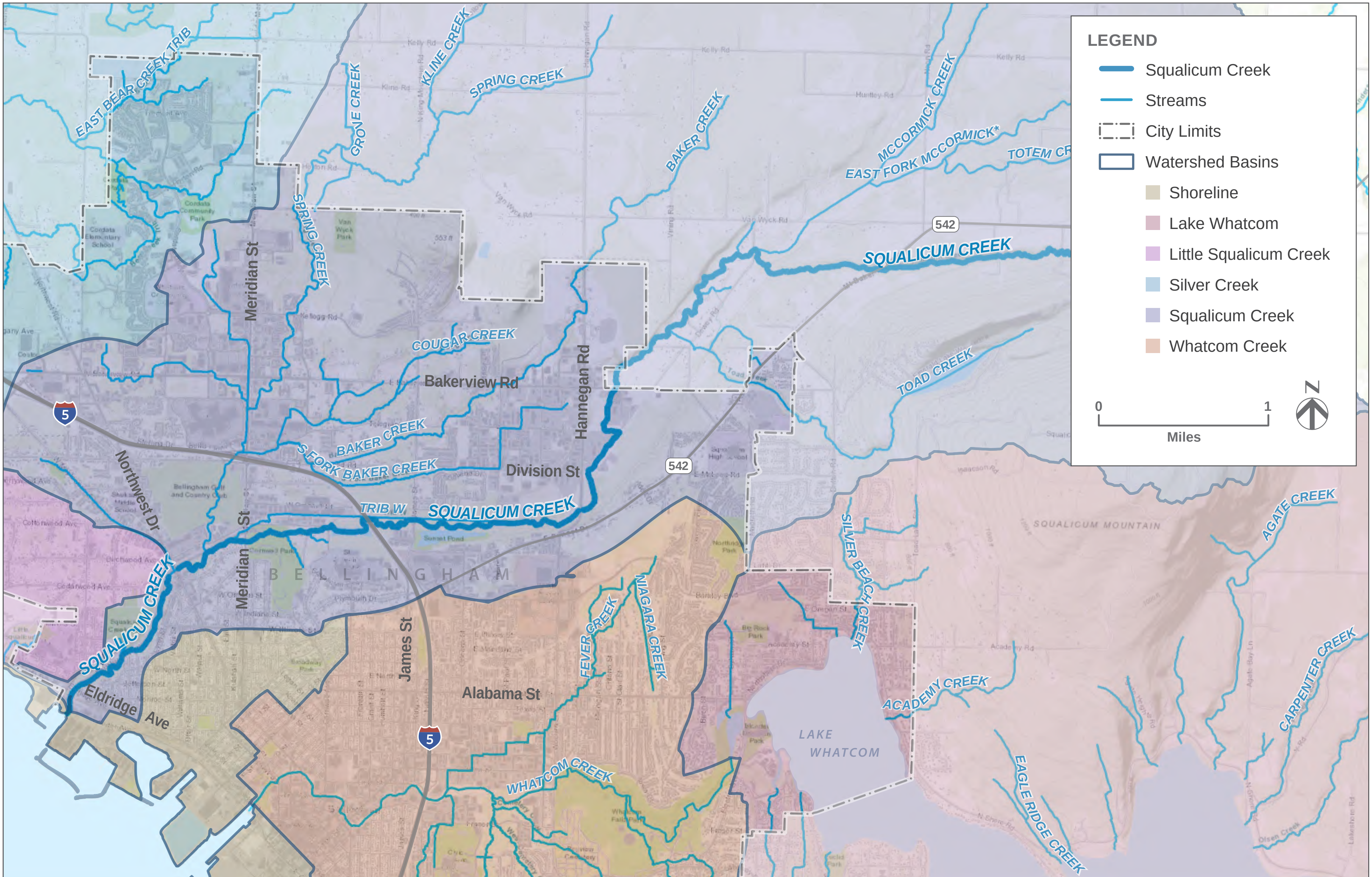
Lower Padden Creek also fosters a biodiverse corridor connecting the Chuckanut and Galbraith Mountains, eastward patches, several wetlands, the Padden Creek estuary, and wildlife including the bald eagle, great blue heron, Townsend's big-eared bat, and western toad (ESA 2015).

2.6.2 Lower Squalicum Sub-Watershed

The Lower Squalicum study area is approximately 3,121 acres, and includes approximately 10.8 stream miles and approximately 364 acres of wetland area (City 2020h). As shown in Figure 2-12, the Squalicum Creek watershed is located north of downtown Bellingham and drains to Bellingham Bay.

Most of the Squalicum watershed is located outside of the city limits and is forested or developed in low-density residential or agricultural land use. The city of Bellingham has high-density development west of I-5 and along Guide Meridian. Established residential neighborhoods are found in the downstream sub-basins near the bay and out to Irongate, an industrial site north of the stream. Some significant forests remain within Lower Squalicum along with a relatively contiguous riparian corridor along the main stem (ESA 2015). Within the Lower Squalicum sub-watershed the area-weighted impervious average is 28.4 percent according to 2020 land use analysis. Land use is predominantly residential with some commercial land use near the mouth of the creek.

The watershed is drained primarily by the main stem of Squalicum Creek and two major tributaries: Baker Creek and Spring Creek (ESA 2015). Most drainage features consist of streams and culverts, with pipes and ditches in the more heavily developed southwest/downstream sub-basins. Between Guide Meridian and Hannegan Street, Squalicum Creek lies in a relatively flat- bottomed valley. The creek flows through a single contained channel, but may also flow underground in some locations.



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UPDATED 8/20/2020

LOWER SQUALICUM CREEK SUB-WATERSHED

FIGURE 2-12

City of Bellingham
Surface and Stormwater Comprehensive Plan

Squalicum Creek is barrier-free to salmon passage for most of its distance within city limits. Salmonids, Chinook salmon, steelhead, bull trout, coho salmon, chum salmon, and cutthroat trout use the sub-watershed (WDFW 2015a, 2015b). Problem passage sites previously identified in the 1992 R.W. Beck study consisted of (1) a footpath in Cornwall Park upstream of Guide Meridian, (2) an underground channel upstream of Bug Lake, (3) entering the I-5 culverts, and (4) a heavily braided channel between I-5 and Bug Lake and upstream of Sunset Pond. These all have been addressed by the City. In 2015, the City constructed a portion of a project to reroute Squalicum Creek around two man-made ponds (Bug Lake and Sunset Pond) to reconstruct the stream in the floodplain and improve fish passage under I-5 (ESA 2015).

An industrial site north of the stream (Irongate industrial area) discharges untreated stormwater to the sub-watershed (ESA 2015). The riparian corridor consists of immature forest vegetation and some development encroachment.

The lower reaches of Squalicum Creek (as with many urban reaches) suffer from nonpoint source pollution due to the proximity of residential and commercial development and runoff from the I-5 corridor. Squalicum Creek is 303(d) listed for dissolved oxygen and fecal coliform and a single TMDL related to temperature has been developed for Whatcom, Squalicum, and Padden Creeks (ESA 2015). The creek has been identified as inadequate (for its intended use) relating to water quality (Hood 2006) and non-functional for instream flow conditions (lacking sustained flow) and runoff rates (Nahkeeta 2003; City 2009). Further, lower Squalicum Creek was identified for not functioning for instream flow conditions and runoff rates (Nahkeeta 2003; City 2009).

2.6.3 Lower Baker Creek Sub-Watershed

The 47-acre Lower Baker Creek (occasionally referred to as South Fork Baker Creek) is part of the Squalicum Creek watershed as shown in Figure 2-13. Lower Baker Creek includes approximately 5.4 stream miles, including the main stem Baker Creek and Irongate Creek, along with 47 acres of wetland (City 2020h).

Baker Creek includes relevant physical, chemical, and biological conditions that contributed to its Tier 1 classification (ESA 2015). Notably, along I-5, culvert crossings pose as fish passage barriers (WDFW 2015b). Where Baker Creek flows downstream of I-5 through the Bellingham Golf and Country Club golf course, there is little riparian cover with scattered deciduous trees (ESA 2015).

Further, a 100- to 500-foot-wide corridor of forested upland and riparian buffer is present from approximately Hannegan Road downstream to approximately 1,500 feet southwest of James Street (ESA 2015).

Baker Creek includes the Irongate industrial area that has water quality and peak flow issues typical of industrial areas. Much of the industrial subcatchment drains untreated and un-detained stormwater to Baker Creek, making this a prime area for water quality retrofit projects. The City's stormwater regulations require new and redeveloping properties to implement flow control and water quality treatment BMPs if area thresholds trigger the regulations. Downstream of I-5, Baker Creek is 303(d) listed for fecal coliform bacteria (Ecology 2008).

The primary focus for this sub-watershed coming from the 2015 Habitat Restoration Assessment indicated a focus on riverine, wetland, and forest actions consisting of a combination of restorative and protective actions, such as the Baker Creek Wetland Restoration (LBC-WR1) and Riparian Buffer Restoration (LBC-RR2). In 2006 the City completed a major restoration along Baker Creek with a 0.75-acre parcel dedicated to salmon habitat restoration. In 2004 the City's Culvert Replacement Program removed a barrier culvert, restoring access for anadromous salmonids.

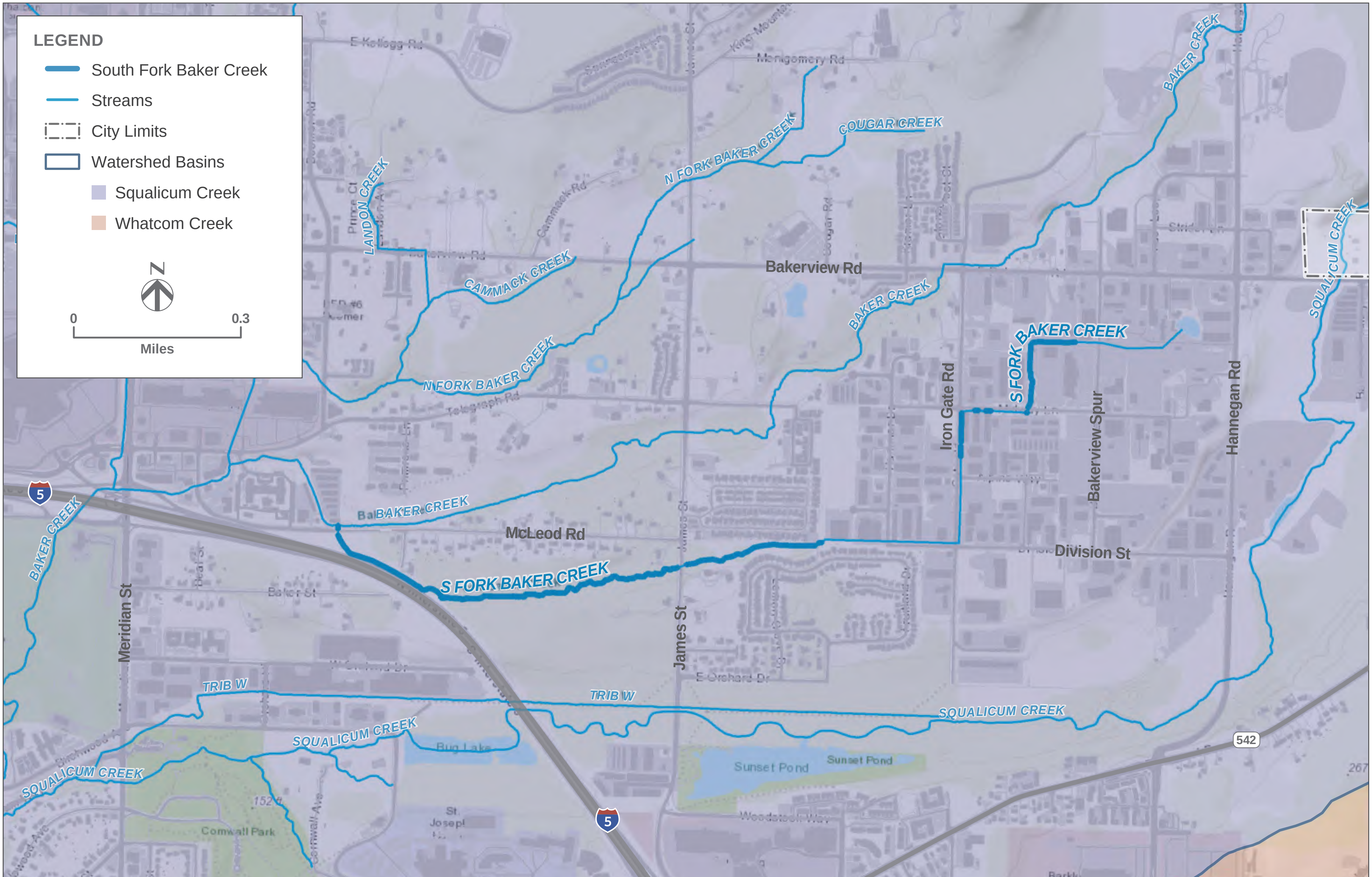
2.6.4 Spring Creek Sub-Watershed

The 1,705-acre Lower Spring Creek sub-watershed is part of the larger Squalicum Creek watershed as illustrated in Figure 2-14. Lower Spring Creek includes approximately 5.2 stream miles, including the main stem, West Fork, and Middle Fork of Spring Creek, along with 158 acres of wetland (City 2020h).

While neither the main stem of Spring Creek nor associated tributaries are listed for 303(d) exceedance, the sub-watershed does support anadromous fish. The Lower Spring Creek sub-watershed has documented presence of chum salmon, cutthroat trout, and steelhead to West Kellogg Road with coho salmon presence in Lower Spring Creek (WDFW 2015a, 2015b). Further, several small and large forest patches are located in the southern portion of the basin (ESA 2015). Similar to Lower Baker Creek, this sub-watershed was recommended in the 2015 Habitat Restoration Assessment for riverine, wetland, and forest actions consisting of a combination of restorative and protective actions, in addition to stormwater restorative actions that address water quality and flow control.

2.6.5 Baker Creek Tributary Sub-Watershed

Within the Squalicum Creek watershed, the South Fork Baker Creek study area is a major tributary (as depicted in Figure 2-13), consisting of approximately 395 acres with approximately 2.9 stream miles and 36 acres of wetland (City 2020h) draining the northern portion of the watershed. The Baker Creek basin is adjacent to and primarily north of I-5. The southern and western portions of the basin along I-5 and Guide Meridian are generally covered by commercial land uses, except for the drainage area immediately downstream of I-5 that is within the Bellingham Golf and Country Club property. The eastern and northern portions are primarily residential and the headwaters have minimal development (City 2020h).



SOUTH FORK BAKER CREEK

FIGURE 2-13

City of Bellingham

Surface and Stormwater Comprehensive Plan

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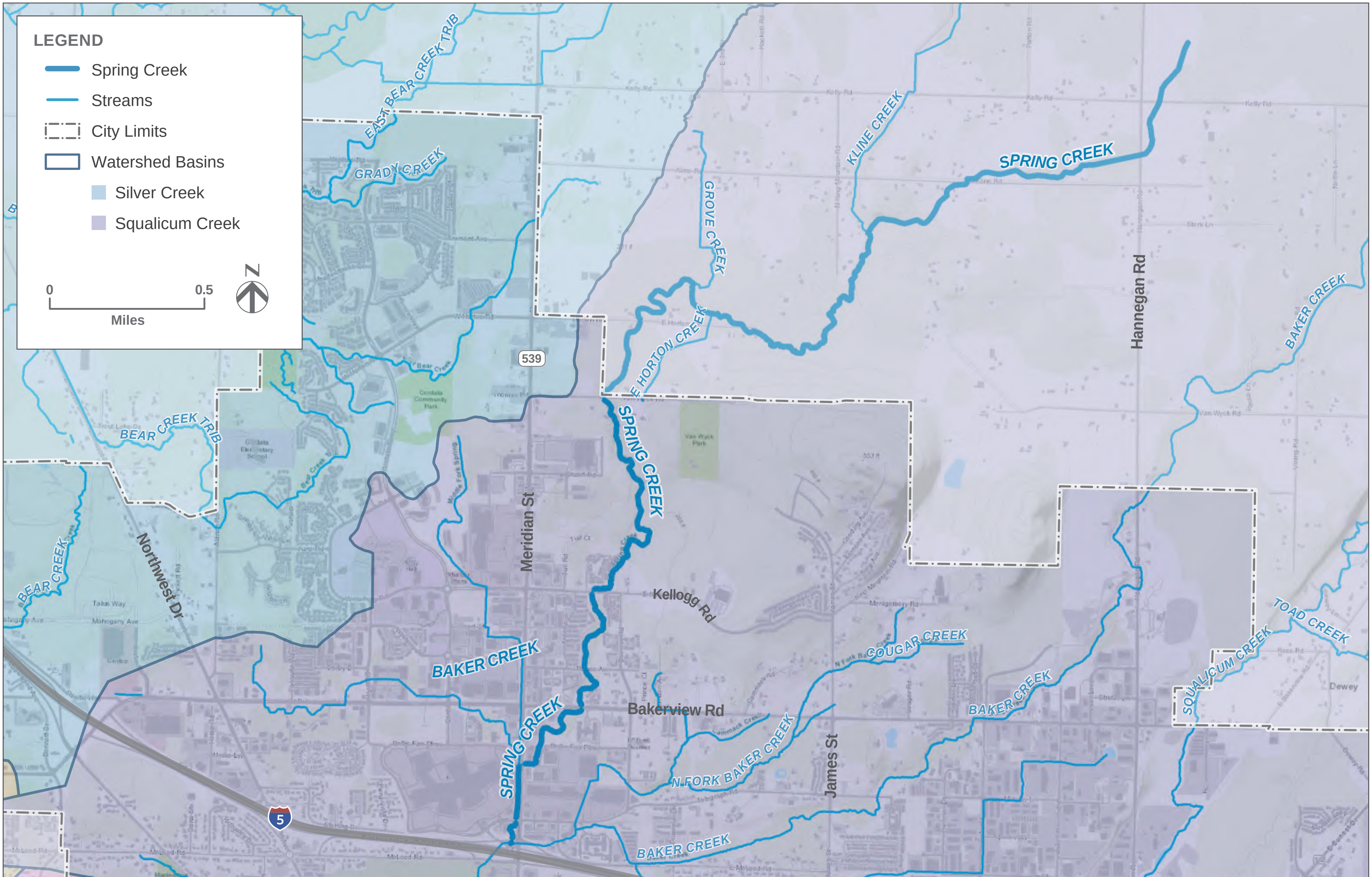

SPRING CREEK

FIGURE 2-14

City of Bellingham

Surface and Stormwater Comprehensive Plan

UPDATED 7/23/2020

Sixteen wetlands in the Baker Creek tributary drainage have previously been identified (City 2020h). In general, these wetlands were situated in low, seasonally saturated bottomlands and were hydrologically connected to Baker Creek or its tributaries. Most of the wetlands were characterized by mixtures of forest and scrub-shrub vegetation. Other areas had wet meadow/pasture grass vegetation (City 2020h).

Baker Creek has a barrier to fish passage a short distance upstream of its confluence with Squalicum Creek (ESA 2015). The culvert under Birchwood Avenue blocks upstream salmon migration, has been addressed by the City. Also, coho salmon use the North Fork Baker Creek to East Bakerview Road with a series of downstream culverts through commercial areas (WDFW 2015b; ESA 2015).

The lower reaches of Baker Creek receive nonpoint source pollution due to the proximity of commercial development and highway runoff (ESA 2015). Automobile-related pollutants from roads and parking areas together with fertilizers and herbicides from lawns are the most likely nonpoint source pollutants entering lower Baker Creek. Upstream, manure runoff from agricultural operations is a significant source of nonpoint pollution entering Baker Creek and its tributaries. The sub-basin is not 303(d) listed; however, there are reported water quality issues related to stream temperature and low dissolved oxygen (Vandersypen 2006).

2.7 Previous Stormwater Planning

The City of Bellingham has historically been proactive in its stormwater planning efforts through watershed studies and comprehensive planning. To provide some context to the past and highlight where previous work is used for this SSWCP, the following sections discuss the 1995 Watershed Master Plan and the 2007 Stormwater Comprehensive Plan.

2.7.1 1995 Watershed Master Plan

The goal of the 1995 Watershed Master Plan (City 1995) was to analyze existing facilities and environmental resources, identify existing and future-projected drainage problems, analyze alternative solutions, make recommendations, and prepare a management plan to implement the recommendations.

The 1995 Watershed Master Plan analyzed all of the major drainage basins in the city by developing hydrologic runoff models for existing- and future-conditions land use (City 1995). An environmental assessment was based on field reconnaissance of inventoried wetlands and qualitative assessments for water quality and channel geometry of the major streams. Similarly, a fishery/aquatic habitat qualitative assessment was performed to identify barriers and degraded habitat locations.

Pollutant loading to receiving waters was estimated using published concentration values of constituents and simulated runoff results. Runoff and hydraulic modeling in the 1995 Watershed Master Plan were based on the methodology shown in Table 2-4.

The basins analyzed were Whatcom Creek and tributaries (Silver Creek, Lincoln Creek, Cemetery Creek, Hannah Creek), Lake Padden basin, Padden Creek, Chuckanut Creek, and Squalicum Creek and tributaries (Baker Creek and Spring Creek). The purpose of the analysis was to analyze the existing conveyance network, identify capacity and velocity issues, identify impacts of future growth, and evaluate the effectiveness of alternative strategies.

Table 2-4. Criteria for hydrologic/hydraulic analysis

Aspect of analysis	Criterion	Value(s)
System capacity	Design storm	
	• Frequency	2-, 25-, and 100-year/24-hour events
	• Total precipitation	As provided by NOAA
Runoff	Hydraulic capacity	System inventory
	Land use	Current: established by aerial photography Ultimate: assumed as full buildout development as currently zoned
	SCS curve numbers	
	• Pervious areas	Variable
	• Impervious areas	CN = 98

2.7.2 2007 Stormwater Comprehensive Plan

The goals and objectives of the 2007 Stormwater Comprehensive Plan were as follows:

- Provide an analysis of existing stormwater facilities and aquatic resources
- Identify existing stormwater problems
- Analyze alternative stormwater solutions
- Document the stormwater plan for implementation by City staff
- Provide City staff a tool to address stormwater and pollutant control

The 2007 Stormwater Comprehensive Plan had a primary focus on the development of citywide, basin-scale continuous-simulation models, developed by Clear Creek Solutions, to identify stormwater conveyance systems that were undersized or risked failure. The Western Washington Hydrology Model (WWHM) with Hydrological Simulation Program-Fortran (HSPF) hydrology and PCSWMM hydraulic inputs were used to determine stormwater facility needs and deficiencies. As part of the 2020 SSWCP update, an evaluation of the 2007 models was done as the City was interested in potentially updating the models for future use. Chapter 3, Hydrology, discusses the findings of that model evaluation.

Several capacity-constrained conveyance lines were identified in the 2007 Stormwater Comprehensive Plan. Those that have not been updated were brought forth into the 2020 CIP.

3 Hydrology

In two previous SSWCP updates (1995 Watershed Master Plan and 2007 Stormwater Comprehensive Plan), the City conducted basin-scale hydrology modeling to generate simulated peak flow rates in all of the city's major watersheds. The 1995 analysis used single-event simulations (Waterworks software) to predict peak flow rates for the 2-, 25-, and 100-year, 24-hour design storms for the objectives of controlling channel erosion, evaluating facility sizing, and recommending facility upgrades. Similarly, the 2007 modeling effort was conducted at the basin scale, but used a continuous precipitation record to predict flow rates and evaluate the capacities of the main conveyance networks throughout the city. The City has made progress in implementing past SSWCP recommendations. The conveyance improvement recommendations from the 2007 Stormwater Comprehensive Plan, not previously addressed, are included in the 2020 CIP.

For the 2020 SSWCP update, hydrologic modeling analyses were focused on the sub-watersheds directly draining to Bellingham Bay for the purpose of establishing design flows for hydraulic conveyance capacity modeling of the drainage systems in those areas (see Chapter 7, Stormwater System Analysis, for details of the conveyance modeling).

The City also maintains a stream gage network and collects both flow and water quality data. The Urban Streams Monitoring Program (USMP) was developed to obtain baseline water quality data for streams in the city and used to detect changes in these streams. The USMP is conducted by the Public Works Operations Division. The City has carried out monthly water quality monitoring of streams since 1990, making the USMP one of the longest-standing status and trends programs in the region. Monitoring currently takes place via monthly grabs at 18 sites, on 10 streams: Whatcom, Hannah, Cemetery, Lincoln, Fever, Padden, Connelly, Chuckanut, Squalicum, and Baker Creeks (see Figure 3-1). USMP annual reports for 2006 through 2015 are maintained on the City's website (https://www.cob.org/services/environment/water-quality/pages/urban-streams-monitoring.aspx). The water quality parameters reported are fecal coliform, dissolved oxygen, temperature, pH, turbidity, and conductivity. Each annual report includes updates of annual flow and water quality data with commentary about stream health.

The purpose of this chapter is to provide an overview of the hydrologic conditions of the streams in Bellingham, and to provide recommendations to close data gaps necessary to upgrade the 2007 hydrologic and hydraulic models for possible use in designing CIP projects and assessing conveyance capacities.

3.1 Flow Monitoring Program

The City collects discharge data from the following five stream flow gage stations, as illustrated in Figure 3-1:

- Chuckanut Creek at Arroyo Park
- Whatcom Creek at Derby Pond
- Whatcom Creek at Dupont

- Padden Creek at Fairhaven Park
- Squalicum Creek at West Street

The City compiles 15-minute stream water level (stage) data at each of the gage stations from which 15-minute discharge data are computed. Daily, monthly, and annual discharge descriptive statistics are calculated. Minimum and maximum flows are recorded, while mean flows are computed. Grades are applied to raw data, depending on the accuracy of the equipment or other environmental causes, including excellent, good, fair, and poor. Data gaps may be due to multiple reasons, such as statistical significance criteria (70 percent statistically significant for daily statistics; 75 percent statistically significant for hourly statistics). The period of record for the flow data used in the following analysis is from 2004 to present-day. Presented in the sections below are updates to the flow data including hydrographs of low, average, and high flows, an analysis of low and high pulse counts (HPCs), and a trend analysis (TQ mean) that evaluates hydrologic response to urbanization.

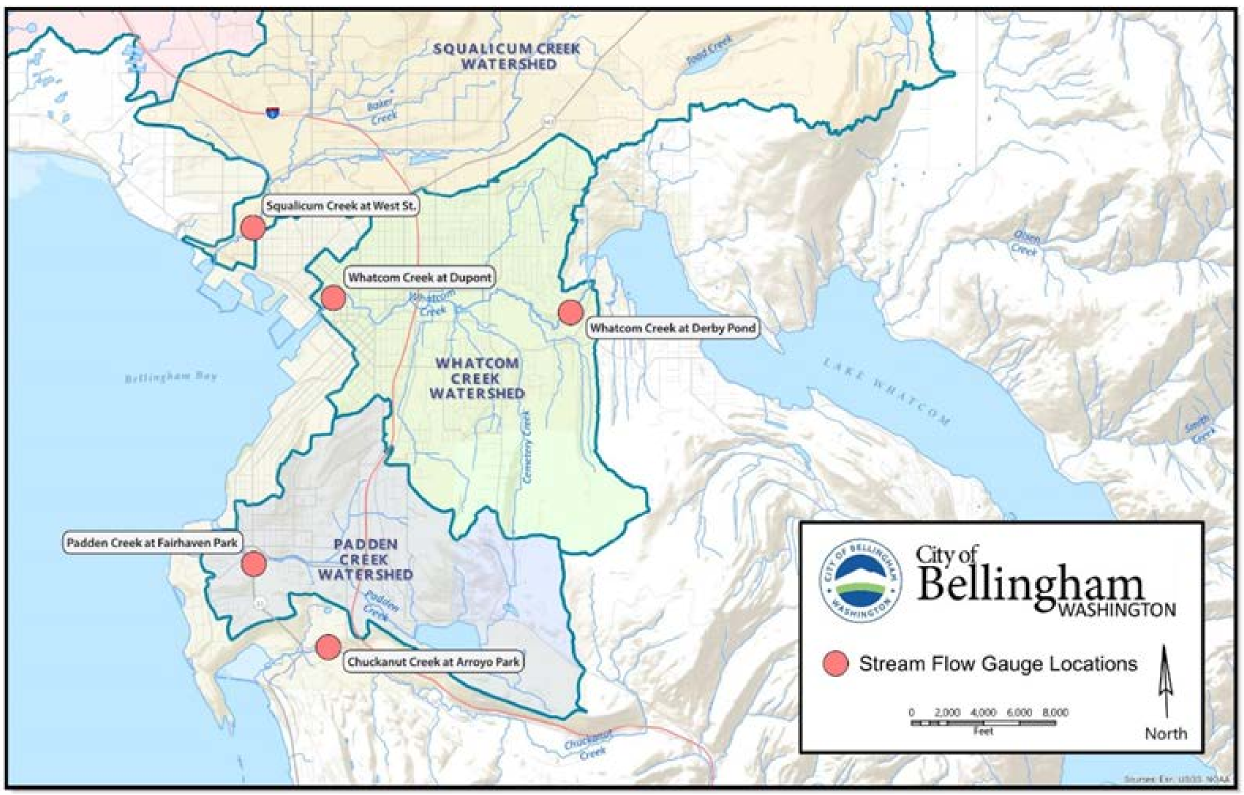

Figure 3-1. City of Bellingham stream flow gage locations

Source: City 2020c.

3.1.1 Flow Data (Average, Low, and High)

Hydrographs of low (10th percentile), high (90th percentile), and average annual flows are presented in this section. Low flows are represented by the 10th percentile flow line, meaning that only 10 percent of the measured flows are below that line, and 90 percent of them are above the value. Conversely, high flows are represented by the 90th percentile flow line, meaning that 90 percent of the measured flows are below the line. Please note differences in scale when comparing graphs between stations. Figure 3-2 through Figure 3-6 show the 10th percentile, average, and 90th percentile annual flows at the respective gage stations.

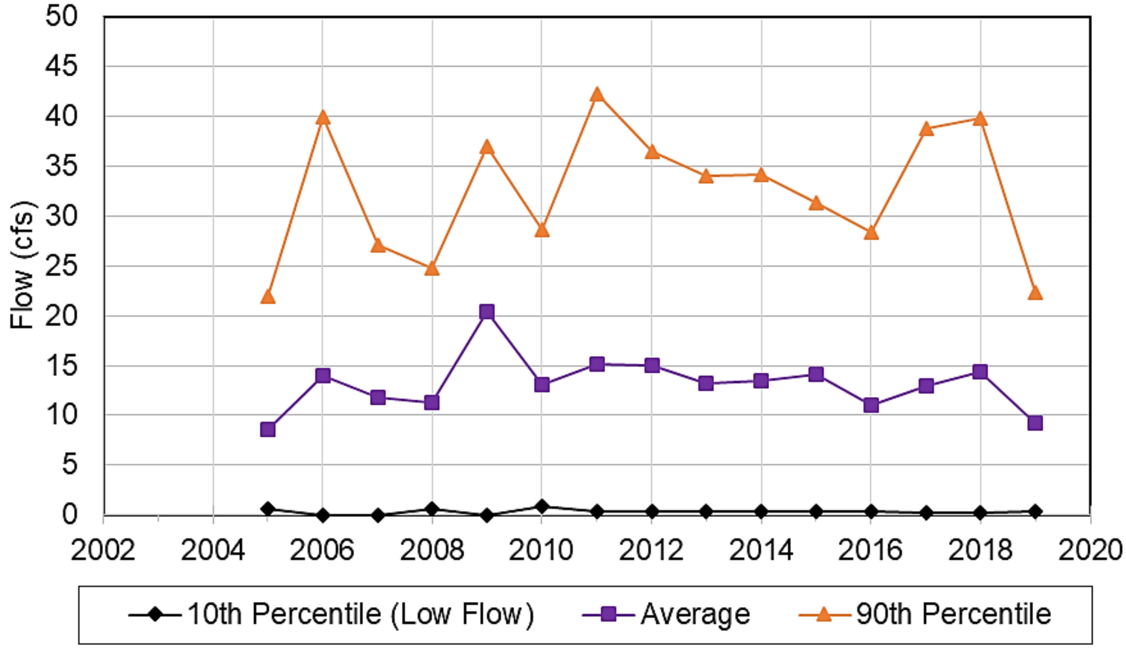

Figure 3-2. Average annual flows Chuckanut Creek at Arroyo Park

Source: City 2020c.

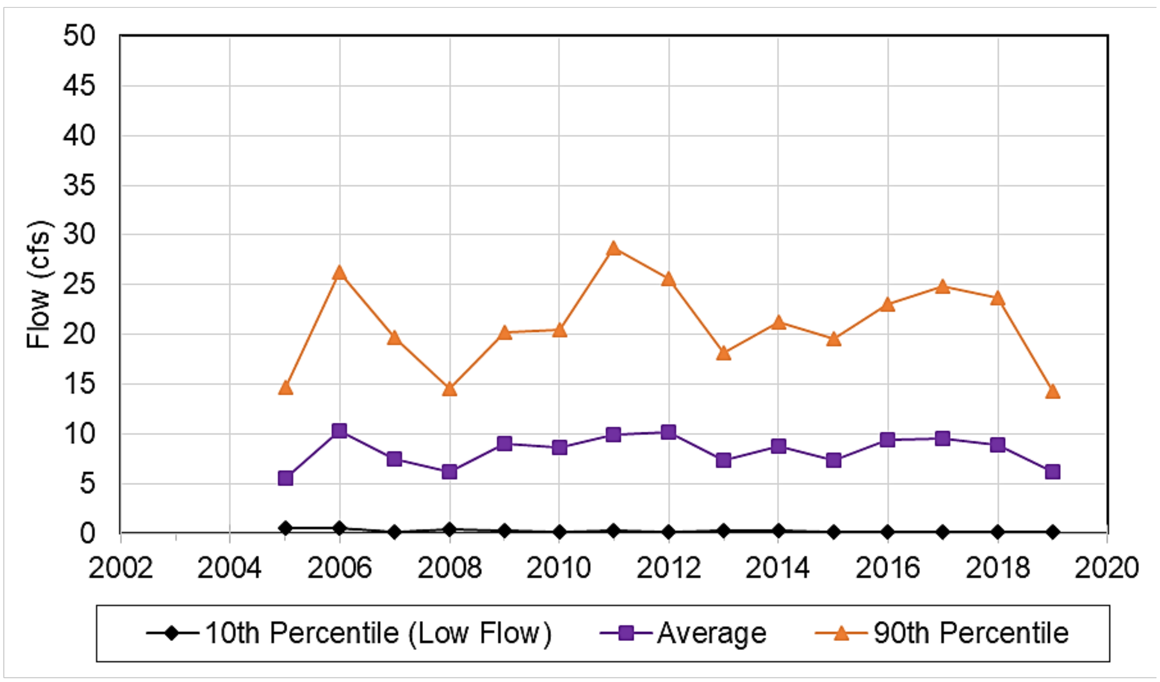

Figure 3-3. Average annual flows Padden Creek at Fairhaven Park

Source: City 2020c.

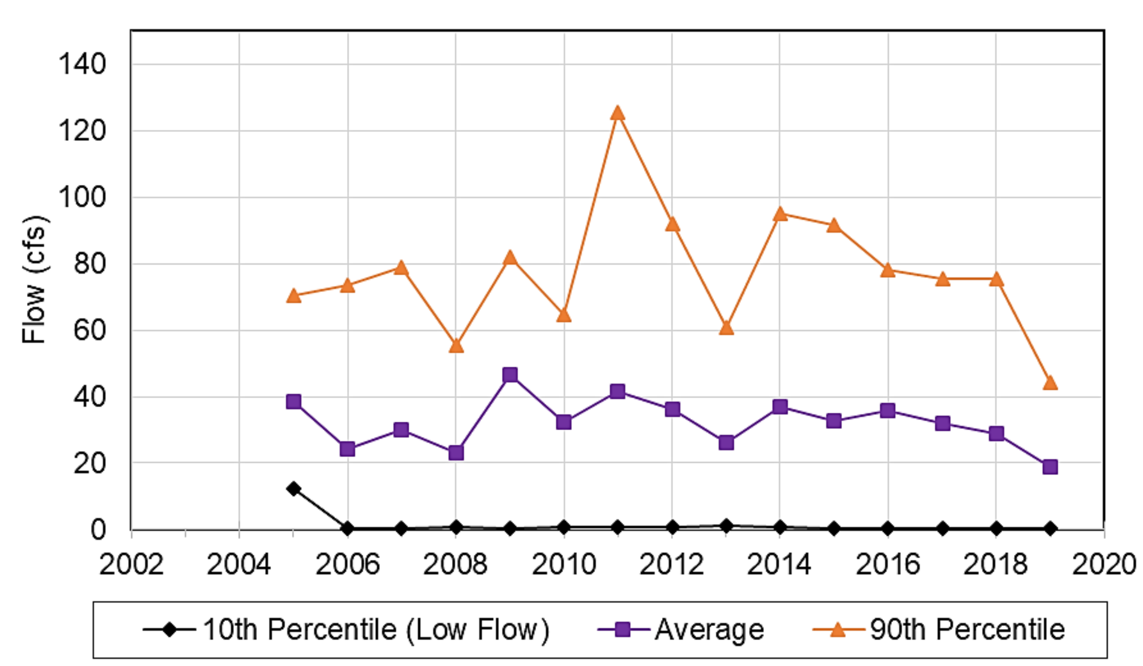

Figure 3-4. Average annual flows Squalicum Creek at West Street

Source: City 2020d.

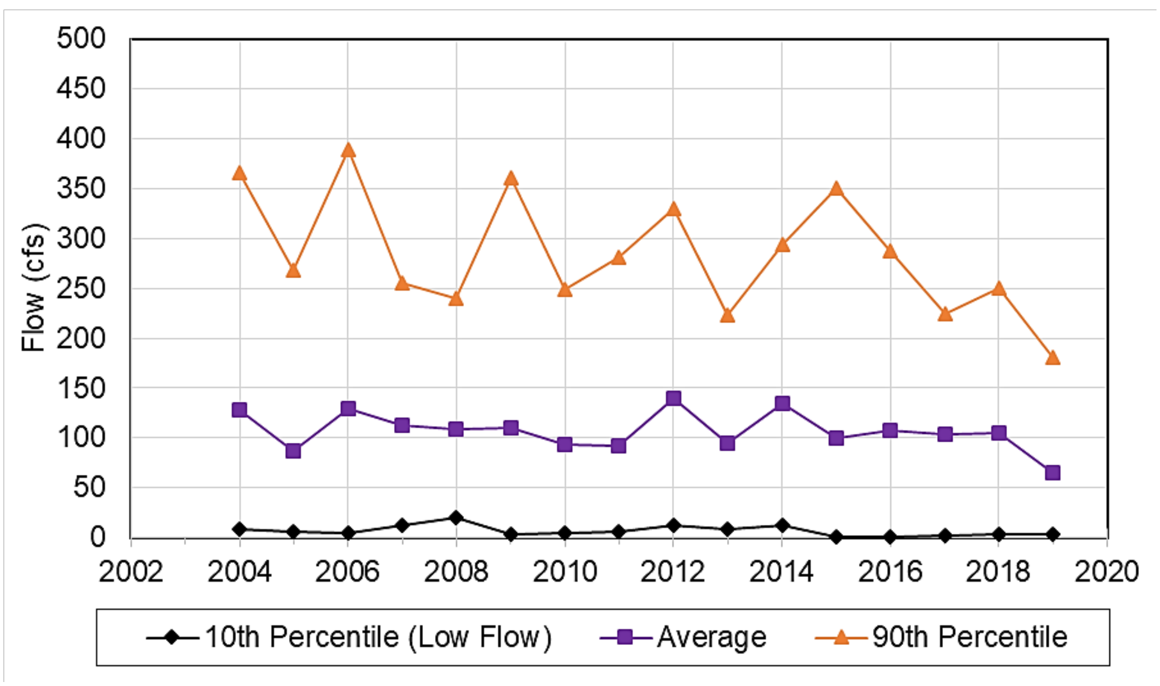

Figure 3-5. Average annual flows Whatcom Creek at Derby Pond

Source: City 2020e.

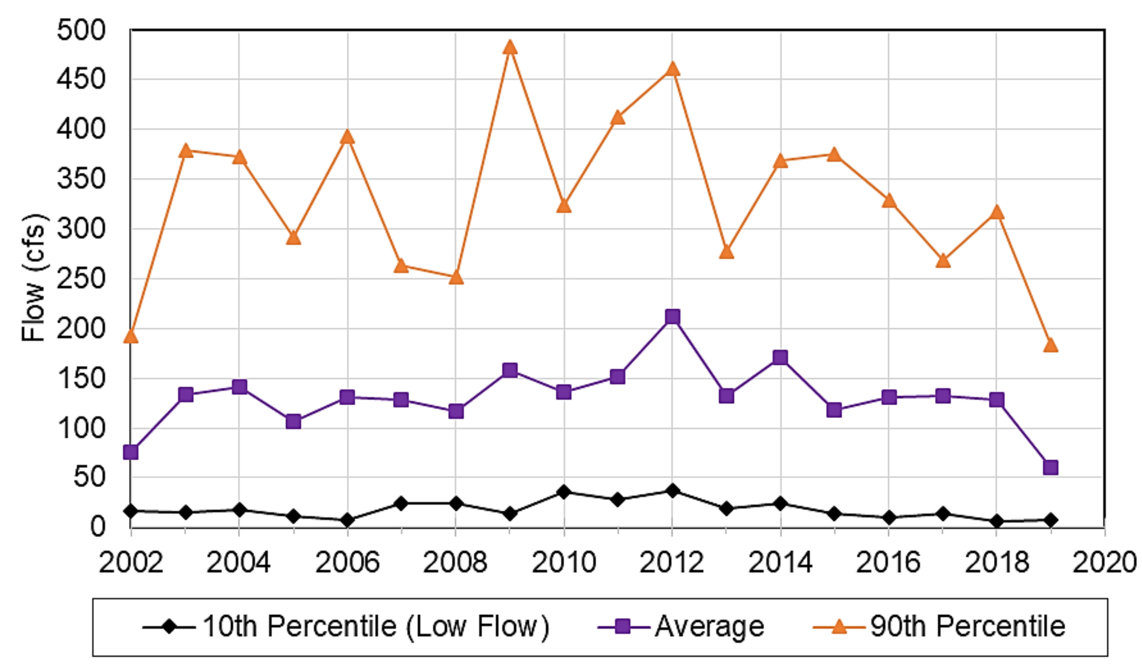

Figure 3-6. Average annual flows Whatcom Creek at Dupont

Source: City 2020f.

3.1.2 Pulse Data Analysis

A pulse count analysis of hydrologic data provides a useful metric to evaluate stream health. Stream health is affected by the frequency and duration of low and high flow events and a pulse count analysis uses existing flow data to count and measure the durations and frequencies of high and low flow events. A pulse refers to a large deviation, either lower or higher, from the long-term daily average flow. For this analysis, a low flow pulse was defined quantitatively as the occurrence of daily average flows that are equal to or less than a threshold set at 50 percent of the long-term daily average flow rate. A high flow pulse was defined as the occurrence of daily average flows that are equal to or greater than a threshold set at twice (two times) the long-term daily average flow rate. High flow pulses occur more frequently in urbanized settings as a result of shorter time of concentrations because of increased impervious area. The expected hydrologic response to urbanization is as follows:

- Baseflow is more frequently interrupted by storm flows, resulting in more frequent high pulse events
- Peak stream flow magnitudes are higher, but durations are shorter
- Flows deviate more frequently from the long-term daily average flow
- Pulse durations decrease as the runoff hydrograph increases in amplitude but decreases in period

Three metrics for the low and high pulse were calculated: count, duration, and range. The five streams have similar values for low and high pulse count and duration. The low and high pulse count values are closer to those of a fully forested condition than a fully urbanized condition.

The results suggest a low percentage of hardscape, a high percentage of vegetation that intercepts rainfall, and/or well-functioning stormwater infrastructure and BMPs. Having an impoundment upstream of a creek would dampen the peak and spread the duration, just as a BMP would, thereby reducing the number of high pulses for large events. Ideally, operating the dam in concert with expected rain events could improve stream health as it could further dampen the pulse, and reduce sediment loss due to channel bank erosion. However, looking at the data on an annual basis would limit the ability to evaluate dam operations.

The third metric, pulse range, is less intuitive and researchers developed this metric after the original count and duration metrics. The range is the number of days between the start of the first flow pulse and the end of the last flow pulse during a year. This provides an indication of whether pulses are seasonal or annual. The low and high pulse ranges increase with greater urbanization. The five streams have similar results. The low pulse range is likely mostly indicative of when baseflow occurs and suggests that runoff pulses can interrupt this pattern throughout this season. The high pulse range (HPR) is annual and indicates that high flows can occur at any time. However, the wide range means any given storm could generate a pulse and be more a function of the types of storms than the runoff response.

Research conducted in Puget Sound lowland streams shows substantial confidence that a goal of raising benthic index of biotic integrity (B-IBI), a measure of stream health, out of the lowest index tier (less than 16 indicating poor stream health) to a fair-condition tier (greater than 16) cannot be achieved if HPCs remain above 15 excursions and HPR is greater than 200 days (King County 2013). Bellingham urban streams as shown in the data in Table 3-1 have HPC below 15, and HPR greater than 200 days, indicating the possibility of similar conclusions. Of course the institution of distributed green stormwater infrastructure (GSI) practices and stormwater BMPs can help reduce the effect of urbanization, thereby bringing HPC up and HPR down.

A comparison to rainfall patterns and additional metrics, which were beyond the scope of the SSWCP update, may be needed to further interpret the meaning of the pulse metrics.

The pulse count data for the five monitoring sites are presented in Table 3-1.

Table 3-1. Hydraulic metrics from City of Bellingham monitoring locations for low and high pulse count and range

		Chuckanut Creek at Arroyo Park gage station			Whatcom Creek at Derby gage station			Whatcom Creek at Dupont gage station			Padden Creek at Fairhaven Park gage station			Squalicum Creek at West Street gage station		
Variable	**Description (units)**	**Minimum**	**Mean**	**Maximum**	**Minimum**	**Mean**	**Maximum**	**Minimum**	**Mean**	**Maximum**	**Minimum**	**Mean**	**Maximum**	**Minimum**	**Mean**	**Maximum**
Low pulse count	Number of low pulse events per year (count)	1	3	6	1	3	6	1	3	4	1	3	6	1	4	6
Low pulse duration	Mean duration of low pulse events (days)	27	70	208	29	71	218	35	82	250	26	77	206	8	70	180
Low pulse range	Range each calendar year over which low pulse events occur (days)	189	235	292	201	257	312	120	225	306	177	227	297	60	249	334
High pulse count	Number of high pulse events per year (count)	4	6	9	1	4	8	1	4	8	4	7	9	4	7	9
High pulse duration	Mean duration of high pulse events (days)	4	9	15	0	17	51	3	14	32	5	11	21	4	9	16
High pulse range	Range each water year over which high pulses occur (days)	268	341	364	0	298	364	2	309	364	280	36	364	196	338	364

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3.1.3 TQ Mean Analysis

“TQ mean” is the fraction of time that stream flow exceeds the daily mean stream flow during the year. This hydrologic measure of stream flashiness provides insight to stream response to urbanization. “Flashiness” is a term that describes how quickly stream flow rises and falls in response to storm events. Urbanized watersheds tend to be flashier than forested or undeveloped watersheds because the impervious areas in the built environment intercept precipitation and quickly direct the runoff to streams, whereas in a forested watershed the precipitation is absorbed into the ground or is returned to the atmosphere through evapotranspiration processes, thus resulting in lower stream flow. Stream flow in a forested watershed, relative to the mean annual flow, tends to have longer periods (sustained flow periods) with lower peak flow rates (smaller amplitudes).

TQ mean is the fraction of time during a water year that average daily flow is greater than average annual flow. Stream data with long periods when the average daily flow was above the mean annual flow produces a relatively high TQ mean value. Long periods of flow above the mean annual flow suggest that the watershed response to storm events mimics more natural conditions. Relatively small TQ mean values indicate short durations when the average daily flow is above the mean annual flow, indicating flashier streams, which is typical of urbanizing watersheds.

TQ mean trends for the years 2005 to 2019 are increasing at four of the five gaging stations (Chuckanut Creek is decreasing). The increasing trends suggest that stormwater management practices are having positive effects on flow quantities. TQ mean trends are shown in Figure 3-7 through Figure 3-11. It is difficult to develop conclusions on the effect that the operation of the control dam has on Whatcom Creek; however, a detailed study that would include tracking operation and stream response could show that dam control could also function similarly as a BMP by prolonging stream flow above average flow.

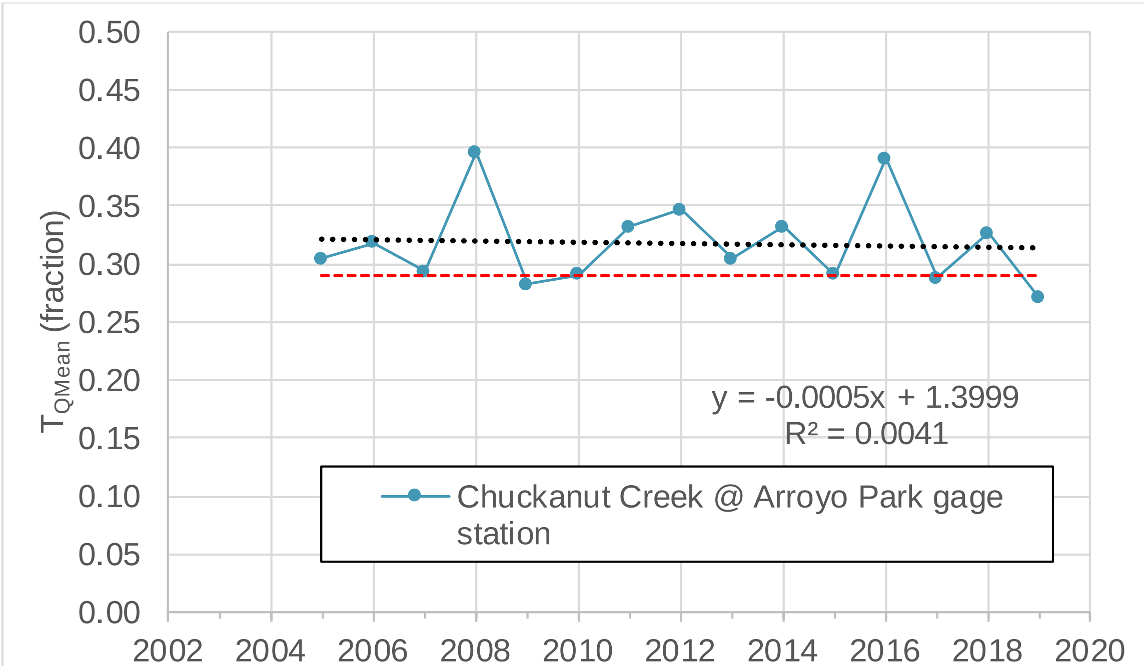

Figure 3-7. TQ mean Chuckanut Creek at Arroyo Park gage

Source: City 2020g.

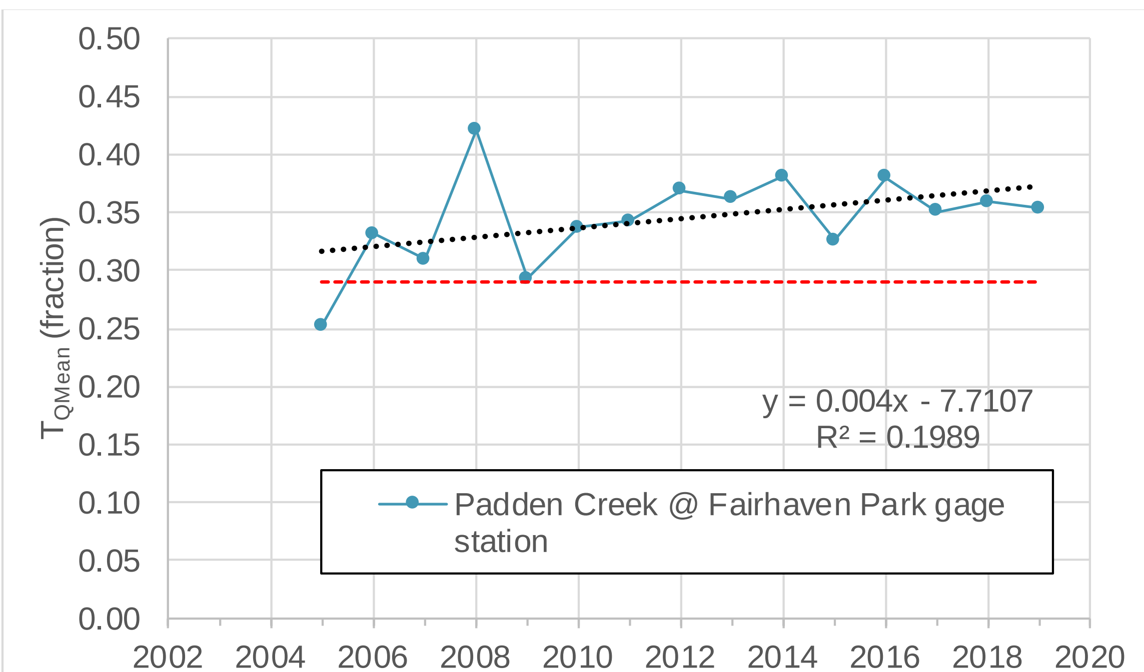

Figure 3-8. TQ mean Padden Creek at Fairhaven Park gage

Source: City 2020g.

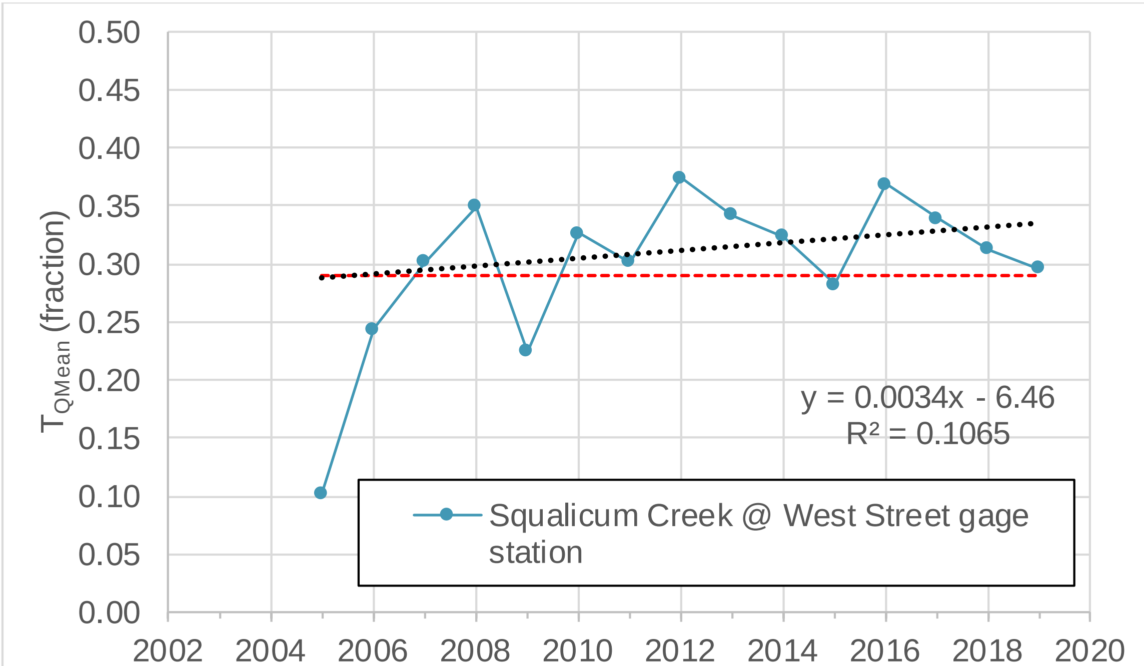

Figure 3-9. TQ mean Squalicum Creek at West Street gage

Source: City 2020g.

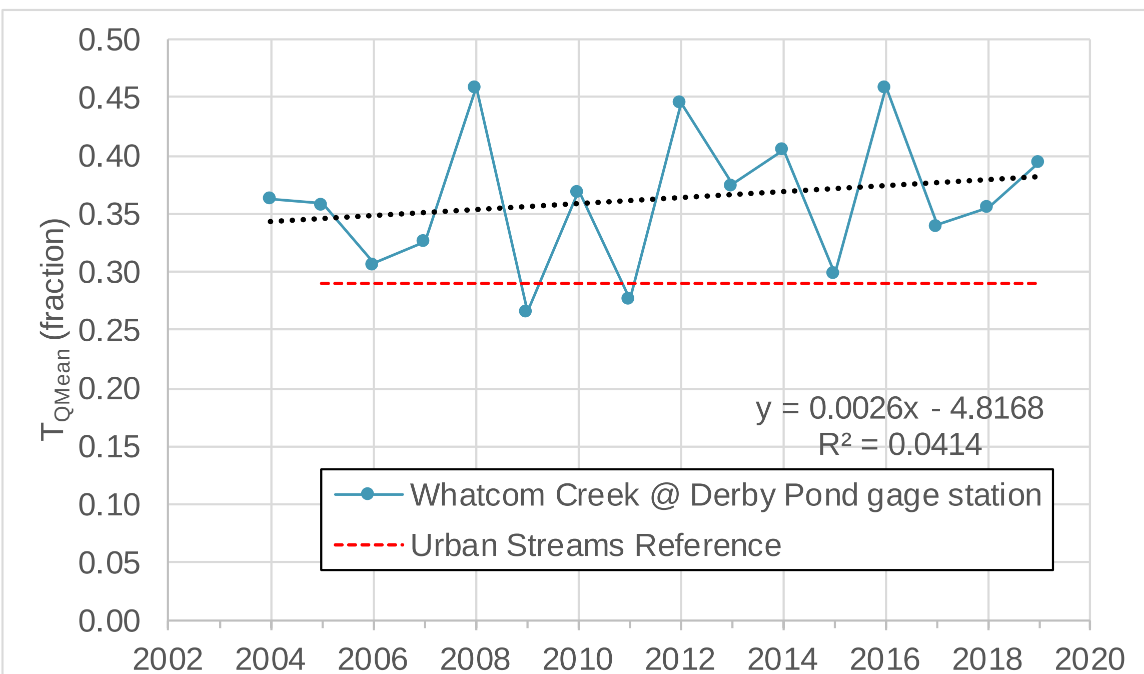

Figure 3-10. TQ mean Whatcom Creek Derby gage

Source: City 2020g.

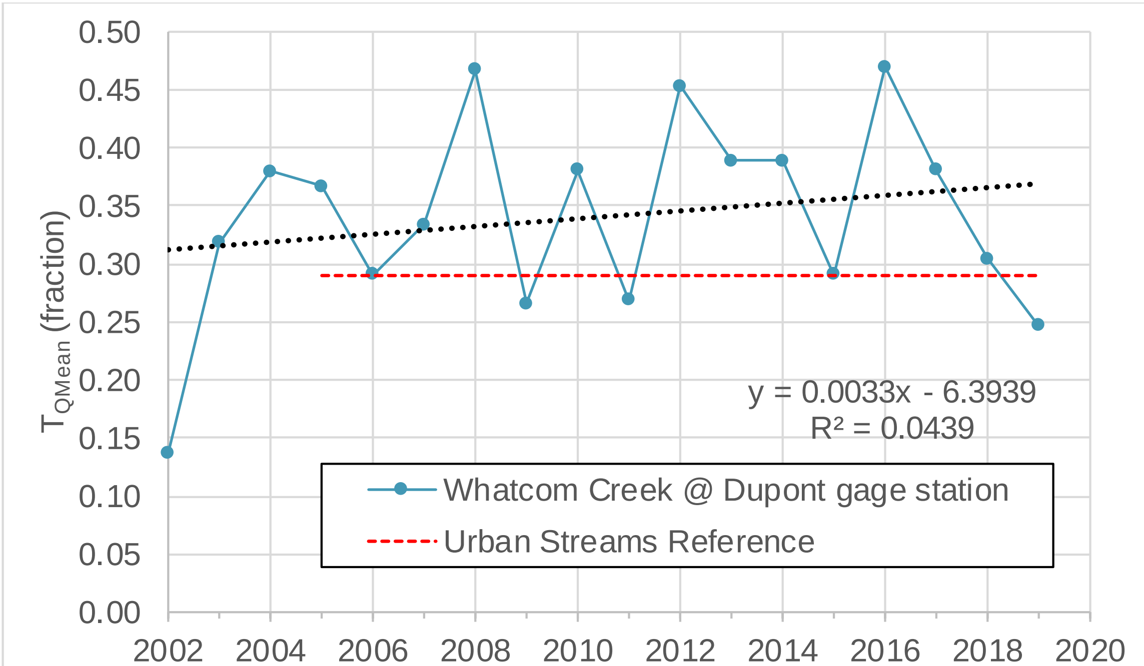

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Figure 3-11. TQ mean Whatcom Creek Dupont gage

Source: City 2020g.

3.2 2007 City of Bellingham Comprehensive Plan Modeling

Under the 2007 City of Bellingham Stormwater Comprehensive Plan, continuous-flow duration hydrologic and hydraulic models were developed to identify stormwater conveyance system locations that were undersized and potentially at risk of failure. Sub-watersheds modeled included the following:

- Silver Creek
- Squalicum Creek
- Silver Beach Creek
- Whatcom Creek
- Padden Creek
- Chuckanut Creek

Each of the sub-watersheds was further subdivided into sub-basins, thus producing numerous hydrologic boundaries throughout the city. These sub-basins were used in the systems analysis and retrofit plan that are described in Chapter 7.

3.2.1 Model Outputs

The results of the model, showing the extent of potential capacity enhancements, are summarized in Table 3-2 below.

Table 3-2. Sub-basin storm conveyance upgrade quantities

Sub-basin	Improvement project group	Pipe upgrade quantity (lf)
Baker and Spring	Culverts, storm drains	3,650
Silver	Culverts, storm drains	1,300
Squalicum	Culverts, storm drains	2,000
Whatcom Creek	Ellis Street 1	2,250
	Ellis Street 2	2,050
	King/Virginia/Lincoln	3,400
	Meador Avenue	200
	State Street	900
	Misc. Whatcom outfalls	250
Fever Creek	Kentucky Street	1,050
	Orleans/Nevada	1,600
	Valencia/North/Verona	3,500
	Misc. improvements	700
Cemetery Creek	*Insufficient conveyance data	
Hannah Creek	Lakeway Drive	800
	Raymond Street	200
Lincoln Creek	Lincoln Creek	1,050
Total		**24,900**

3.2.2 Erosive Flow Analysis

Ecology bases its NPDES permit flow control standard (Minimum Requirement 7) on the range of erosive flows in western Washington streams. Based on work done at the University of Washington by Booth and Jackson (1997), it was found that the typical range of erosive flows in western Washington streams is from half of the 2-year peak flow to the full 50-year peak flow. This standard erosive flow range is the basis for Ecology's Minimum Requirement 7.

Local municipalities have the option of conducting watershed-specific erosive flow analysis to replace Ecology's standard erosive flow range. As part of the 2007 Stormwater Comprehensive Plan, this erosive flow analysis was done for Whatcom Creek. The analysis focused on determining the flow at which erosion/scour of the stream channel bedload begins. Controlling erosive flows will aid in reducing sediment transport from eroding streams, and enhance stream function and habitat preservation.

A summary of the results is presented in Table 3-3 below, indicating the estimated discharge corresponding to sediment movement and its critical shear stress, respectively.

Table 3-3. Whatcom Creek minimum erosive flows

Site	Estimated discharge at incipient point of sediment motion (cfs)		Critical shear stress (lb/ft²)
	Slope = 0.03 (ft/ft)	Slope = 0.01 (ft/ft)	
Falls Park Reach Site 1	29.5	101.1	0.83
Redtail Reach Site 1	2.4	8.2	0.45
Redtail Reach Site 2	3.9	13.3	0.60
Redtail Reach Site 3	3.6	12.4	0.52
Redtail Reach Site 4	6.3	21.5	0.88
Salmon Park Reach Site 1	4.1	14.2	0.59

A Wolman pebble count survey is a process to establish the range of sediment size in a stream. The pebble count analysis shows that erosive flows in Whatcom Creek generally start in the flow range of 10 to 30 cubic feet per second (cfs). The general assumption, from various geomorphic studies, is that these flows should roughly correspond to bankfull flow, which generally corresponds to a flow rate with a return frequency of slightly less than the 2-year return frequency flow.

Parametrix conducted an erosive flow analysis of Whatcom Creek tributaries (Hannah, Lincoln, Fever, and Cemetery) in March 2006. The erosive flow results from the 2007 Stormwater Comprehensive Plan are shown in Table 3-4, indicating estimated discharges at the time of sediment movement for two different slopes along with the critical shear stress (both low and high). D50 is the median particle diameter of the 50th percentile sediment particle, while D84 is the median particle diameter of the 84th percentile sediment particle.

Table 3-4. Whatcom Creek tributaries minimum erosive flow (Bathurst Equation)

Site	Stream width (ft)	Slope = 0.01 (ft/ft) Low D84	Slope = 0.02 (ft/ft) High D84	Low D50 (lb/ft²)	High D50 (lb/ft²)
Site 1: Hannah Creek	10	6.8	24.9	0.10	0.15
Site 2: Hannah Creek	10	6.8	24.9	0.10	0.15
Site 3: Lincoln Creek	6	1.4	5.3	0.05	0.07
Site 4: Fever Creek	12	4.9	17.8	0.07	0.10
Site 5: Cemetery Creek	15	48.3	182.3	0.30	0.42

There is a large range of minimum erosive flows for each tributary stream. No attempt was made to try to correlate these flow values to Ecology's 50 percent of the 2-year flow at these sites.

Minimum Requirement 7, Flow Control, requires property developers to provide measures to reduce runoff from their sites to the forested pre-developed condition. The intent of this requirement is to prevent increases in the frequency of flooding due to new development.

Detention facilities are often designed to maintain peak flow rates at their pre-development levels (e.g., forested conditions) for certain recurrence intervals (e.g., 2- and 10-year). Facilities that control only peak flow rates, however, usually allow the duration of high flows to increase, which may cause increased erosion of the downstream system. For example, a detention facility may keep the magnitude of a 2-year flow from increasing, but the amount of time that flow rate occurs may double. Therefore, Ecology bases the flow control standard on outgoing flow rates that provide protection from erosion, as such detention systems also have a duration control standard for geomorphically significant flows (flows capable of moving sediment). Such detention systems employ lower release rates and are therefore larger in volume, resulting in increased facility size, and in turn higher implementation cost.

Ecology offers a basin-specific method for determining flow control facility sizing. The Ecology-approved watershed approach for establishing flow control standards is based on the unique characteristics of a target watershed that takes into account the specific sediment size and flow rates of the watershed. It requires a detailed study to establish flow rates at various locations in the watershed and a detailed analysis of the dominant sediment regime. The 2007 erosive flow analysis is an example of such a detailed study. The values in Table 3-4 could be used to establish threshold discharge rates in the respective watersheds. Further analyses to establish differences in runoff rates from a fully developed watershed to the values calculated in 2007 could be the basis of alternative flow control standards. Any proposal to use the alternative method would require approval by Ecology.

In conclusion, this alternative approach is not recommended at this time because the generic approach does not appear to be a barrier to redevelopment. If the City experiences problems using the generic approach, for example costs for stormwater mitigation are explicitly identified by developers, then the City could consider developing the watershed-specific standard. It is possible that the findings would result in smaller facilities, thus incentivizing developers to rebuild.

3.2.3 2020 Model Evaluation

The stormwater modeling software provided to the City in 2007 gave City staff a range of tools to use for present and future watershed planning. The intent of the model was also for City staff to evaluate proposed land use developments and mitigation measures within the city's watersheds, determine the effectiveness of upgrading the City's stormwater conveyance system, and simulate how changes in the City's urban growth area will impact stormwater flows in the city's streams. The modeling software options include the ability to update the model with new land use data as they become available.

The modeling and under-capacity pipe analysis has been used during development review by the City in a limited manner to evaluate the potential for the system to handle additional development. It is understood that the previous modeling effort was limited in scope and budget to allow further assessments.

As part of the 2020 SSWCP update, the 2007 hydrologic and hydraulic models were evaluated for the possibility of updating them to current land use conditions and possible use for basin planning. The objective of this task was to provide an assessment of the City's existing hydrologic and hydraulic models and determine their potential for use in completing the modeling and analyses needed to support the conveyance modeling conducted in the 2020 SSWCP, specifically for analysis of Lower Padden Creek, Lower Squalicum Creek, Lower Baker Creek, Lower Spring Creek, and Baker Creek Tributary. The City provided model input and output files, available documentation, and supporting data to the HDR Engineering, Inc. (HDR) team for this evaluation.

Appendix A contains the technical memorandum that details the results of the model assessment. The assessment has the following conclusions:

- WWHM models of 2007 conditions for the Chuckanut Creek, Padden Creek (Lower and Upper), Silver Creek, and Silver Beach Creek basins are available.
- Updates to the models of the four basins listed above to simulate full buildout conditions would be relatively straightforward.
- WWHM models of the Whatcom Creek and/or Squalicum Creek basins would be more difficult and would rely on being able to locate the actual WWHM models for those basins or all of the necessary input data.
- Data gaps in the existing models need to be closed before the models can be used for their stated objectives. The analysis provided a scope and budget to update the models and close the data gaps. The technical memorandum that describes the analysis and includes the scope for updating the models is included in Appendix A.
- The process for opening the model files in Western Washington Hydrology Model 3 (WWHM3) as described in the 2007 report was not successful. It is recommended to set up new WWHM models from scratch for future use.
- The archived Storm Water Management Model (SWMM) model was missing SWMM input files that could be directly used in current versions of SWMM. Furthermore the 2007 Stormwater Comprehensive Plan provides limited detail on how the data for the SWMM models were derived. Some of the data apparently came from the City's GIS and other data were obtained from an earlier 1995 Watershed Master Plan study.
- The 2007 report also states that "Missing or incomplete GIS conveyance system data were filled based on 'adjacent data.'" It is recommended to collect measured-down distances between the rim and the inverts in catch basin structures with missing data.
- Given the lack of usable SWMM input files, the lack of clear documentation on how the SWMM input data were derived, and the statement that the 2007 models were only "conceptual and intended for planning-level decision-making," it is recommended that creating new SWMM models for the five targeted sub-watersheds would be more efficient and cost-effective than spending any additional effort to locate or use the earlier SWMM models.

4 Climate Change Considerations for Stormwater Planning

This chapter describes expected changes to SLR in Puget Sound and expected changes in precipitation patterns in western Washington.

Observed sea level trends show an increase in SLR of 1 inch every 55.6 years (Cherry Point, Washington tidal gage) and 1 inch every 21.3 years (Friday Harbor, Washington tidal gage). These are the closest tidal gages to Bellingham with applicable data. Bellingham has a tidal gage; however, it is relatively new with only 2 years of data, and would not be sufficient to use for analysis yet. Ideally, at least 30 years of recent data are necessary for SLR trend analysis.

Projected sea level trends were graphed with high and low greenhouse gas (GHG) estimates. Both projections show an increase in SLR.

Projected precipitation intensities were analyzed with high and low GHG estimates. The trends overall show increasing precipitation intensities.

4.1 Historical Sea Level Trends

The nearest tidal gage to Bellingham, Washington, is the Cherry Point tidal gage, which has a period of record from 1973 to 2018, shown below in Figure 4-1 (NOAA 2020). This graph shows a relative sea level trend of 0.45 millimeter per year, which equates to 0.018 inch per year or 1 inch every 55.6 years. However, these data should be used cautiously as the margin of error is twice the yearly value.

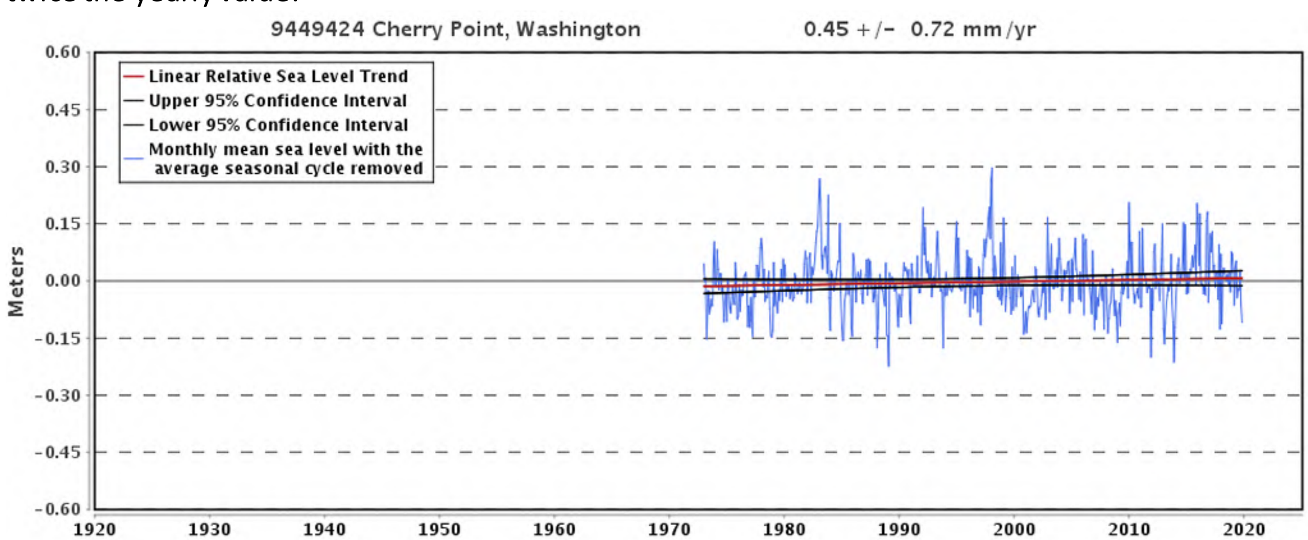

Figure 4-1. Cherry Point sea level trend

The nearby tidal gage of Friday Harbor was also analyzed as it had a longer period of record, thus providing more accurate analysis for historical trends. The period of record of the Friday Harbor tidal gage, which is from 1934 to 2018, is shown below in Figure 4-2 (NOAA 2020). This graph shows a relative sea level trend of 1.2 millimeters per year, which equates to 0.047 inch per year or 1 inch every 21.3 years. The Friday Harbor error margin is more reasonable for analysis.

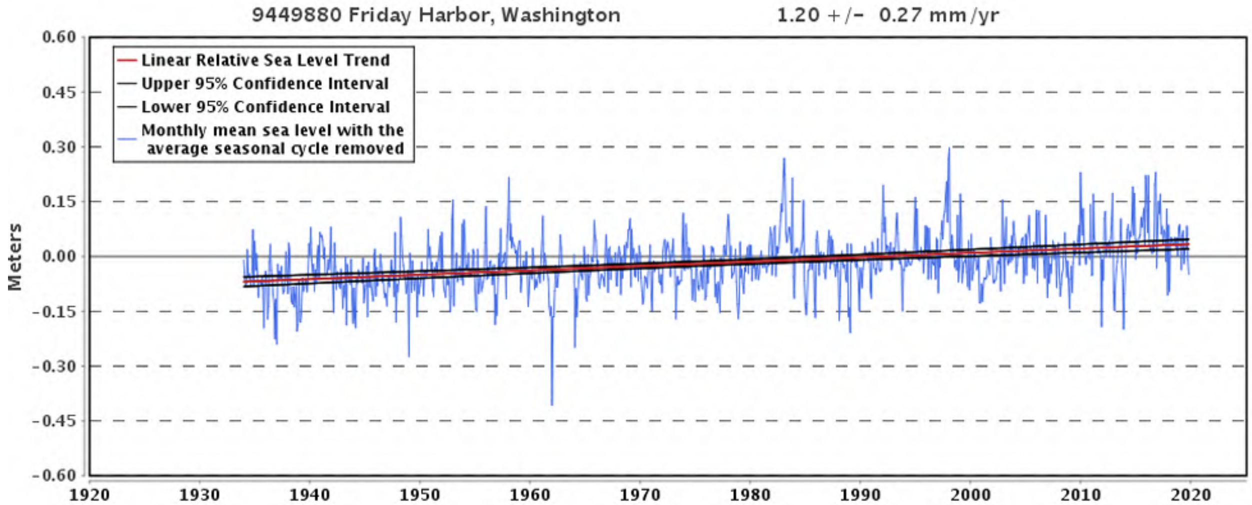

Figure 4-2. Friday Harbor sea level trend

4.2 Projected Relative Sea Level Change

A recent study of projected SLR within Puget Sound was conducted by Washington Sea Grant, University of Washington (UW) Climate Impacts Group (CIG), University of Oregon, University of Washington, and the United States Geological Survey (USGS). The report, titled "Projected Sea Level Rise for Washington State," provides projections in SLR across the state of Washington including the city of Bellingham (UW 2018). The following evaluations are based on Representative Concentration Pathways 4.5 and 8.5. The Representative Concentration Pathway is a GHG concentration trajectory standard adopted by the Intergovernmental Panel on Climate Change (IPCC). Representative Concentration Pathway 8.5 is a predicted trajectory based on very high GHG concentrations, while Representative Concentration Pathway 4.5 is considered moderate concentrations.

Figure 4-3 and Figure 4-4, shown below, graph these SLR projections for two different forecasted GHG emissions for the years 2030, 2050, and 2100. Figure 4-3 shows a Representative Concentration Pathway of 4.5, which projects a reduction scenario in which significant GHG mitigation policy is implemented. Figure 4-4 shows a Representative Concentration Pathway of 8.5, which projects very high GHG emissions without additional efforts to constrain emissions.

The UW CIG estimates that the median value of relative SLR in Bellingham Bay will be between 0.9 foot and 1.1 feet by 2070. The modeling of the flood reduction alternatives for this SSWCP was run assuming the tidal boundary condition was raised by 1.1 feet. As can be seen in Figure 4-3, even a 2-foot rise by 2070 has approximately 1 percent probability of exceedance. Setting a higher SLR expectation may not be prudent given the minor impact to levels of service and the relative short life span of built stormwater assets (usually 50 years) compared to the SLR adjustments that can be made over the next 20 to 30 years. In comparison to the SLR analysis used on the stormwater assets, the City requirements for building structures (deemed to last considerably longer than storm sewers) along the waterfront are using 55 inches of SLR as their time frame for protection.

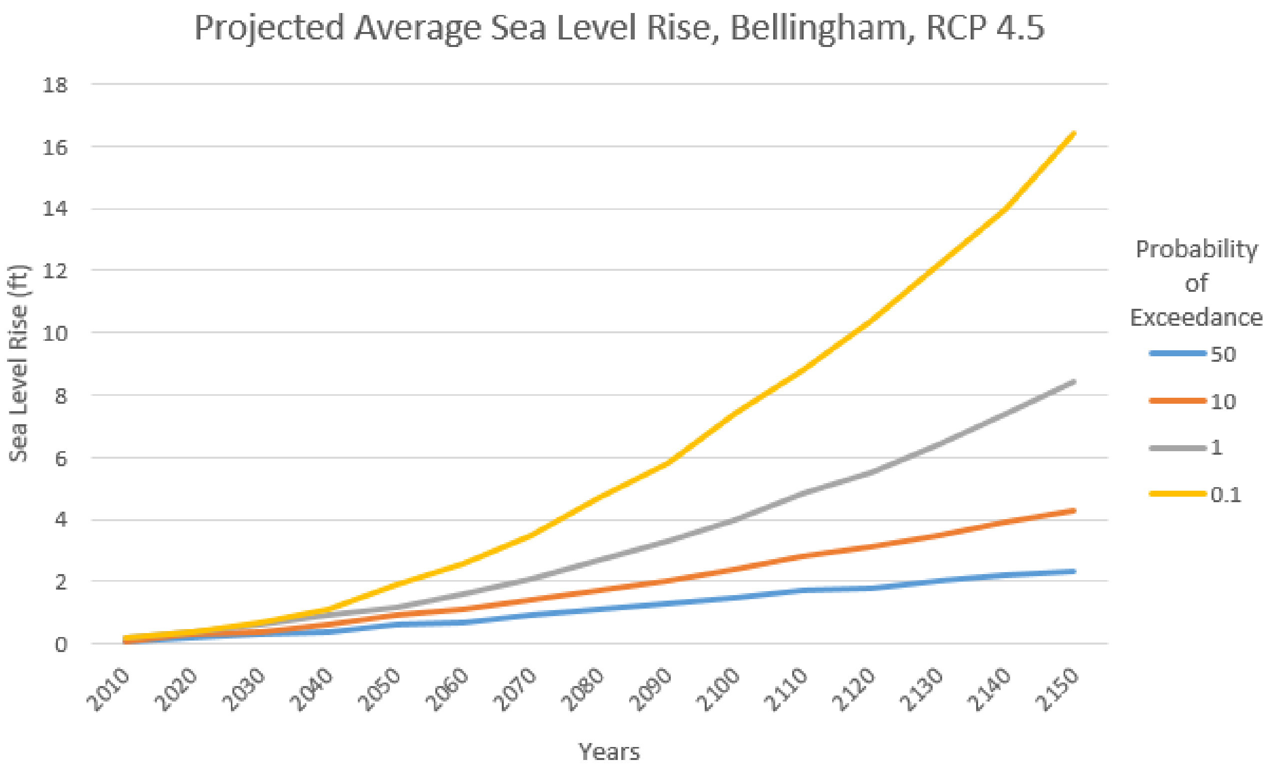

Figure 4-3. Bellingham projected sea level rise, Representative Concentration Pathway 4.5

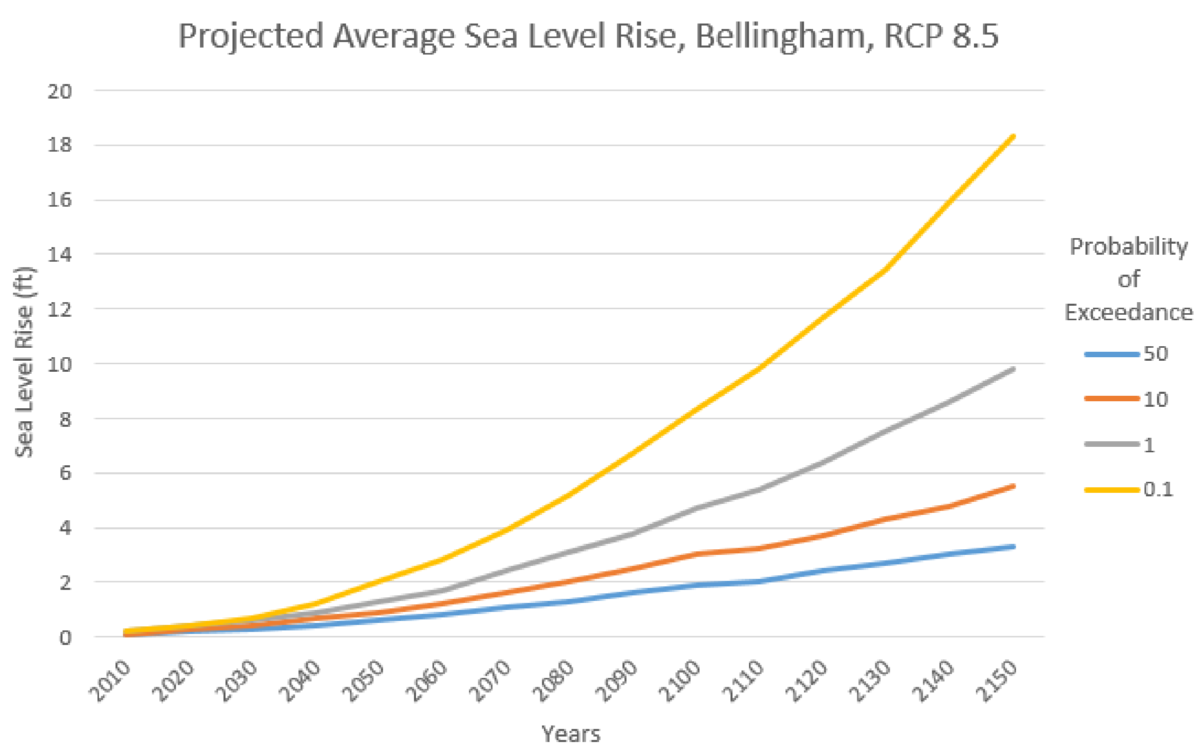

Figure 4-4. Bellingham projected sea level rise, Representative Concentration Pathway 8.5

4.3 Projected Trends and Changes in Precipitation Intensities

The UW CIG developed a study titled "Regional Model Projections of Heavy Precipitation for Use in Stormwater Planning" (CIG 2019). The future climate projects from this study show increasing precipitation intensities in western Washington that are likely to continue and consequently produce more intense hydrologic extremes. The study used a National Oceanic and Atmospheric Administration (NOAA) rain gage in nearby Burlington, approximately 20 miles to the south, which is characterized by a climate similar to that in Bellingham. A correction factor was applied given the proximity. Figure 4-5 shows the locations of rain gages that were used in the study.

Figure 4-6 through Figure 4-8 show the projected change in 24-hour precipitation at the Burlington location as a percentage of the recent climatological mean (e.g., 1980 - 2009) at the future time scales of 2030s (Figure 4-6), 2050s (Figure 4-7), and 2080s (Figure 4-8). The high-end precipitation values were produced using a Representative Concentration Pathway value of 8.5 and the low-end precipitation values were produced with a Representative Concentration Pathway value of 4.5.

The figures show that the projections of future climate scenarios demonstrate an overall increase in precipitation extremes. This can be important in long-range resilience planning for critical infrastructure and public safety.

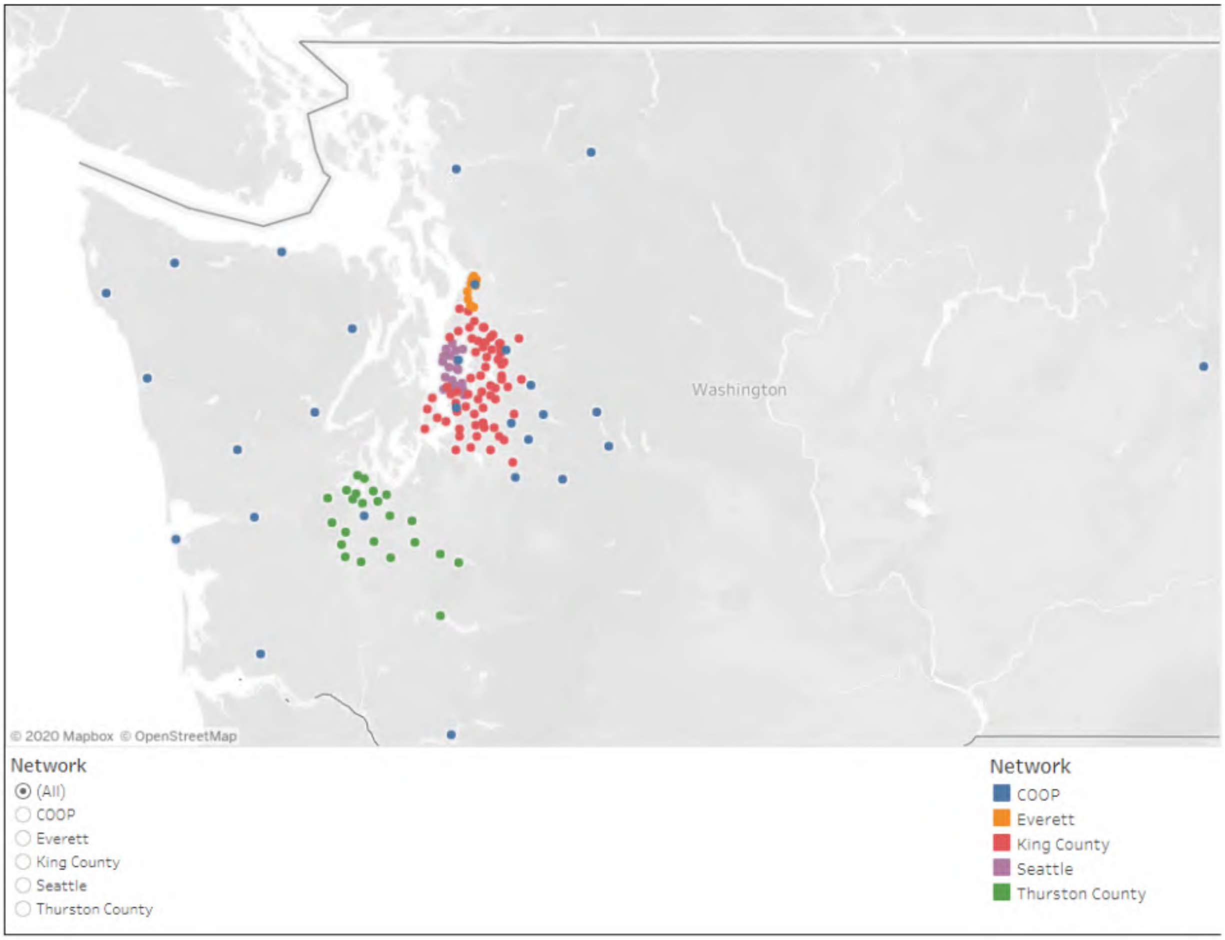

Figure 4-5. Locations of rain gages

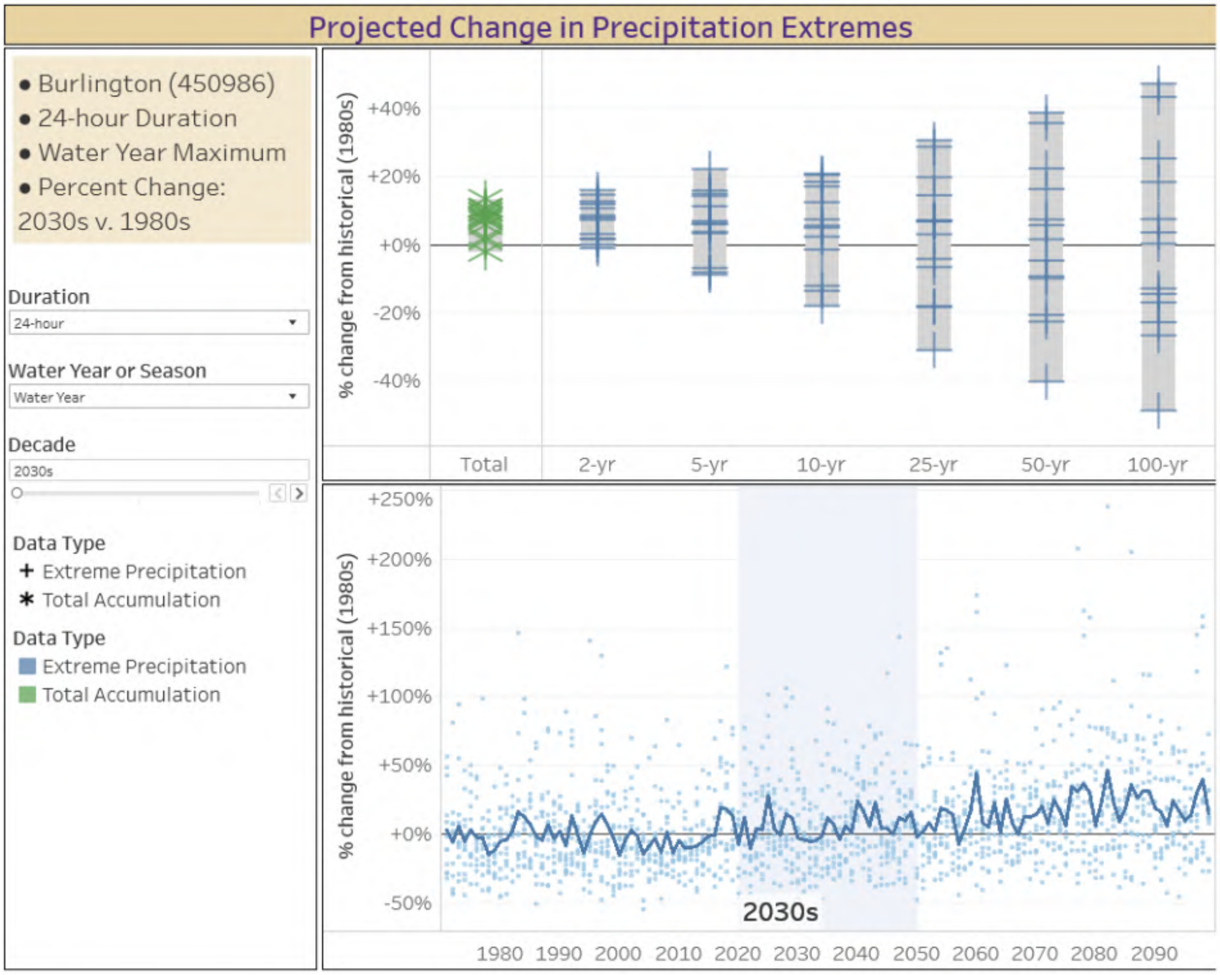

Figure 4-6. Projected change in precipitation extremes for Burlington, Washington, by 2030

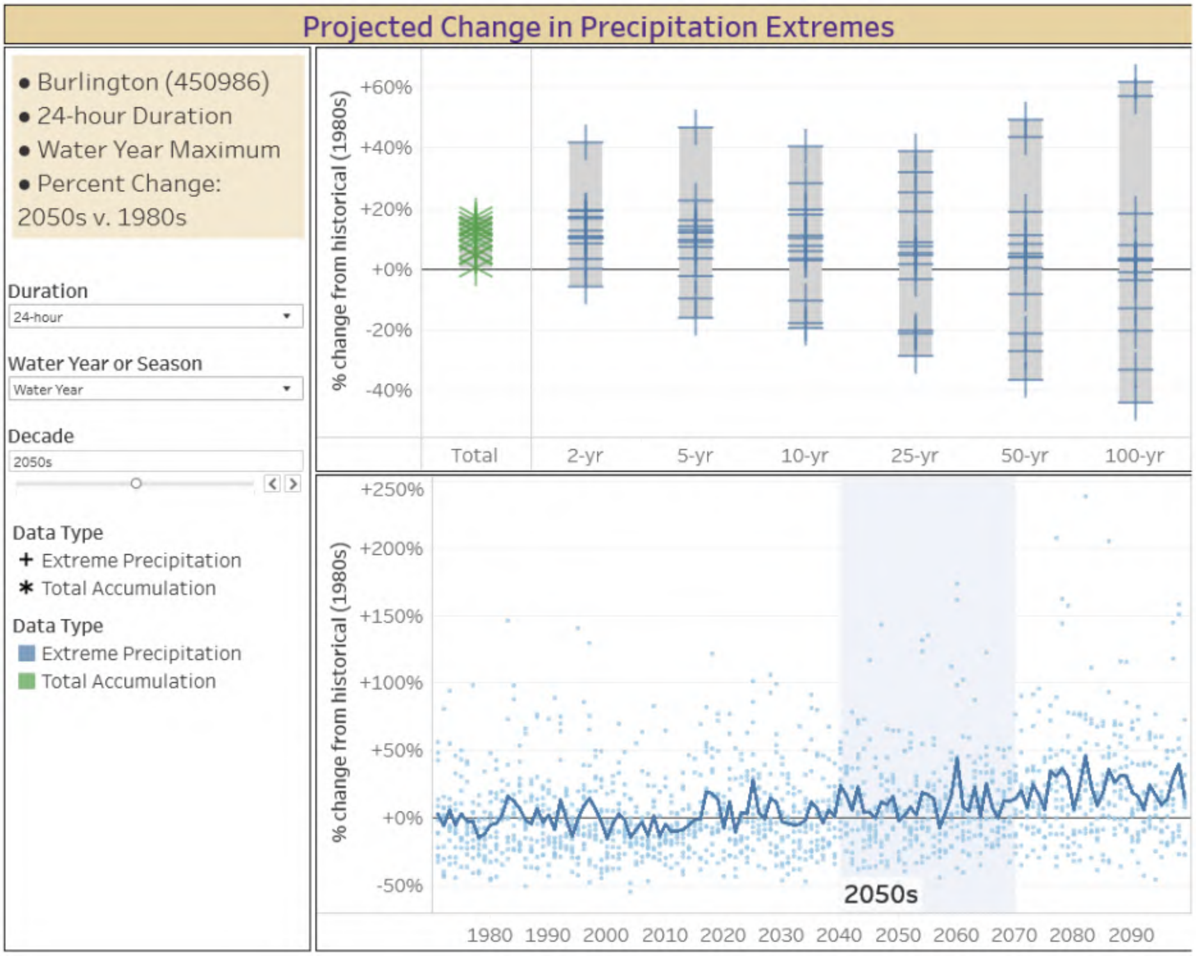

Figure 4-7. Projected change in precipitation extremes for Burlington, Washington, by 2050

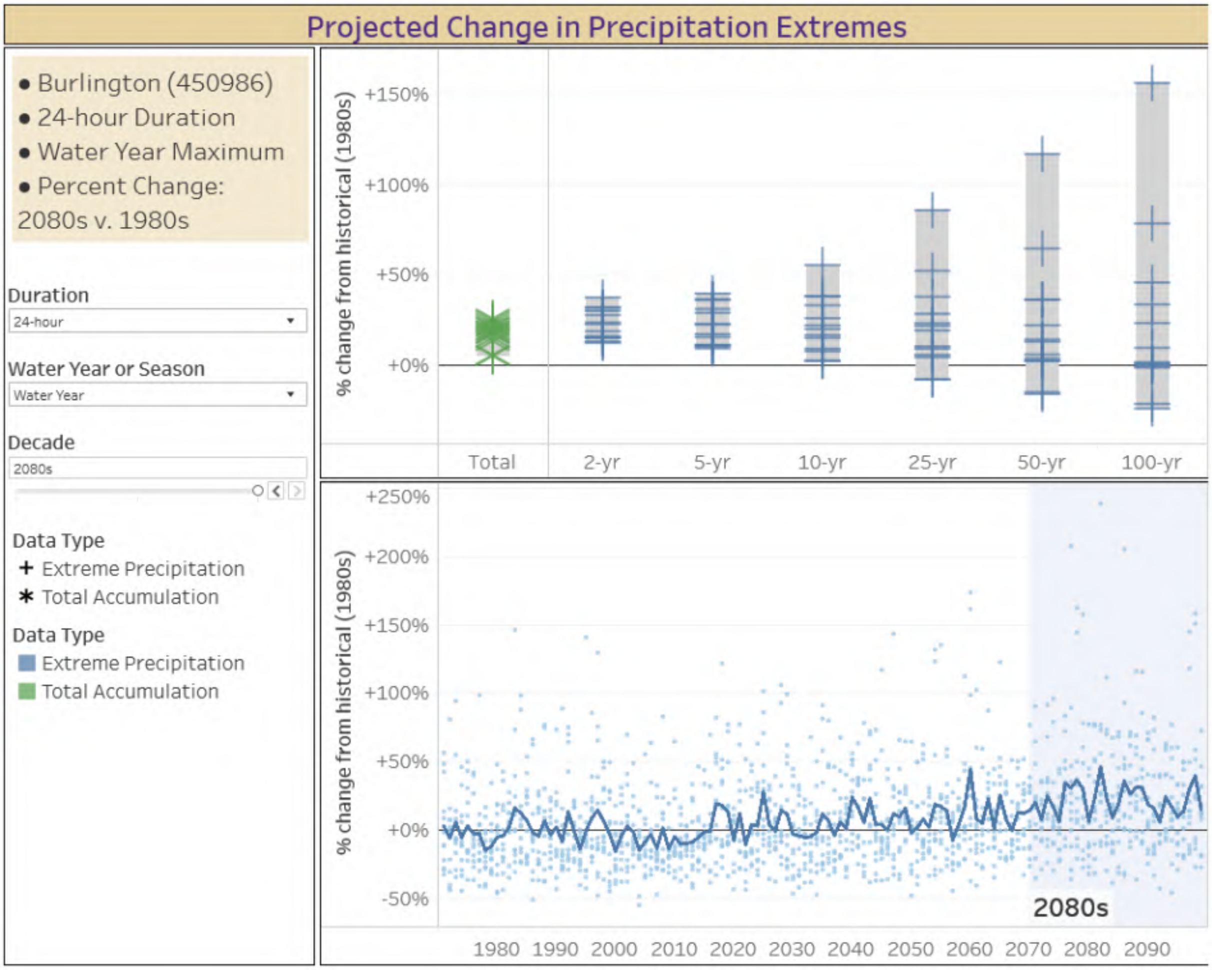

Figure 4-8. Projected change in precipitation extremes for Burlington, Washington, by 2090

4.4 Recommendations Based on Changes in Precipitation Data

Because of the increasing precipitation values discussed in Section 4.3, some recommendations in this section are provided to help improve the effectiveness of stormwater facilities. Horsley Witten Group, a private consulting firm that specializes in sustainable water resource engineering practices, performed an assessment for Massachusetts to evaluate the effects of climate change on stormwater facilities and provided recommendations on how to contribute to stormwater BMP resilience (Horsley Witten Group 2015). Even though this assessment was performed in Massachusetts, many of the recommendations apply as the area is experiencing similar precipitation and SLR effects as what is occurring in the Puget Sound region because of climate change.

The study found that when designing vegetated facilities, practices should be used that are acceptable for existing site conditions and are adaptable for future conditions. For example, the report suggests that selecting plants that can handle higher rainfall intensities and wetter environments builds resilience into the design. The term "green infrastructure" is used to define stormwater infrastructure that contains a natural or vegetative element for controlling and/or treating stormwater runoff, whereas "gray infrastructure" is used to define the more traditional stormwater infrastructure comprising pipes, culverts, manholes, and catch basins. Gray infrastructure with higher precipitation surges generally requires more maintenance to function properly. The report also suggests that choosing green infrastructure over gray infrastructure when possible helps with facility performance.

Modifying design standards to create redundancy in facility design reduces the effects of climate change on stormwater facilities. For example, increasing the design standards for sizing facility forebays dampens the effects of additional sediment being deposited in facilities located near shorelines because of SLR and storm surges. A larger forebay would also reduce the maintenance schedule. Other examples of redundancy would be using combination inlets instead of grate inlets to provide additional inlet capacity or upsizing pipes to allow for larger storm surges.

Another recommendation from the report is to increase maintenance to help facilities perform correctly. Greater storm surges can increase the risk of clogging in inlets, outlets, or pipes as well as increased sediment transportation. As the facilities receive higher flows, it is even more important to keep the facilities well maintained and functioning properly.

Green infrastructure is more adaptable to changing environments than gray infrastructure. A large concrete vault cannot change or adapt to increasing storm surges. It will only perform for the storms it was designed to manage and beyond that it will overtop. In contrast, green infrastructure can adapt to increased rainfall or increased storm surges. When the correct soils and vegetation are selected, the green infrastructure can adapt to changing environments, just as it does in nature.

4.5 Conclusions

This chapter has presented the predicted effects of climate change consisting of rising sea levels and increasing precipitation intensities. These effects of climate change will provide a challenge that government agencies and designers alike will need to adapt to. In May 2018 the Bellingham City Council passed Resolution 2018-06 to create the Climate Action Plan Task Force to develop recommendations to achieve accelerated 100 percent renewable energy targets, taking into account financial, technological, and societal challenges resulting from such a transition. On December 9, 2019, the task force presented its report to the City Council. Recent actions and future activities by the City and across the region clearly indicate the importance placed in understanding and planning for climate change.

In response to the effect of climate change, this chapter also discussed recommendations in how the design of stormwater facilities can adapt to the effects of climate change. The purpose of these recommendations is to help provide general guidance on selection and design for future stormwater improvement projects, and is not intended to be a comprehensive or exhaustive approach that sets firm policy. However, the City should continue to engage with regional and state leaders in developing an approach that is widely supported. The City is currently contracting with USGS to produce a local climate model that will include SLR and anticipated increased storm surge. As such, climate change data and information will continuously be refined.

As the region and state continue to examine SLR and precipitation increases and set widely agreed-upon values for both, the City should equally adopt these as design standards for future infrastructure improvements, and for development approval. From a short-term perspective, the City should be diligent in keeping all facilities well maintained and functioning properly. Each new project should include an SLR analysis to examine if proposed improvements need SLR-related modifications. From a long-term perspective, the City should maintain an inventory of locations in the city that are at risk from extreme precipitation and SLR that may impact emergency evacuation routes, and other key transportation corridors and facilities for protection. For example, continued assessment of the City's inventory to identify at-risk stormwater facilities and vulnerability assessments should be conducted including adaptation strategies for all new public and private critical aboveground assets.

5 Stormwater Condition Assessment Program

Effective utility management requires an approach to handling assets and making decisions to plan, inspect, and care for aging infrastructure based on the goal of maximizing life-cycle performance while managing life-cycle cost. Condition assessment is a foundational component to life-cycle asset management because it provides the basis for making infrastructure-related decisions based on risk.

The City's condition assessment program covers the stormwater system through a combination of inspection and preventive maintenance (PM) schedules by asset class. The program relies on asset information residing in several City information systems.

The City of Bellingham Public Works Department Asset Management Policy states:

> Assets are the people, infrastructure, facilities, tools, institutional knowledge and business relationships that our Department has. Asset Management is the systematic and coordinated activities and practices that are used to manage these assets.
>
> The Department's Asset Management approach will treat all assets as interrelated components and provide sustainable, high quality service to our customers; optimize asset value, while minimizing lifecycle costs; and manage risks to the delivery of established service levels.

5.1 Asset Inventory

The City's stormwater asset inventory resides in its GIS, which also contains other City utility infrastructure, including wastewater conveyance, water distribution, and roadway assets.

The following attribute information is recorded for conveyance assets:

- Material type
- Installation date
- Size
- Lining type (if applicable)
- Main versus lateral designation, where laterals are any pipeline less than 8 inches in diameter (lateral asset attribute information is less detailed/complete than main line asset attribute information) (conveyance only)
- Componentry [non-conveyance, such as catch basins and control structures only]

The asset inventory is nearly complete in GIS (with about 6 percent missing pipe size and only 9 percent lacing pipe material); however, at this time, expected useful life or other attribute information that may be used to predict age-based condition is not yet included in the database. To advance its utility management efforts, the City is a developing an Asset Management working group that will focus on life-cycle management for the Public Works Department. The initial intent of this group is to identify and analyze additional attribute information to help the Stormwater Maintenance group prioritize inspection and maintenance activities.

The City also maintains a computerized maintenance management system (CMMS) to track work orders and maintenance-related activities. The City is transitioning to Cityworks™ for this purpose; it historically used Infor (Hansen). The configuration between GIS and Cityworks™ is still to be established; however, it is anticipated that GIS will remain the database of record for the asset inventory, and will "push" information to Cityworks™. Once implemented, some information may also move from Cityworks™ to GIS to facilitate regular uploading of data to the storage database.

The City also maintains closed-circuit television (CCTV) inspection footage in a GraniteNet database, which includes video inspection footage for the last 5 to 6 years (since approximately 2013 when the Public Works Department began video inspections of stormwater conveyance infrastructure).

5.2 Condition Assessment Strategy

The City uses defined PM programs for each major asset class to assess and monitor the condition of the stormwater system. Additionally, some condition assessment is performed in response to customer inquiries and complaints.

5.2.1 Preventive Maintenance Programs

The City has the following PM programs in place, by asset class:

- **Conveyance CCTV inspection**: Conveyance assets are video-inspected once every 5 to 7 years. The entire system is divided into geographic sections, and inspections are run from end to end (once a section is completed, the next section is started, until all are completed, and then the process is started again). Lines are cleaned as needed to allow crews to complete video inspections. The City's video inspection program has been in place since 2005 and 2013 for stormwater. With the implementation of Cityworks™, geographic scheduling of work may change for conveyance assets as well as catch basins and other assets; the optimal schedule breakdown is still being assessed.
- **Catch basin inspection and cleaning**: The City visits all catch basin structures once every 2 years, or within an alternative schedule compliant with its Phase II Permit requirements. An inspection of each catch basin is conducted to determine if cleaning is required: crews measure the depth from the invert to the outlet of the catch basin to calculate how much sediment has developed. If cleaning is required, a work order is written, and cleaning is performed separately by a crew in a vactor truck. As with conveyance assets, the entire system is divided into geographic sections, and inspections are run from end to end.
- **Detention facilities, vaults, and fat pipes**: All assets are visited one time per year. Any maintenance needs identified at the time of inspection are performed immediately; no work order is written.
- **Bioretention facilities and other green stormwater infrastructure**: All assets are visited two times per year for cleaning. At the time of the visit, any material that needs to be replaced is replaced; no work order is written.

- **Control structures**: All assets are visited one time per year for servicing and cleaning (as needed). Any maintenance needs identified at the time of inspection are performed immediately; no work order is written.
- **Trash racks and other debris collection devices**: Assets are visited monthly on average, depending on the season (during periods of high flows and debris buildup, such as fall and leaf season, assets are visited more frequently; in summer, less frequently). Areas prone to flooding are targeted for more frequent inspection and cleaning, and have their own asset-level PMs. No work order is written. Targeted areas are identified primarily through customer service requests (CSRs).
- **Pollution control devices and oil/water separators**: All assets are visited one time per year. Any maintenance needs identified at the time of inspection are performed immediately; no work order is written.
- **Permeable pavement**: All assets are inspected and cleaned one to two times per year, depending on availability of resources. Any maintenance needs identified at the time of inspection are performed immediately; no work order is written.
- **Infiltration trenches**: All assets are visited one time per year and maintenance is performed immediately as necessary; no work order is written.
- **Media filters**: All assets are inspected and cleaned one to two times per year, depending on availability of resources. No work order is written for any required cleaning.
- **Ditches**: There is no established PM program; inspection and maintenance is performed as needed (if a crew working in the area identifies a problem, or a customer complaint is received); no work order is written.

5.2.2 Customer-Driven Condition Assessment

Customer-driven (or reactive) condition assessment occurs in response to problems identified by users of the system using CSR as described above. CSRs are received by the City, which investigates the source of each complaint. In some cases, the investigations require video inspections.

CSRs are tracked by location and, where possible, by address. In some instances, a CSR may be linked to a work order written in response. If enough CSRs are received against a given asset, a specific PM program may be developed for the asset. For example, trash racks and other debris-capturing devices may have a specific PM program for cleaning if enough CSRs related to localized flooding have been received.

5.3 Condition-Based Maintenance and Renewal

O&M staff make maintenance and renewal decisions based on findings from asset inspections. For most non-conveyance asset classes, maintenance decisions are made by inspection crews on site, and work is performed immediately or shortly thereafter. This decision process is described in each asset PM, in Section 5.2.1. Currently, if work is performed on site, a maintenance work order is not written. If the required maintenance cannot be performed at the time of inspection, a work order is written to a specific asset and scheduled by the group supervisor.

Once Cityworks™ is implemented, staff will write work orders for all needed work that is identified, and supervisors will schedule work based on work order priority. In all cases, major failures that require capital resources are elevated to the Pavement and Utility Rating Committee (PURC) for review.

5.3.1 Conveyance Renewal Decision Making

Inspection of conveyance assets is performed by the Video Inspection Group, which identifies failures or defects through CCTV inspection. Separately, maintenance and renewal needs are identified following the inspection by supervisors reviewing CCTV footage. Maintenance and renewal that can be performed in-house with existing resources is then planned over the course of a year via work orders.

Inspection Rating System

When conveyance assets are CCTV-inspected, their condition is scored using a defect rating system included in the inspection database software (GraniteNet). Defects include both structural defects (such as voids in a pipe or cracks in pipe material) and O&M defects (such as root intrusion or debris buildup). After a geographic section has been completely inspected, a report of all defects by asset is run and reviewed. The Video Inspection Program supervisor then reviews the defects identified and creates work orders for necessary repairs and/or maintenance.

Emergency Repairs

The exception to this is if a serious defect is observed during the video inspection; in this case a repair work order is written immediately. The work order and associated video is reviewed by either the Stormwater Maintenance Group supervisor or the Video Inspection Program supervisor (or their seniors). At this time there is no standard operating procedure (SOP) or guideline for the types, number, or severity of defects that warrant an emergency work order; however, staff are generally knowledgeable in which types of defects need to be elevated to this status.

Inspection Training

Currently two maintenance staff are trained to perform CCTV inspections using the coding system, with an additional staff currently being trained. The City's goal is to train all maintenance staff to be able to perform these inspections. All training is done by the Video Inspection Program supervisor to ensure that a consistent approach is used.

5.3.2 Short-term Renewal

Short-term renewal consists of those types of repairs that can be addressed by the City's maintenance staff without additional resources or funding. In-house maintenance crews can perform most repairs to conveyance assets, including pipe sections up to 100 feet in length, spot repairs, etc. There are no documented thresholds to identify which renewal activities require additional support, as it typically is determined by an individual project's scope. Work that typically requires outside resources includes those types of renewal projects that require longer than 5 days to complete, require the support of specialty subcontractors, and/or those that require engineering design. These projects are elevated to the PURC for long-term renewal.

Emergency work orders identified during inspections are addressed immediately by in-house crews, unless in-house crews are not able to perform the work. While a large backlog of work orders exists, there is no backlog of emergency repair work orders. Generally cities experience large backlogs of work orders for a variety of reasons, including system growth, competing priorities between funding for aging infrastructure and capacity/regulatory demands, new technologies without well-understood maintenance needs or useful life, and staff retirements and vacancies. Currently, there is no process or standard for prioritizing work orders in the backlog. However, experienced operators can typically assess work orders to determine which should be done first based on risk and need. The City performs re-inspections as necessary, both to check on the progression of certain types of defects and to confirm the type of repair needed.

5.3.3 Long-term Renewal

Long-term renewal refers to rehabilitation and replacement projects that can be performed in-house. Often, these projects may require significant capital investment, outside of annual operating budgets. These typically large projects may have other drivers in addition to deteriorating infrastructure; for instance, a capacity upgrade may be required on a pipe segment requiring replacement.

The City's PURC prioritizes all infrastructure projects using a point system that takes into account the risk and criticality of delaying or not doing a project.

An A and B condition rating is established and is based on field assessments; however, at this time, the field assessment scores are not tied directly to CCTV inspection scores. The City intends to tie field assessment scores to CCTV inspection results for conveyance assets in the future.

5.4 Recommendations for the Condition Assessment Program

Based on interviews with City maintenance staff, a series of recommendations has been developed that may enhance the City's current condition assessment program, which are shown in Table 5-1. These are for the City's consideration, and should be reviewed in further detail as necessary. Additionally, some of these recommendations may already be under consideration or in process at the City.

Table 5-1. Condition assessment program recommendations

Recommendation	Description
Asset inventory	
Additional asset attributes	For each asset class, review existing attribute information and identify additional information that may be included, with the purpose of supporting a risk-based condition assessment and renewal program. For example, develop an expected life for each asset based on type, material, etc. The expected life can be used to create a "percent consumed" measure as a preliminary risk of failure measure.
Condition assessment strategy	
Risk-based framework	Develop a risk-based framework to prioritize condition assessment strategies by asset class (while keeping strategies in accordance with Phase II Permit requirements). The framework may also be used to prioritize repair work orders in the backlog and expanded to include projects reviewed and prioritized by the PURC (the PURC uses some risk factors for assessing projects; these may be expanded). A risk-based framework should take into account both likelihood-of-failure factors and consequence-of-failure (criticality) factors. A formal framework will also help convert staff institutional knowledge into a replicable approach. As Cityworks™ is implemented (or once a risk framework is developed), consider using geographic scheduling that takes into account asset risk when developing asset inspection schedules. The City is doing this in limited ways, for example scheduling more frequent inspections of trash racks in areas prone to flooding; this type of scheduling may be expanded over time using formal risk factors.
Condition score	Develop a simple condition scoring system for non-conveyance assets that can be quickly assigned during routine asset inspections. The condition score should take into account structural defects, as well as other failure types, which would be defined for each asset class. For conveyance assets, develop a "quick score" that accounts for size, type, and number of defects from the GraniteNet condition scoring system.
Customer service request and repair activity tracking	Tie any follow-up work order(s) to a CSR; assign both to one asset. By doing this, it will be easier to perform trend analyses on assets, and to identify problem areas or "hot spots" that should be on an aggressive PM schedule.
Training	Ensure that training is provided to staff performing inspections and maintenance on infrastructure, particularly infrastructure involving new stormwater management technology. Also ensure that for all new infrastructure accepted by the City, O&M manuals, as-builts, and other relevant information are provided prior to acceptance.
Condition assessment and renewal program resourcing	Develop an approach for estimating resource needs (capital and O&M budget, staffing, vehicles, and equipment) to support the current condition assessment and renewal program. This may include quantifying system growth and corresponding maintenance needs, a projection of need to reduce the current backlog over a certain period, and/or a one-time projection of system condition and corresponding renewal needs. It may also leverage the Risk-Based Framework to help determine the size and scope of condition assessment that should be occurring (outside of Phase II Permit requirements).

Recommendation	Description
Condition-based maintenance and renewal	
Inspection training	To supplement the existing training, and as new staff begin performing video inspections, develop a quality control (QC) program for reviewing scores given to pipes in the field. This may be done by a dedicated reviewer, or when videos are reviewed to determine follow-up actions. The intent of the QC program would be for training purposes only, to ensure that scores are consistently being applied by all inspectors.
Renewal decision-logic	Develop formal guidelines for the type, severity, number, and size of defects that trigger an emergency repair work order, and to ensure that all inspectors are trained in the guideline. Also develop formal guidelines for the types of renewal technologies preferred for different defect types, numbers, and severity. For instance, a point repair may be preferable for a pipe with only one defect, but replacement or lining may be preferable for a pipe with multiple defects throughout. Guidelines will help formalize staff institutional knowledge and create a replicable approach. They will also create additional prioritization criteria for the existing work order backlog. Finally, the City may wish to bundle together several individual projects into larger programmatic repair packages, which may be identified and budgeted as capital projects.

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6 Stormwater Management Program Evaluation

The City of Bellingham is one of 80 western Washington municipalities that are regulated by the Western Washington Phase II Municipal Stormwater Permit, issued by Ecology under authority of EPA's NPDES program. The City's original Phase II Permit was issued in 2007 by Ecology, as was the case for the other regulated jurisdictions in western Washington. The Phase II Permit is reissued every 5 years. The City's current Phase II Permit, reissued on August 1, 2019, expires on July 31, 2024.

This chapter provides an overview of the Phase II Permit and evaluates the City's SWMP for compliance.

6.1 NPDES Phase II Municipal Stormwater Permit Overview

Like all NPDES permits in western Washington, Bellingham's Phase II Permit is organized into Special Conditions and General Conditions, and with compliance it allows the regulated jurisdiction to discharge stormwater runoff from its MS4 to the waters of the state. As a Phase II Permit condition, each calendar year the City updates and publishes a SWMP that describes the City's programs and documents how it meets the conditions of the Phase II Permit. The City's current SWMP is available on its website:
https://www.cob.org/services/planning/environmental/pages/stormwater-program.aspx.

Regulatory details of operating a SWMP are contained in Sections S5, S7, S8, and S9 of the SWMP. Evaluating how the City is complying with these sections, where gaps in compliance may exist, and where opportunities are presented for value-added enhancements is one of the goals of the comprehensive planning process. The SWMP evaluation and gap analysis were specific to these sections of the SWMP.

General Conditions of the Phase II Permit describe what actions a Permittee must take to meet Phase II Permit requirements and the Special Conditions describes how to implement the Phase II Permit conditions. Special Conditions are specific to each Permittee and are summarized in the sections below, whereas General Conditions are more general in nature and are common to all permits in Western Washington. The Special Conditions sections are listed in Table 6-1 according to the current Phase II Permit released in August 2019.

Table 6-1. Phase II Permit Special Conditions

Phase II Permit section	SWMP Special Condition
S1	Phase II Permit coverage area and permittees
S2	Authorized discharges
S3	Responsibilities of Permittees
S4	Compliance with standards
S5	Stormwater Management Program
S6	Stormwater management for secondary Permittees (not applicable to Bellingham)
S7	TMDL
S8	Monitoring and assessment
S9	Reporting and record keeping

6.1.1 Special Conditions

The Special Conditions sections of the Phase II Permit are specific action items that each regulated Permittee must undertake to allow permissible discharges to the waters of the state. Listed below is a brief description of each section.

S1. Permit Coverage Area and Permittees

Special Condition S1 designates the areas in western Washington subject to the conditions of this Permit (the Phase II Municipal permit). It includes areas located west of the eastern boundaries of the following counties: Whatcom, Skagit, Snohomish, King, Pierce, Lewis, and Skamania. This Phase II Permit is applicable to owners or operators of regulated small MS4s.

S2. Authorized Discharges

Special Condition S2 authorizes the discharge of stormwater to surface waters and groundwaters of the state from MS4s owned or operated by each Permittee covered under this Permit (the Phase II Municipal permit, in the geographic area covered pursuant to Special Condition S1.

S3. Responsibilities of the Permittees

Special Condition S3 formally declares the responsibility of each Permittee for compliance with the terms of this Permit (the Phase II Municipal permit) for the regulated small MS4s that it owns or operates.

S4. Compliance with Standards

Special Condition S4 details applicable water quality standards and methods for achieving the standards. In summary, this section:

- Prohibits the discharge of toxicants to waters of the state.

- Provides instructions to Permittees on specific actions they must take when a discharge occurs that is in violation of the Permit (the Phase II Municipal permit).
- Allows Permittees to use practices that reduce the discharge of pollutants to the maximum extent practicable (MEP).
- Allows Permittees to use all known, available, and reasonable methods of prevention, control, and treatment (AKART) to prevent and control pollution of waters of the state of Washington.
- Outlines actions each Permittee can take to remain compliant when prohibited discharges are unintentionally discharged to the waters of the state.

S5. Stormwater Management Program for Cities, Towns, and Counties

Special Condition S5 states that each Permittee will develop and implement a SWMP that includes a set of actions and activities the Permittee will undertake to meet the objectives of the NPDES program.

S6. Stormwater Management Program for Secondary Permittees

Special Condition S6 is not applicable to the City of Bellingham because it is not listed as a secondary Permittee.

S7. Compliance with Total Maximum Daily Load Requirements

Special Condition S7 states that Permittees that have an applicable TMDL approved for stormwater discharges from MS4s must meet all requirements as specified in Appendix 2 of the Phase II Permit for individual TMDLs.

S8. Monitoring and Assessment

Special Condition S8 describes the requirements for a permitted jurisdiction to conduct water quality monitoring of its MS4 discharge.

S9. Reporting Requirements

Special Condition S9 standardizes reporting requirements for all regulated jurisdictions.

6.2 Stormwater Management Program Gap Analysis

The evaluation and gap analysis of the City's SWMP is focused on Special Conditions S5, S7 (TMDL requirements), S8 (monitoring), and S9 (reporting). Special Conditions S1 through S4 are not part of the evaluation and Special Conditions S6 is for secondary Permittees and therefore does not apply to Bellingham. Special Conditions S5 includes a set of "Special Conditions" for agencies responsible for operating an MS4. The responsible agencies implement the Special Conditions that will programmatically achieve the goals of the Phase II Permit.

Special Condition S5 is subdivided into Parts A, B, and C. Part A is the rules section of the Phase II Permit stating that jurisdictions shall prepare a SWMP. Part B states the objectives and standards that the SWMP must meet. Part C lists the activities required in the SWMP and is divided into eight subsections. Special Conditions S7, S8, and S9 are also included in the gap analysis.

Table 6-2 lists the Special Conditions of the Phase II Permit included in the evaluation.

Table 6-2. Phase II Permit Special Conditions and program components analyzed

Special Conditions number	Special Condition
S5.A	Stormwater Management Program
S5.B	Reduce discharge of pollutants
S5.C.1	Stormwater planning
S5.C.2	Public education and outreach
S5.C.3	Public involvement and participation
S5.C.4	MS4 mapping and documentation
S5.C.5	Illicit discharge detection and elimination (IDDE)
S5.C.6	Controlling runoff from new development, redevelopment, and construction
S5.C.7	Operations and maintenance
S5.C.8	Source control program for existing development
S7	Compliance with TMDL requirements
S8	Monitoring and assessment
S9	Reporting requirements

6.2.1 Stormwater Management Program Evaluation

HDR reviewed 73 individual Phase II Permit requirements in Section S5 and 16 additional conditions in Sections S7, S8, and S9. To assess possible program gaps with respect to these requirements, HDR reviewed the City's existing SWMP, O&M manuals, and the City's website and called on City staff when additional details were needed. The 2019 Annual Report, submitted in 2020 documenting the progress by the City in 2019, was also reviewed. The information gathered was compared to the requirements of the Phase II Permit to identify SWMP gaps. The following sections summarize the findings of the gap analysis for each subsection of Section S5. New Phase II Permit requirements are also discussed. Requirements that are in full compliance are noted along with areas that are lacking (creating a gap). The evaluation also looked at opportunities for added enhancements to those activities that are in compliance but would bring value to the City in meeting its overall program goals and objectives.

Overall, the City is doing quite well in meeting its obligation toward Phase II Permit compliance. In fact, it is already making strides at completing tasks that are new in the current Phase II Permit. For example, the City has accomplished 80 out of the 89 individual tasks evaluated from the 2015 Phase II Permit, or 90 percent, representing an exceptional track record of performance. Of the nine tasks noted as not accomplished, some are enhancement recommendations only. Also, the City has begun on the new permit conditions found in the 2019 Phase II Permit by initiating or completing four individual tasks, with some progress already made on many of the outstanding items not to be completed for some time.

S5.A Stormwater Management Program

Under the Western Washington Phase II Municipal Stormwater Permit, cities, towns, and counties are required to develop and implement a SWMP. The SWMP functions as the written record of how they are complying with the Phase II Permit and includes all reporting requirements outlined in the Phase II Permit. The City provides its annual SWMP on its website.

During analysis it was found that the City could improve SWMP compliance in the following area:

- **S.5.A.3(a)**: track the estimated cost of development and implementation of each component of the SWMP

New requirements under the 2019 Phase II Permit for the City are:

- Disaggregate the respective records from the TRAKiT™ software program, the City's workflow management software, into number of inspections, follow-up actions as a result of inspections, and official enforcement actions
- Develop coordination mechanics among departments within each jurisdiction to eliminate barriers to compliance

S5.B Discharge Reduction

The City's SWMP reduces the discharge of pollutants to the MEP, and meets state AKART requirements; no gaps were identified.

S5C.1 Stormwater Planning

A Stormwater Planning Program is a new requirement under the 2019 Phase II Permit. The intention of this Phase II Permit program is to inform and assist in the development of policies and strategies as water quality management tools to protect receiving waters.

New requirements under the 2019 Phase II Permit for the City are:

- Create an interdisciplinary team to inform and assist in the development, progress, and influence of the Stormwater Planning Program.
- Respond to Stormwater Planning Annual Report questions to describe how anticipated stormwater impacts on water quality were addressed, if at all, during the 2013–2019 Phase II Permit term.
- Submit a report to describe how water quality is being addressed, if at all, during this Phase II Permit term in updates to the citywide Comprehensive Plan (or equivalent) and in other locally initiated or state-mandated, long-range land use plans that are used to accommodate growth or transportation.

- Annually, assess and document any newly identified administrative or regulatory barriers to implementation of LID principles or LID BMPs, and the measures developed to address the barriers. If applicable, the report shall describe mechanisms adopted to encourage or require implementation of LID principles or LID BMPs.
- Review, revise, and make effective codes, rules, standards, or other enforceable documents to incorporate and require LID principles and LID BMPs.
- Document and assess existing information related to local receiving waters and contributing area conditions to identify receiving waters that will benefit from stormwater management planning. Submit a watershed inventory and include a brief description of the relative conditions of the receiving waters and contributing areas.
- Prioritize and rank identified water basins that would benefit from implementation of stormwater facility retrofits and management actions to reduce pollutant loading and address hydrologic impacts from existing development.
- Develop a Stormwater Management Action Plan (SMAP) for at least one high-priority area.

S5C.2 Public Education and Outreach

The City's Public Education and Outreach Program aims to increase awareness of stormwater pollution issues and to provide tools, assistance, and incentives to reduce or eliminate behaviors and practices that cause or contribute to adverse stormwater impacts.

The following initiatives are included in the City's Public Education and Outreach Program, with further detail being provided in the SWMP available online:

- Habitat News newsletter
- Bellingham Water School program
- We Scoop pet waste campaign
- Wash Right outdoor washing campaign
- Lake Whatcom Management Program
- Don't Drip and Drive vehicle leak campaign
- Local source control
- Neighborhood meetings
- Habitat restoration outreach
- Natural yard care and water use efficiency outreach
- Online outreach
- Bellingham Television (BTV) aired programs

The City's Public Education and Outreach Program fully meets the requirements of the 2015 Phase II Permit. New requirements under the 2019 Phase II Permit for the City are:

- Conduct a new evaluation of the effectiveness of the ongoing behavior change program. This may not be required if the City chooses to develop a strategy and schedule for a new target audience and BMP behavior change.
- Develop a strategy and schedule to have at least one of the following results:
  - To more effectively implement the existing behavior change program
  - To expand the existing program to a new target audience or BMPs
  - To create a new target audience and BMP behavior change campaign
- Evaluate and report on the changes in understanding and adoption of targeted behaviors resulting from the implementation of the strategy and any planned or recommended changes to the program.

S5C.3 Public Involvement and Participation

The City offers public involvement and participation opportunities by holding open weekly City Council meetings, holding open public houses to discuss code amendments for LID, and annually reviewing its SWMP, which is provided to the public online. These measures fully meet the requirements of the Phase II Permit; no gaps were identified.

S5.C.4 MS4 Mapping and Documentation

MS4 mapping and documentation is a new requirement under the 2019 Phase II Permit. The City's online map viewer, CityIQ, allows GIS data to be downloaded from the Internet that meet the requirements of the new Phase II Permit; no gaps were identified.

S5.C.5 Illicit Discharge Detection and Elimination

An illicit discharge detention and elimination (IDDE) program is a Special Condition in the Phase II Permit that requires agencies operating an MS4 to implement a program to address the issue of illicit stormwater discharges. The City's IDDE programs meet all requirements of the 2015 Phase II Permit with improved SWMP compliance possible in the following area:

- **S.5.C.5.e**: Develop formal SOPs of characterizing, tracking, and eliminating illicit discharges, spills, and connections.

New requirements under the 2019 Phase II Permit for the City are:

- Screen or track 12 percent of the MS4 in the field annually. Review showed that the City is inspecting approximately 13.5 percent of its MS4 program per year, but this is not formally tracked. The Cityworks™ software used to manage assets may work as a method for isolating inspection records to create formal records of this inspection process.
- Submit data for all illicit discharges investigated during the previous calendar year into the annual report and to Ecology's WQwebIDDE database. The City is encouraged to develop SOPs describing the timing and protocols for uploading IDDE data, which the City is already tracking in a database.

S5.C.6 Controlling Runoff from New Development, Redevelopment, and Construction

The City's permitting process requires plan review and site inspections for development and redevelopment projects. The City requires that Stormwater Site Plans be designed in accordance with current editions of Ecology's *Stormwater Management Manual for Western Washington* (SWMMWW), the City of Bellingham "Development Guidelines and Improvement Standards," and the BMC. The program meets all requirements of the 2015 Phase II Permit with improved SWMP compliance possible in the following area:

- **S.5.C.6.e**: Develop formal training database to track and report on completion of required training, follow-up training, certifications, etc.

A new requirement states that:

- The program shall make links to Construction and Industrial Stormwater General Permit Notice of Intent (NOI) forms available.

S5.C.7 Operations and Maintenance

Permit conditions stipulate that City maintenance standards must be equal to those in Ecology's SWMMWW. It also requires that standards be developed for practices that are not covered by the SWMMWW. Rigorous inspection schedules and maintenance standards are required, and Stormwater Pollution Prevention Plans (SWPPPs) are required for certain categories of municipal sites.

Evaluating the City's maintenance and inspection manuals yielded a determination the City meets almost all Phase II Permit requirements. Recommendations and improvements noted:

- **S.5.C.7.b(iii)**: "The program shall include a procedure for keeping records of inspections and enforcement actions." This gap can be corrected by including screen shots of TRAKiT™ records in the SWMP annual report to Ecology along with a program description and requirements in the formal procedure for record keeping.
- **S5.C.7.c**: No gap was identified. The City plans and tracks all treatment and flow control facility inspection and maintenance activities in the TRAKiT™ workflow management system; however, this reference can be strengthened by providing a specific location in TRAKiT™ where inspection records are kept.
- **S5.C.7.d**: The City plans and tracks all catch basins and stormwater facility inspection and maintenance activities in the Cityworks™ workflow management system; however, there are not enough details in the SWMP (pages 23 and 30) to determine requirement compliance. The reference may be strengthened by providing a specific location in TRAKiT™ where inspection records are kept. Recommend that the City provide the program description and requirements in the SWMP. Automated reporting may be useful to verify compliance.

A new requirement is as follows:

- Meet maintenance deadlines once an inspection identifies an exceedance.

S5.C.8 Source Control Program for Existing Development

A source control program for existing development is a new requirement under the 2019 Phase II Permit, for which the city's current activities includes some of the requirements. Additional documentation will be needed in accordance with the current Phase II Permit details.

New requirements are as follows:

- Implement a program to prevent and reduce pollutants in runoff from areas that discharge to MS4s to the maximum extent practicable (MEP)
- Adopt an ordinance, or other enforceable documents, requiring the application of source control BMPs for pollutant-generating sources associated with existing land uses and activities to the maximum extent practicable (MEP)
- Establish an inventory that identifies publicly and privately owned institutional, commercial, and industrial properties that have the potential to generate pollutants to the MS4
- Implement an inspection program for the identified properties
- Implement a progressive enforcement policy that requires sites to comply with stormwater requirements within a reasonable period
- Train staff who are responsible for implementing the source control program

S7 Compliance with Total Maximum Daily Load Requirements

The 2019–2024 Phase II Permit has new TMDL requirements for compliance with respect to the Lake Whatcom TMDL.

New requirements are as follows:

- Develop a repeatable public outreach survey to measure beliefs, behaviors, and attitudes over time toward Lake Whatcom water quality
- Annually report on progress of the survey
- Submit results of the survey with the annual report
- Provide Ecology the informational packet distributed to watershed residents, and track how many new property owners received copies
- Provide Ecology with the Lake Whatcom Cooperative Management Program Five-Year Work Plan, Program Area 9 update
- Update and prioritize a list of new treatment and flow control capital improvement projects to be included in the annual report
- Develop and provide a list of retrofit opportunities to Ecology
- With each annual report, evaluate and track phosphorus reductions
- Submit a watershed-specific appendix to the City's operation plan for managing public areas such as parks, trails, rights-of-way (ROWs), and open spaces by March 31, 2024

- Submit a Quality Assurance Project Plan (QAPP) jointly with Lake Whatcom Cooperative Management Program to Ecology for approval
- Track and report the status of the timelines in the QAPPs approved by Ecology in the annual report
- Provide an evaluation of the effectiveness of built stormwater treatment and flow control facilities
- Submit Lake Whatcom implementation tasks for 2024–2029
- Submit a new loading capacity based on new models

S8 Monitoring and Assessment

The City joined the Stormwater Action Monitoring (SAM) in 2013 and contributes to the fund, which conducts water quality monitoring of stormwater discharging from the MS4. This meets the Phase II Permit requirements; no gaps were identified.

S9 Reporting .Requirements

The Phase II Permit standardizes reporting requirements for all regulated jurisdictions. The City is fully meeting these requirements. Program strengthening improvements noted:

- **S.9.B**: Post all previous SWMPs in a centralized location on the City's SWMP website page: https://www.cob.org/services/planning/environmental/pages/stormwater-program.aspx
- **S9B.C**: Post all previous SWMPs and annual reports online for at least 5 years

6.2.2 NPDES Permit Compliance Strategies

Full details of the NPDES gap analysis are provided in Appendix B (B.1 Gap Analysis Table). The result of the SWMP review was that there are 9 areas identified for completion and/or enhancement from the 2015 Phase II Permit, and 38 new requirements to work toward compliance for the 2019 Phase II Permit. Table 6-3 below includes relevant 2015 Phase II Permit gaps, and compliance improvement recommendations for said gaps and/or areas for enhancement. Table 6-4 includes the new requirements in the 2019 version of the Phase II Permit along with completion dates. It also indicates the progress made by the City as reported in the 2019 Annual Report. Completion dates indicated as "immediate" refer to requirements needed upon Phase II Permit issuance.

Table 6-3. List of existing Phase II Permit gaps and compliance improvements

Special Conditions number	Gap	Compliance improvement recommendation
S4.F	None. Currently provide a stormwater hotline number posted to the City's website.	Formal documentation in the form of an SOP or similar would demonstrate the City's compliance with the defined actions.
S5.A.3.a	The City does not track all related costs or estimate the costs of the SWMP.	Use newly implemented Cityworks™ to track all related costs and estimated costs related to the SWMP.
S5.C.5.e	The City currently has SOPs in place describing how outfall field screening occurs, but formal documentation is lacking.	Develop SOPs for characterizing, tracking, and eliminating illicit discharges, spills, and connections.
S5.C.6.e	While City Public Works Department staff is trained on implementing BMPs, stormwater facility design, pollution prevention, stormwater code training, SWMMWW training, and Phase II Permit overview, there are no records, other than Certified Erosion and Sediment Control Lead (CESCL) certifications, of training and City staff that has received it.	Create a training database to track and report on completion of required training, follow-up training, certifications, etc.
S5.C.7.b(iii)	The City plans and tracks all inspection and maintenance activities in the Cityworks™ workflow management system; however, formal procedures for record keeping are not in place.	Include screen shots of Cityworks™ records in the SWMP annual report to Ecology along with a program description and requirements in the SWMP. Develop a formal procedure for record keeping.
S5.C.7.c	None. The City plans and tracks all treatment and flow control facility inspection and maintenance activities in the TRAKiT™ workflow management system; however, this reference can be strengthened by providing a specific location in TRAKiT™ where inspection records are kept.	Include screen shots of TRAKiT™ records in the SWMP annual report to Ecology along with a program description and requirements in the SWMP.

Special Conditions number	Gap	Compliance improvement recommendation
S5.C.7.d	The City plans and tracks all catch basins and stormwater facility inspection and maintenance activities in the Cityworks™ workflow management system; however, there are not enough details in the SWMP (pages 23 and 30) to determine requirement compliance. The reference may be strengthened by providing a specific location in TRAKiT™ where inspection records are kept.	Recommend that the City provide the program description and requirements in the SWMP. Automated reporting may be useful to verify compliance.
S9.B	Annual SWMP updates, specifically 2014, are missing.	Suggest posting all previous SWMPs in a centralized location on the current SWMP page (https://www.cob.org/services/planning/environmental/Pages/stormwater-program.aspx).
S9.C	None. Compliance strengthening recommendation.	Recommend that the City provide the SWMP and annual reports online for at least 5 years.

Table 6-4. List of new 2019 Phase II Permit compliance requirements

Special Conditions number	Requirement	Compliance recommendation	Compliance date
S5.A.2	Effective 8/1/2019, several Phase II Permit requirements will take effect and the SWMP will need to be updated accordingly.	Conduct a third-party review of the 2019 annual report verifying that the new Phase II Permit conditions are captured.	Annually
S5.A.3.b	The SWMP annual report separates out inspections, enforcement actions, and public education activities, and tracks follow-up actions.	Disaggregate the respective records from the TRAKiT™ software program, begin tracking follow-up actions as a result of inspections, and include this information in the SWMP annual report.	8/1/2019

Special Conditions number	Requirement	Compliance recommendation	Compliance date
S5.A.5.b	Have written descriptions of internal coordination mechanisms among departments within each jurisdiction within the SWMP annual report.	Beginning in 2021 or sooner, include in the annual report to Ecology meeting minutes and decision logs demonstrating cross-departmental coordination. Establish meeting frequency, roles and responsibilities, and a team charter.	3/31/2021
S5.C.1.a	Create an interdisciplinary team to inform and assist the development, progress, and influence of the SWMP.	Beginning in 2021 or sooner, include in the annual report to Ecology meeting minutes and decision logs demonstrating cross-departmental coordination. Establish meeting frequency, roles and responsibilities, and a team charter.	8/1/2020
S5.C.1.b.i.(a)	Respond to Stormwater Planning Annual Report questions describing how anticipated stormwater impacts on water quality are addressed during the 2013–2019 Phase II Permit term.	Include responses to questions in the Phase II Permit.	3/31/2021
S5.C.1.b.i.(b)	Submit a report responding to the questions from above to describe how water quality is being addressed, if at all, during the Phase II Permit term.	Include the findings and recommendations from the citywide Water Quality Prioritization project.	1/1/2023
S5.C.1.c.i	Annually, assess and document newly identified barriers to implementation of LID principles/BMPs and the measures developed to address the barriers.	Include in the annual report a description of how the City's codes are reviewed for LID requirements.	3/31/2024

Special Conditions number	Requirement	Compliance recommendation	Compliance date
S5.C.1.c.ii	Submit a summary of results of reviewed and revised codes, rules, standards, and other enforceable documents to incorporate and require LID principles and LID BMPs.	Include in the annual report a description of how the City's codes are reviewed for LID requirements.	3/31/2024
S5.C.1.d.i	Conduct a receiving water basin assessment.	Include the findings and recommendations from the citywide Water Quality Prioritization project.	3/31/2022
S5.C.1.d.ii	Conduct a water basin prioritization.	Include the findings and recommendations from the citywide Water Quality Prioritization project.	6/30/2022
S5.C.1.d.iii	Develop a Stormwater Management Action Plan.	Include the findings and recommendations from the citywide Water Quality Prioritization project.	3/31/2023
S5.C.2.a.ii.d	Begin implementation of a new behavioral change study.	Keep data and report on Education and Outreach program survey.	4/1/2021
S5.C.2.a.ii.e	Evaluate and report on the newly adopted behavior change program.	Keep data and report on Education and Outreach program survey.	3/31/2024
S5.C.2.a.ii.f	Use results of the evaluation to continue to direct effective behavior change methods.	Keep data and report on Education and Outreach program survey.	3/31/2024
S5.C.5.d.(i)(a)	Screen or track 12% of the MS4 in the field annually.	Develop SOPs explicitly describing how outfall field screening occurs and include in the annual report a copy of the tracking data.	Immediate
S5.C.5.g	Submit data from illicit discharge investigations into the annual report as specified in Appendix 12 and the WQwebIDDE.	Develop SOPs for timing and protocols for uploading IDDE data to Ecology's WQwebIDDE database.	Immediate

Special Conditions number	Requirement	Compliance recommendation	Compliance date
S5.C.6.d	Provide links to forms relevant to the Construction Stormwater General Permit NOI and, as applicable, a link to the Industrial Stormwater General Permit NOI.	Add an active link to the Construction Stormwater General Permit NOI form to the City's website.	Immediate
S5.C.7.a.ii.	Meet maintenance deadlines once an inspection identifies an exceedance.	Develop or update O&M standards to match the new inspection frequencies in the Phase II Permit.	6/30/2022
S5.C.8.a	Implement a program to prevent and reduce pollutants that runoff to areas that discharge to MS4s.	Prepare a source control program report that describes how the City developed its program and includes SOPs for staff who implement the program.	[See S5.C.8.b]
S5.C.8.b.i	Adopt an ordinance, or other enforceable documents, requiring source control BMPs for pollutant generating sources from existing land uses and activities.	Update City ordinance.	8/1/2022
S5.C.8.b.ii	Inventory publicly and privately owned institutional, commercial, and industrial properties that discharge to the MS4.	Develop a source control program to meet upcoming permit requirements.	8/1/2022
S5.C.8.b.iii	Implement an inspection program for the sites identified in S5.C.8.b.ii.	Develop a source control program to meet upcoming permit requirements.	1/1/2023
S5.C.8.b.iv	Implement an enforcement policy to comply with stormwater requirements.	Develop a source control program to meet upcoming permit requirements.	1/1/2023
S5.C.8.b.v	Train staff responsible for implementing the source control program.	Develop a source control program to meet upcoming permit requirements.	Ongoing
S.7.A.1.a	Develop a survey to measure watershed residents' beliefs, behaviors, and attitudes over time toward Lake Whatcom water quality.	Future requirement to be met.	Immediate

Special Conditions number	Requirement	Compliance recommendation	Compliance date
S.7.A.1.b	With each annual report, report on progress of the Lake Whatcom water quality survey.	Future requirement to be met.	Annually
S.7.A.1.c	Submit results of the Lake Whatcom water quality survey with the annual report.	Future requirement to be met.	3/31/2022
S.7.A.1.d	Provide Ecology the informational packet distributed to watershed residents, and track how many new property owners received copies.	Future requirement to be met.	3/31/2022
S.7.A.1.e	Provide Ecology with the Lake Whatcom Cooperative Management Program Five-Year Work Plan, Program Area 9 update.	Future requirement to be met.	3/31/2020
S7.A.2.a	With each annual report, update and prioritize a list of new treatment and flow control capital improvement projects.	Future requirement to be met.	Annually
S7.A.2.b	Provide a list of retrofit opportunities with a timeline for incorporation.	Future requirement to be met.	3/31/2024
S7.A.2.c	With each annual report, evaluate and track phosphorus reductions.	Future requirement to be met.	Annually
S7.A.3	The City must submit a watershed-specific appendix to its operational plan for managing public areas such as parks, trails, ROWs, and open spaces.	Develop a watershed-specific appendix to the City's operational plan for managing public areas such as parks, trails, ROWs, and open spaces.	3/31/2024
S7.A.4.a	Submit QAPP jointly with Lake Whatcom Cooperative Management Program to Ecology for approval.	Develop procedures for tracking and reporting the status of the QAPP.	3/31/2020

Special Conditions number	Requirement	Compliance recommendation	Compliance date
S7.A.4.b	Track and report the status of the timelines in the QAPPs approved by Ecology in the annual report.	Develop procedures for tracking and reporting the status of the QAPP.	Annually
S7.A.4.c	Provide an evaluation of the effectiveness of built stormwater treatment and flow control facilities and an assessment of overall performance in reducing phosphorus and fecal coliform in the annual report.	Develop procedures for tracking and reporting the status of the QAPP.	3/31/2021
S7.A.5.a	The City must submit the Lake Whatcom Implementation tasks for 2024–2029 by 12/31/2023 with a new loading capacity by March 2024 based on updated models.	Update the Lake Whatcom plan to reflect revised loading capacities predicted by the models.	12/31/2023
S7.A.5.b	The City must submit the Lake Whatcom Implementation tasks for 2024–2029 by 12/31/2023 with a new loading capacity by March 2024 based on updated models.	Update the Lake Whatcom plan to reflect revised loading capacities predicted by the models.	3/1/2024

6.3 Resource Analysis

The objective of the resource analysis is to estimate full-time equivalent (FTE) resources needed to close SWMP gaps and/or implement new strategies to strengthen SWMP compliance toward meeting the Phase II Permit requirements. An FTE is equivalent to the annual number of hours an employee works in a year, or 2,080 hours.

The analysis uses time estimates to calculate the number of hours needed to close each identified SWMP gap. If existing staff's workload diminishes from the elimination of a program element (such as the Ecology Local Source Control Program), then the time allocation for those existing staff could be assigned to fill these gaps. Some gaps have ongoing programmatic resource demands while others are considered one-time events. The one-time events are assumed to be addressed with existing resources and therefore do not contribute toward the final FTE calculation. The ongoing programs have time estimates divided into "development" time estimates and "ongoing maintenance" time estimates for the years in the planning period.

Many Phase II Permit gaps exist simply because of new requirements scheduled to take effect on different dates within the Phase II Permit window (2019–2024); therefore, the FTE estimate is also sensitive to the implementation date.

Time estimates used in the analysis are based on the type of program work that is needed. Each Phase II Permit gap was categorized into one of the following four compliance gap categories:

- Compliance tracking
- SWMP documentation
- Policy development and implementation
- SWMP evaluation

These categories helped to establish basic assumptions describing the work, which became the basis for the estimated number of hours necessary to address the identified gaps. Table 6-5 shows the various categories and descriptions used in the resource model. Table 6-6 shows rates and hours needed to close the Phase II Permit gap.

Table 6-5. Phase II Permit compliance categories

Type of compliance measure	Description
Compliance tracking	Data collection and capture for reporting purposes.
SWMP documentation	Program reporting. Additional resources not expected (level of effort to achieve compliance is negligible).
Policy development and implementation	Documentation of strategies, procedures, etc. and training and execution as needed.
SWMP evaluation	Assessment of current practices for impact.
SWMP documentation	Formal documentation to meet regulatory requirement.

Table 6-6. Rate analysis assumptions

Assumption	Value	Unit
Average hourly rate [a]	175	Dollars
Hours per page [b]	4	hours
Annual days off	25	Days
Timespan	1	Calendar year
Start date	8/1/2019	Date
End date	7/31/2024	Date
Budget start date	2020	Year

a. Discussion and review by City staff, includes benefits and overhead.
b. HDR professional judgment and agency experience.

The details of the time estimates needed for each SWMP gap compliance work item are included in Appendix B (B.2 Gap Analysis). For SSWU budgeting purposes, the costs for each SWMP compliance activity were also included in the resource estimate. Table 6-7 shows the additional FTEs determined by the analysis for the planning period. This table should be interpreted to show the additional staff needed for any given year, and not to be additive, but cumulative. Thus the City would need to add two FTEs for 2020, and not need additional staff until fiscal year (FY) 2023, at which time two additional FTEs would be needed for the remaining 2 years of this planning period.

Table 6-7. FTE resource requirements

Budget year	FTE
2020	1.6
2021	1.1
2022	1.4
2023	3.8
2024	3.6

6.4 Recommendations

From the evaluation of the City's activities to satisfy the previous Phase II Permit, it was found that only a modest amount of activities are identified to either fill a gap or provide value-added enhancements to the SWMP as outlined in Table 6-3 above. Table 6-4 outlines the new requirements in the current Phase II Permit, many of which are yet to be due for completion. It is mainly from the added requirements of the current Phase II Permit that it is recommended to consider additional staffing. Therefore, based on the results of the SWMP gap analysis and resource calculation, it is recommended that the staffing requirements shown in Table 6-7 be included in the SSWU rate study analysis.

7 Stormwater System Analysis

The chapter summarizes the evaluations conducted for stormwater retrofit, conveyance capacity modeling, Lake Padden water balance, and reviews of existing data to help with the identification of system deficiencies. The City's stormwater drainage system was analyzed for the purpose of identifying system deficiencies that could be addressed by either maintenance activities or capital improvement projects. Many of the results of the analyses were submitted as recommended capital improvement projects that are identified and discussed in greater detail in Chapter 8, Capital Improvement Plan. Other results did not merit inclusion in the CIP, but are included in this chapter to document the existing problems and subsequent analysis. The objective of this chapter is to describe evaluations of identified drainage system deficiencies with the following subsections describing how problems were identified, the strategy for conducting the retrofit study, an analysis of hydraulic capacity of mainline storm pipes directly discharging to Bellingham Bay (marine outfalls), the City's fish passage prioritization plan, and an analysis of infrastructure deficient in capacity or condition.

7.1 Data Collection

Background data used for the stormwater system analysis were obtained from the City's GIS, existing reports, staff interviews, and direct field measurements. The following subsections briefly describe each data collection method.

7.1.1 Geographic Information System Data

City staff transmitted GIS data to HDR for use in the system analysis. The GIS data comprise geo-spatial and attribute information about the built stormwater drainage network including information on pipes, catch basin structures, detention ponds, and water quality BMPs. They also included information on streams, land use, drainage basin boundaries, and property ownership plus other features necessary for the analysis. GIS data layers acquired for the project were presumed to be complete and error-free. When data gaps were identified, City personnel were deployed to collect direct field measurements. For example, in support of the marine outfall hydraulic analysis, pipe attribute data were missing in numerous locations. City personnel provided HDR with depth-to-invert measurements and pipe material information that was critical to the analysis.

7.1.2 Existing Reports

The following reports were integral to the 2020 stormwater systems analysis and the identification of CIP projects and programs: the 1995 Watershed Master Plan, 2007 Stormwater Comprehensive Plan, Prioritization Report (City 2010), and Habitat Restoration Assessment (ESA 2015). Each report provides background information and recommendations that inform the 2020 system analysis.

7.1.3 City Staff Interview

City staff were interviewed to provide firsthand knowledge of drainage complaints, flooding problems, and other stormwater system deficiencies. The superintendent of maintenance, one of the two stormwater maintenance supervisors, and the GIS systems analyst, who is responsible for maintaining the City's GIS database that includes data on stormwater assets, attended the October 2018 meeting.

Topics discussed included the status and quality of attribute data needed for conducting the marine outfall hydraulic analysis of the conveyance lines directly discharging to Bellingham Bay. Known flooding problems, detention pond maintenance practices, and maintenance equipment needs were also discussed. The following decisions and actions were identified:

- The City provided survey invert elevations of the outfall pipes in the analysis. Other missing data and/or incorrect data would be (and eventually were) provided by City Maintenance and Operations (M&O) crews physically measuring the distance from the catch basin rim to the pipe invert.
- The City reported that a persistent flooding problem exists on Iowa Street just east of I-5 near the intersection of Moore Street. Otherwise, the City did not report other known flooding problems to be evaluated.
- Detention pond maintenance costs are increasing over time as the City accepts maintenance responsibility for privately constructed detention ponds. The City requested that the rate study include funding plans for detention pond maintenance.
- The City's PURC list of stormwater pipes identified those needing replacement because of condition.

7.2 Retrofit Program

The objective of the systems analysis retrofit task was to identify specific capital improvement projects that treat stormwater runoff from sub-watersheds where no water quality treatment facilities exist. Stormwater retrofit planning in this context targets developed areas where water quality treatment facilities do not currently exist and, if any were installed, they would benefit downstream receiving waters, in addition opportunities to equitably distributing neighborhood improvements (e.g., Birchwood Neighborhood CIP projects). The steps used to identify where and what type of retrofit BMP are as follows:

1. Focus priority sub-watersheds categorized by the City in past studies as Tier 1 sub-watersheds, and also areas where stormwater retrofit would provide ecological lift to the downstream receiving waters through LID opportunities. Also consider opportunities beyond just the Tier 1 areas.
2. Subdivide the target areas into smaller drainage areas (sub-basins) and develop "heat maps" that show impervious area gradations of each sub-basin.
3. Based on levels of impervious area and land use, propose stormwater retrofit BMPs for sub-basins with the highest levels of impervious surfaces. Select the BMP option known for addressing typical pollutants of concern based on land use.

4. The City and HDR discuss each proposed BMP and select top-priority projects to advance to concept design for the proposed CIP.

7.2.1 Targeted Sub-Watersheds

Retrofit planning for the 2020 SSWCP leveraged past planning investments made by the City. Target areas were identified in the Habitat Restoration Assessment (ESA 2015). In that earlier plan, stormwater retrofit was cited as a primary mechanism for improving aquatic habitat in downstream receiving waters by collecting and treating otherwise untreated stormwater runoff prior to it entering nearby streams. The Habitat Restoration Assessment (ESA 2015) focused on Tier 1 sub-watersheds, defined as sub-watersheds with high potential for ecological lift for multiple habitats and multiple functions. Among several methods cited in the 2015 Habitat Restoration Assessment, stormwater retrofit was specifically identified in the following Tier 1 sub-watersheds as a means for improving aquatic habitat. As such, the 2020 retrofit plan focused on the following Tier 1 sub-watersheds where stormwater retrofit was specifically identified:

- Baker Creek Tributary
- Lower Baker Creek
- Lower Padden Creek
- Lower Spring Creek
- Lower Squalicum Creek

With a focus on improving aquatic habitat, the next step was to narrow down areas within each Tier 1 sub-watershed where retrofits could have the greatest effect on improving water quality.

The Birchwood neighborhood was also evaluated for retrofit opportunities in addition to the above sub-watersheds, as this area exhibits soil characteristics to support infiltration, and has opportunities to support near-term habitat and nearshore restoration projects.

In looking beyond these sub-watersheds and the emphasis on retrofits, the next step in advancing the City's goals for stormwater management and watershed management in general should consider the other Tier 1 sub-watersheds, as well as the opportunity for natural stream corridor protection and restoration. The 2015 Habitat Restoration Assessment is well documented with these other opportunities and provides rankings to guide the City in deciding to expand the CIP in this manner. For example, Chuckanut Creek and Cemetery Creek are both Tier 1 sub-watersheds with areas designated for protection. Lower Squalicum Creek also has restoration opportunities identified. Policies and procedures would need to be evaluated with regard to streams on private property and what covenants would be necessary to preserve and/or restore these natural assets.

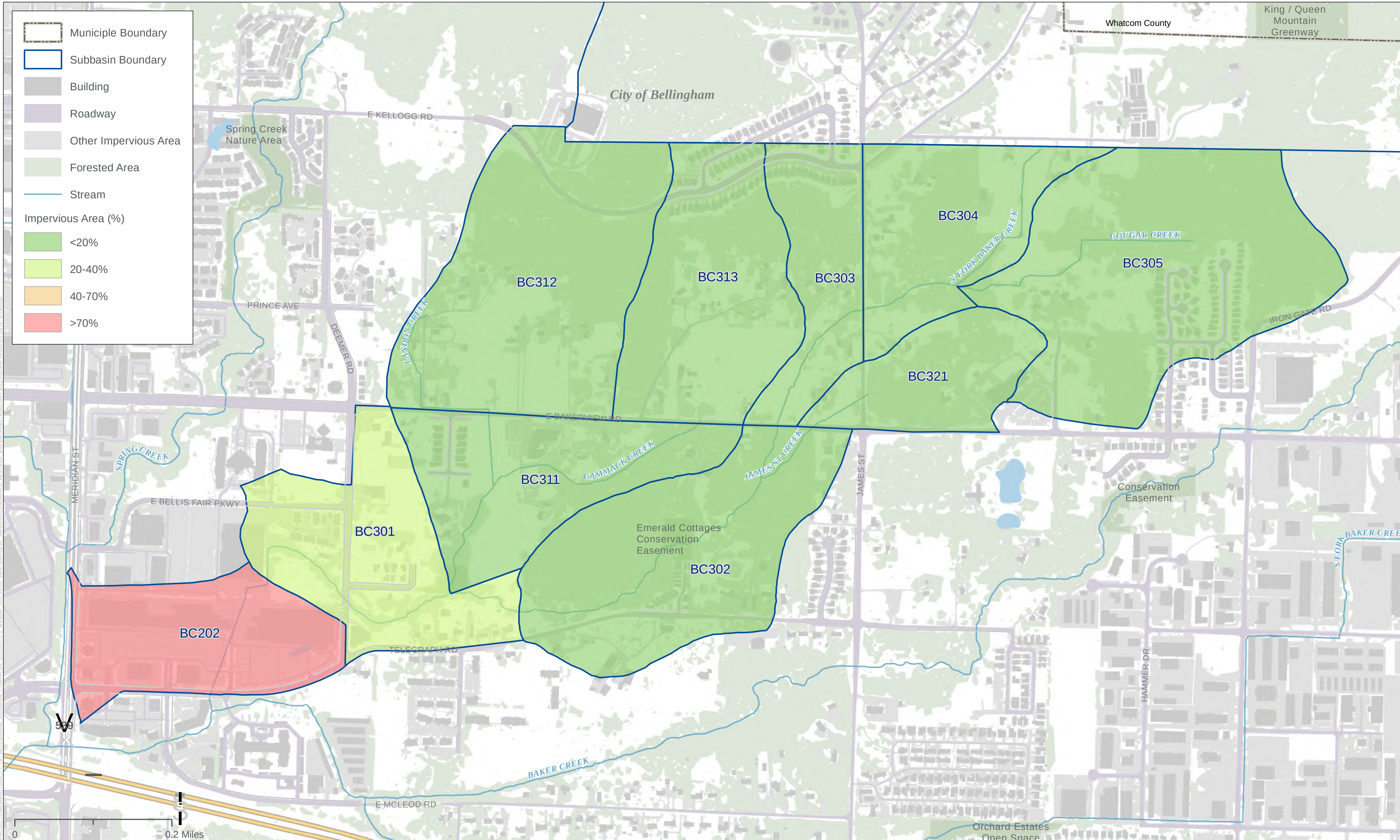
7.2.2 Heat Maps

Using the City's existing drainage basin boundary line data, each Tier 1 sub-watershed was subdivided into smaller drainage basins to enable a desktop analysis that calculates impervious area. Impervious area is a surrogate for quantifying retrofit potential because impervious areas are where the highest concentrations of pollutants are found and therefore offer the greatest potential for water quality improvement (see stormwater research data published by the Stormwater National Database in Chapter 2 showing pollutant loading rates by land use category). The desktop analysis identified the following four categories of impervious surface area intensity to focus the analysis:

- Less than 20 percent
- 20 to 40 percent
- 40 to 70 percent
- Greater than 70 percent

"Heat maps" were developed for each sub-basin within the sub-watershed to show gradations of impervious area, which narrowed down the study areas to smaller sub-basins that could be efficiently analyzed for retrofit opportunity.

In this application, heat maps are GIS-produced maps with color gradations that display retrofit potential. Existing drainage sub-basin delineations, identified in the City's GIS database, were overlaid onto the heat maps to disaggregate the sub-watersheds into smaller sub-basin drainage areas. The results of the desktop analysis highlighting retrofit potential as a function of impervious area are shown in Figure 7-1 through Figure 7-5.



BAKER CREEK TRIBUTARY

FIGURE 7-1

City of Bellingham

Surface and Stormwater Comprehensive Plan

SOURCE: City of Bellingham, WSDOT, etc.

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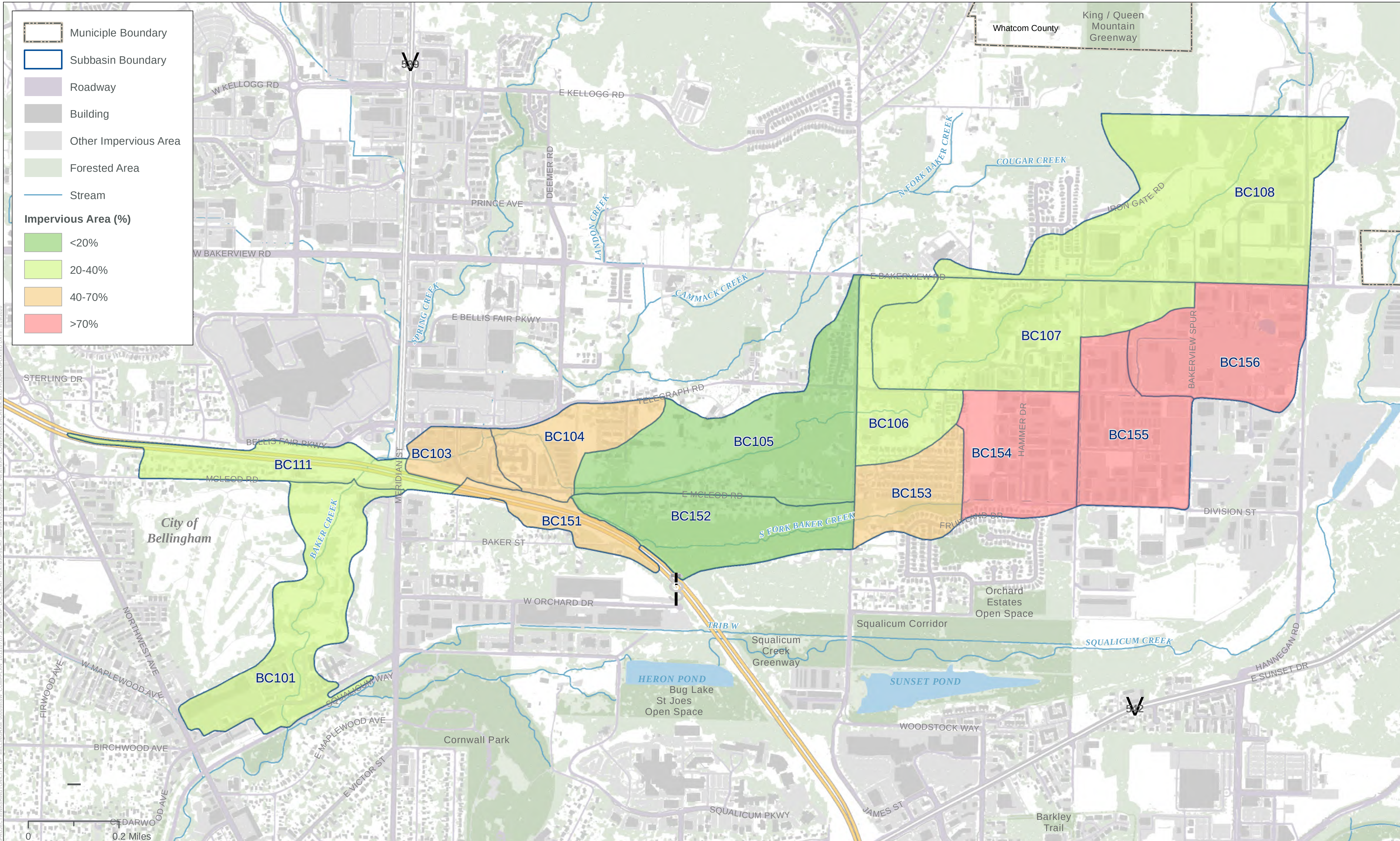

LOWER BAKER CREEK

FIGURE 7-2

City of Bellingham

Surface and Stormwater Comprehensive Plan

SOURCE: City of Bellingham, WSDOT, etc.

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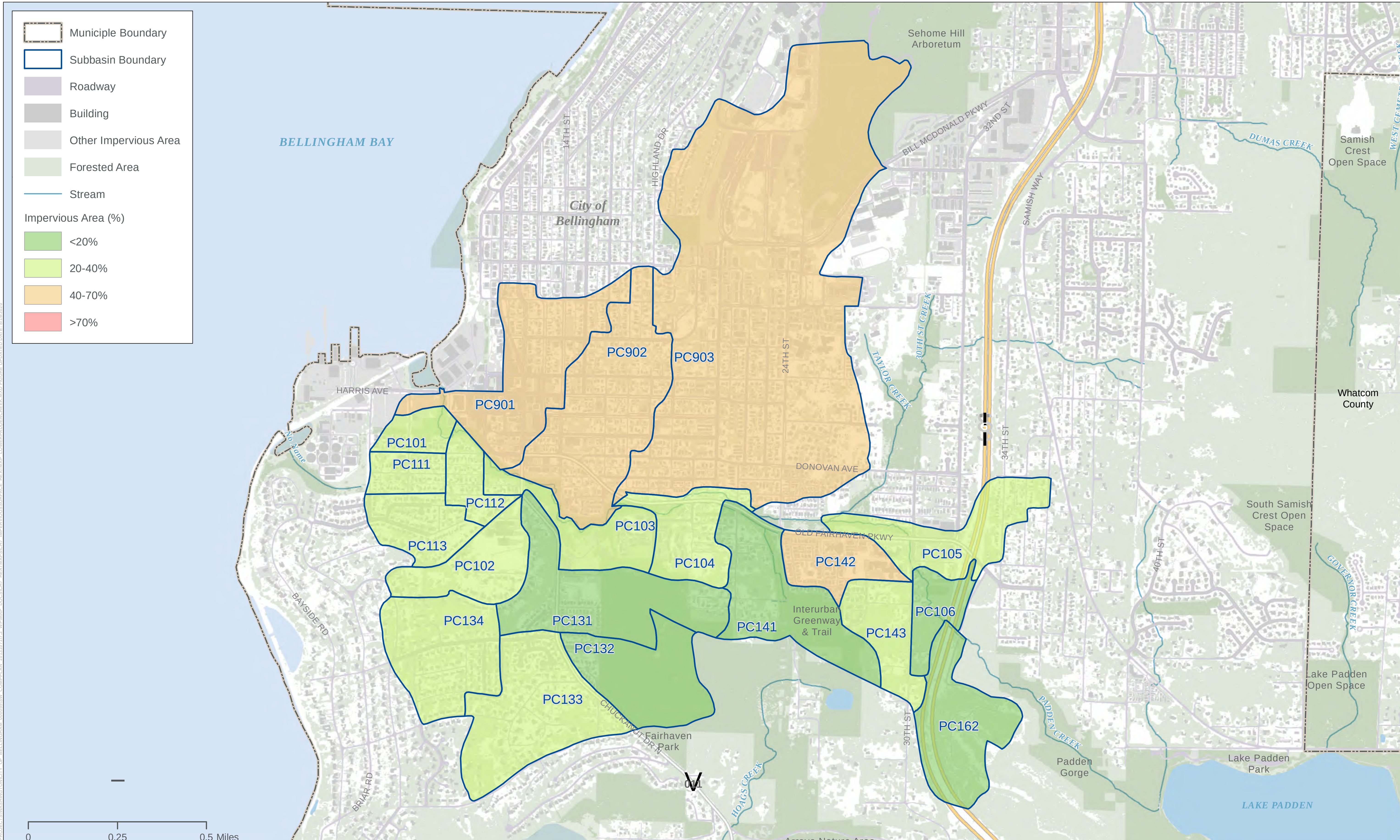

LOWER PADDEN CREEK

FIGURE 7-3

City of Bellingham

Surface and Stormwater Comprehensive Plan

SOURCE: City of Bellingham, WSDOT, etc.

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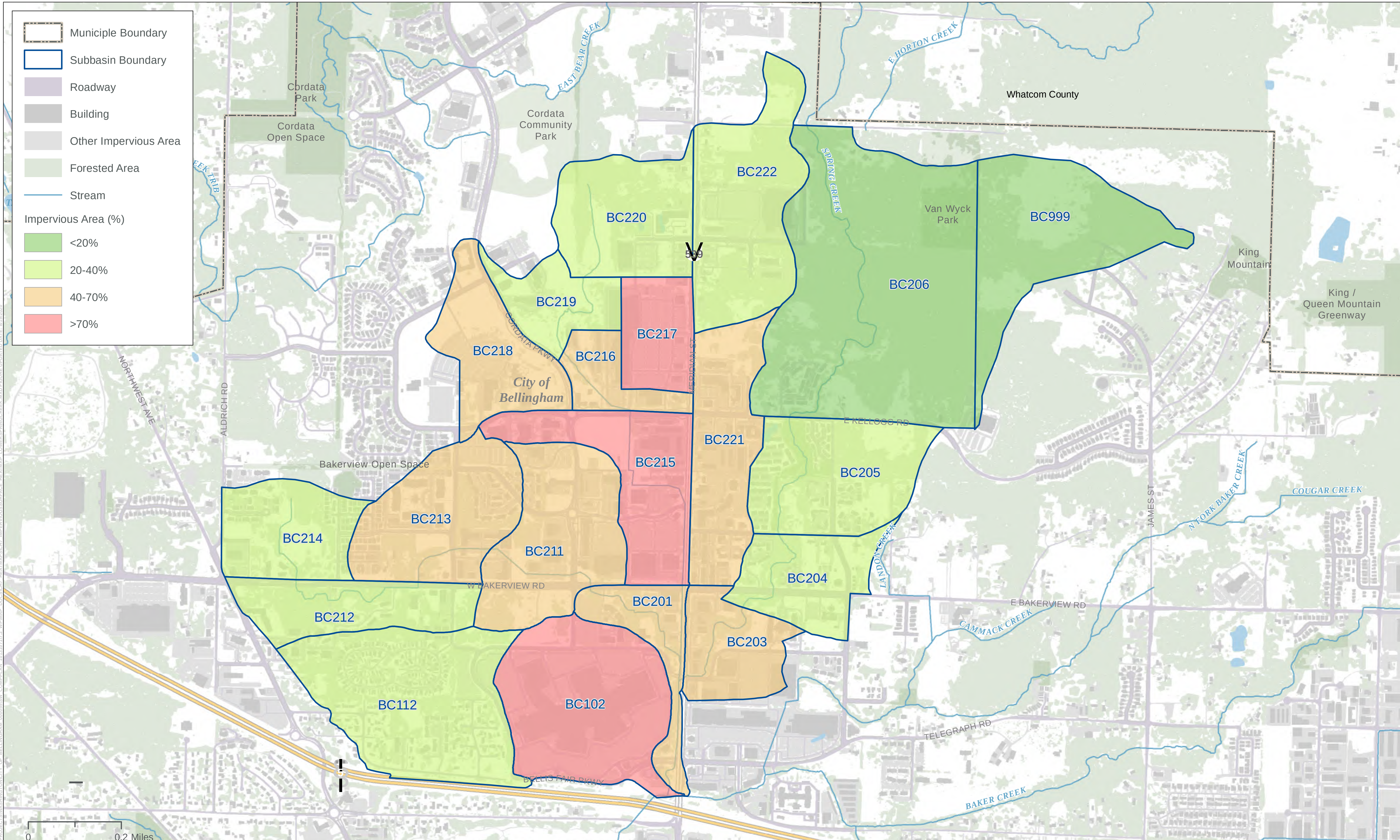

LOWER SPRING CREEK

FIGURE 7-4

City of Bellingham

Surface and Stormwater Comprehensive Plan

SOURCE: City of Bellingham, WSDOT, etc.

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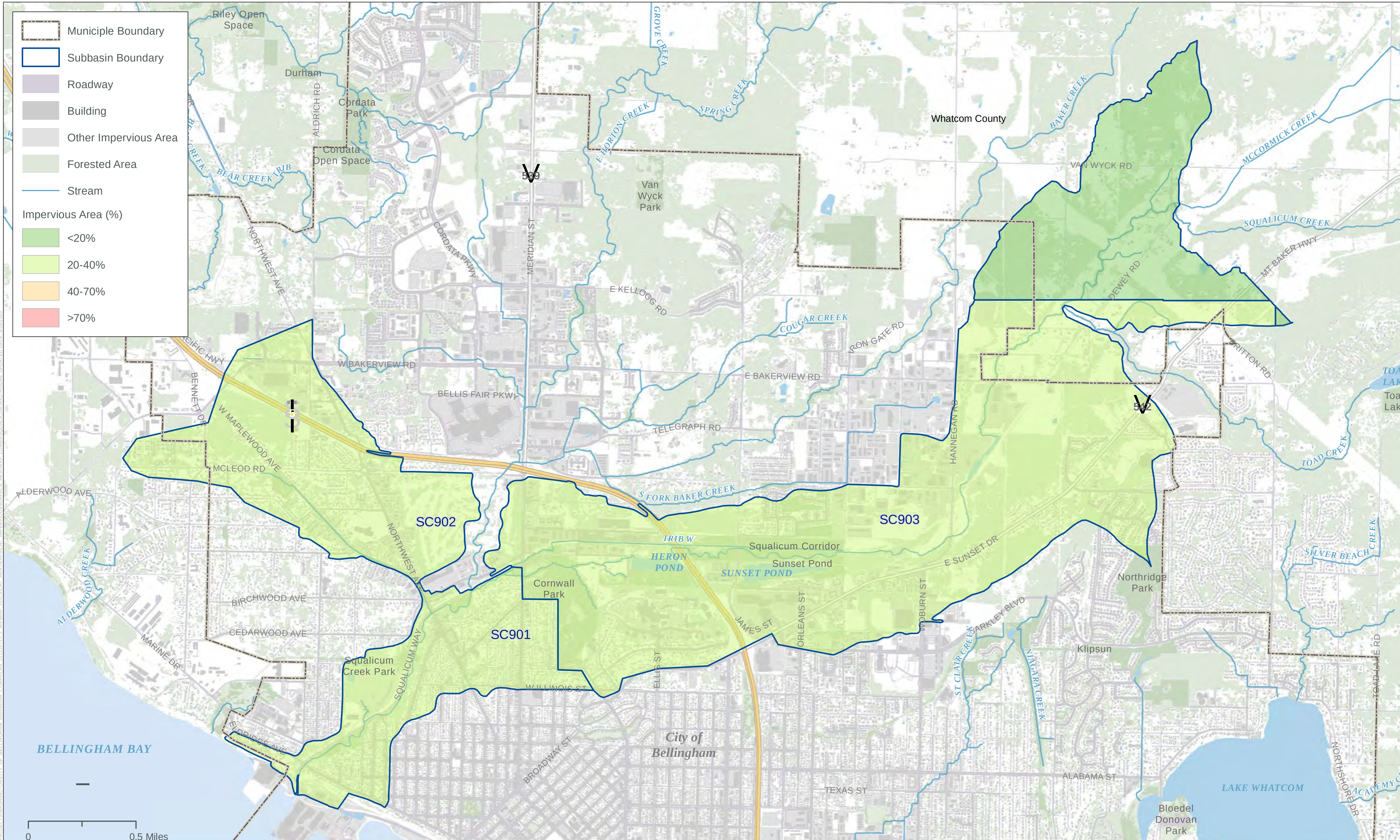

LOWER SQUALICUM

FIGURE 7-5

City of Bellingham
Surface and Stormwater Comprehensive Plan

SOURCE: City of Bellingham, WSDOT, etc.

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Based on impervious area intensities as shown in the heat maps, the top three sub-basins in each retrofit sub-watershed were selected for further analysis. A suite of water quality BMPs were initially identified for the top three sub-basins in each study area and presented to the City for its review. With assistance from City personnel, HDR selected BMPs to advance to concept design. The proposed BMPs reviewed at the workshop are shown in Appendix C, (C.1, Retrofit BMP Types and C.2 Retrofit Basin Maps Projects). The following sections summarize the retrofit projects evaluated for the targeted sub-watersheds.

Baker Creek Tributary

The Baker Creek Tributary basin is located north of I-5 and east of Guide Meridian Road. Except for the commercial district at the intersection of Guide Meridian Road and Telegraph Road, much of the Baker Creek Tributary sub-watershed has less than 20 percent impervious area, suggesting that stormwater retrofit potential is limited. Nonetheless, the following potential retrofit BMPs were proposed:

1. Filtration media vaults to capture and treat runoff from the commercial areas near the intersection of Telegraph Road and Guide Meridian Road
2. A bioretention or media filtration facility along Telegraph Road near the crossing of North Fork Baker Creek
3. A water quality basin filtration area that would be situated in the natural area upstream of the Telegraph Road dam

Each of the proposed BMPs listed above was discussed with the City within a workshop setting. Projects were not selected in this sub-watershed because of limited site availability and the relatively low level of impervious surface areas (that would aid in significant habitat improvement or water quality enhancement).

Lower Baker Creek

Lower Baker Creek comprises several smaller sub-basins that range in impervious area from less than 20 percent to greater than 70 percent. The heat map for this area indicated that the 130-acre (ac) industrial area in the eastern extent of the study area provides the best opportunity for stormwater retrofit.

Other sub-basins were evaluated for retrofit opportunities focusing on siting facilities on City-owned properties or within the ROW. Media filtration vaults, bioretention, and a regional water quality treatment facility were considered for the Lower Baker Creek sub-watershed. Based on contributing drainage area, impervious surfaces, and land use, a regional water quality treatment facility will provide the best retrofit opportunity to treat stormwater runoff. The site works well because it takes advantage of City-owned property, will treat runoff from an industrial area, and will result with a single end-of-pipe facility. Other areas within the sub-watershed sites that were considered, but dropped from retrofit BMPs, were not advanced because of property ownership, feasibility, and qualitative assessments of water quality improvement opportunity.

Lower Padden Creek

The impervious area in the Lower Padden Creek sub-watershed is split evenly between less than 20 percent, primarily south of Fairhaven Parkway, and the next higher category (20–40 percent), north of Fairhaven Parkway. The sub-basins with less than 20 percent impervious area were not good candidate areas for stormwater retrofit because there is little to no development in need of retrofit. The sub-basins north of Fairhaven Parkway, composed primarily of single-family residential (SFR) homes where impervious area ranges from 20 to 40 percent, became the focus for retrofit opportunities in this sub-watershed.

Infiltrating BMPs were considered because the soils map for this area indicated that good infiltration rates were possible (159—Squalicum-Urban land complex, gravelly loam soil with moderately well drained soils). Therefore, bioretention facilities were determined to be the preferred BMP type. Research and confirmation from the City indicated the presence of an existing regional water quality facility reducing the area for additional treatment to an area along Bill McDonald Parkway.

Lower Spring Creek

Retrofit opportunities in Lower Spring Creek focused on the sub-basins with commercial developments and public streets with high traffic counts. Filtration vaults and bioretention facilities were evaluated. Decisions at the CIP workshop supported use of filtration vaults along East Bakerview Road and Eliza Avenue, but when the sites were considered by the engineering team, challenges to locate the facilities where sufficient runoff volumes could be captured resulted in all of the facilities not advancing to the CIP.

Lower Squalicum Creek

Based on the heat map analysis, the impervious surface area analysis for Lower Squalicum Creek indicated that the sub-basins have less than 20 percent impervious area throughout, suggesting that retrofit potential is limited as a whole. However, the stream does experience flashy responses to storm events. Consequently, the City has been performing stream habitat restoration and bank stabilization activities such as in 2005 with the installation of large woody debris structures to enhance habitat and protect the banks. This area is monitored routinely for maintenance activity such as surveying for and controlling noxious weeds and other invasive plants. Squalicum Way, a high-volume truck route between the Port of Bellingham and I-5, provides opportunities for stormwater retrofit based on traffic volume. Filtration vaults and regional flow control facilities were explored and discussed at the CIP workshop. The filtration vaults emerged as the best option for this sub-watershed.

Birchwood Neighborhood Improvements

Retrofit opportunities in the Birchwood neighborhood focused on bioretention given the soil classifications, and with an emphasis on construction in the City-owned ROW to aid in implementation and maintenance. Ten facilities were evaluated using similar analysis conducted for this SSWCP that generated unit cost (dollars per square foot of bioretention area).

7.3 Potential Retrofit Facilities

The following retrofit facilities were analyzed and conceptually designed for the 2020 CIP. Each facility is described in greater detail in Chapter 8, Capital Improvement Plan.

7.3.1 Regional Flow Control

At the CIP workshop, City personnel supported developing a regional water quality and flow control facility in this sub-watershed where portions have industrial operations. The stormwater outfall pipe from the industrial basin is located on City-owned property, making the site a good candidate for a regional retrofit facility.

The proposed Baker Creek regional water quality and flow control treatment facility is a treatment-train system that includes a detention pond, pre-settling vault, and oil/water separator followed by a filtration chamber. The proposed facility layout is depicted in Figure 7-6.

The facility would receive runoff from two stormwater mainline conveyances from the east, one north and the other south of the facility and sized for the planning-level 2-year peak flow. The 2-year flow was selected based on Ecology SWMMWW treatment BMP criteria that filtration treatment downstream of detention ponds be sized for the 2-year pond discharge. The 2-year flow in the northern conveyance line is predicted to be 20 cfs, all of which would be routed to the detention pond. Flows exceeding 20 cfs would bypass the detention pond and would be routed directly to the facility, which would also be equipped with a high flow bypass at the southern end of the pre-settling vault. With this configuration, high flows in excess of the water quality design flow (3 cfs) would bypass the treatment train and discharge directly to Baker Creek.

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LITTLE SQUALICUM CREEK

FIGURE 7-6

City of Bellingham

Surface and Stormwater Comprehensive Plan

SOURCE: City of Bellingham, WSDOT, etc.

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The southern conveyance line drains an area approximately 8 acres in size. Runoff flow rates for the 2-year event are expected to be about 0.15 cfs per acre or 1.2 cfs for the 8-acre sub-area. The cfs per acre value is derived from modeling results calculated for the northern conveyance line. Flows from the south line would also flow through the treatment facility.

The treatment-train design is premised on purchasing undeveloped land adjacent to and north of the proposed treatment facility, where a detention pond would be sited. The proposed detention pond attenuates flow and serves as a pre-settling facility removing large sediment particles and lowering total suspended sediment (TSS) prior to runoff being routed to and treated by the water quality BMPs. The water quality facility would comprise three components, in the following order of treatment:

1. A pre-settling chamber would further decrease TSS and create laminar flow conditions for effective removal of hydrocarbons and oil residue by the oil/water separator unit.
2. An open-air filtration unit would use bioretention soil mix and vegetation to remove metals from the runoff.
3. The treated stormwater would be collected in an underdrain pipe and discharged to South Fork Baker Creek.

Design Parameters

The Baker Creek sub-watershed was delineated and modeled in MGSFlood to determine water quality flow rates (see Appendix C, C.3, BC 154 Design Summary). Within the model, the default extended time series precipitation data (158-year period) for the region was used. The input parameters for pre- and post-conditions that characterize land use types delineated with GIS software based on 2019 pervious land (PERLND) and impervious land (IMPLND) areas are shown in Table 7-1 below.

Table 7-1. Existing and proposed impervious and pervious areas for Lower Baker Creek

Existing conditions		Proposed conditions	
Land use type	**Area (ac)**	**Land use type**	**Area (ac)**
Outwash forest	128	Till forest	0.95
		Till pasture	6.87
		Till grass	1.23
		Outwash forest	2.65
		Outwash pasture	4.64
		Outwash grass	3.81
		Wetland	1.06
		Impervious	107

In MGSFlood, these areas were routed through a flow splitter that conveyed 20 cfs of runoff into the pretreatment pond and the remainder of runoff into bypass as depicted in Figure 7-6 above. Water quality modeling results calculated total runoff volume to be 2,461 acre-feet (ac-ft) and the 2-year discharge rate to be 3.15 cfs.

This proposed treatment facility would clean stormwater runoff originating from an industrial/commercial drainage area. The detention/treatment facility would lower peak flow rates and remove petroleum hydrocarbons and heavy metals from stormwater prior to being discharged to South Fork Baker Creek. This facility would reduce flood risk, improve aquatic habitat, and generally improve the quality-of-life standards for the community.

7.3.2 Filtration Vaults

Filtration vaults are proprietary water quality treatment units that typically use filter cartridges or filtration media contained within a precast concrete vault (e.g., Modular Wetlands, Filterra units) to collect, treat, and then discharge stormwater runoff to receiving waters. They work particularly well in existing stormwater drainage lines because they integrate well into existing lines with minimal disruption.

In the 2020 retrofit plan, filtration vaults are proposed along heavily traveled roadways in the Squalicum and Padden Creek sub-watersheds. Two filtration units are proposed in Squalicum Way, a heavily traveled truck route between the Port of Bellingham and I-5.The two filtration units are proposed just upstream of outfalls to Squalicum Creek.

Both filtration vaults are included in each CIP scenario; therefore, a prioritization evaluation was not conducted.

7.3.3 Bioretention Facilities

Bioretention facilities sited in City-owned ROW are proposed in the Birchwood neighborhood. Ten Birchwood neighborhood facilities were identified in the 2019 Birchwood Retrofit Plan (Appendix C, C.4 Birchwood Retrofit Plan). Each was evaluated for inclusion in the proposed 2020 CIP though the area was not expressly identified as a Tier 1 sub-watershed. HDR evaluated the proposed facilities using desktop analyses and web-based Google street view technology to verify that recommended sites meet minimum criteria for siting ROW bioretention facilities. The criteria used in the evaluation and site ranking are discussed below.

Bioretention siting criteria include the presence or absence of mature trees, planter strip widths, adjacent grades, driveway frequency, landscaping, street parking, and utility conflicts. The Baker Creek sub-watershed was delineated and modeled in MGSFlood to determine water quality flow rates (see Appendix C, C.3, BC 154 Design Summary). Within the model, the default extended time series precipitation data (158-year period) for the region was used. Table 7-2 lists the 10 sites and includes summary notes describing site conditions. Appendix C illustrates the locations of these sites.

Table 7-2. Bioretention sites and ranking criteria

Site ID	Intersection	Recommendation	Notes
1	W Illinois St. and Nome St.	Yes	Site facilities on both sides of W Illinois St., east of Nome St. No sidewalks, no trees, OHP, but can work around.
2	Cedarwood Ave. and Pinewood Ave.	Maybe	Mature trees along Cedarwood Ave. (SW corner), below grade lot on NW corner, sidewalk (SE). NE corner could work, but small.
3	Cedarwood Ave. and Firwood Ave.	Maybe	Landscaping improvements (NW), mature tree (NE), trees/shrubs (SE), one possible site (SW).
4	Birchwood Ave. and Pinewood Ave.	No	Driveway (NW), mature trees (NE), mature trees, below-grade lot (SE), pavement improvements/parking (SW).
5	Birchwood Ave. and Firwood Ave.	Yes	Conflicts: mature trees, landscaping (SW), 1 mature tree but could work around it. Site facilities along Birchwood Ave. eastward and Firwood Ave. southward.
6	Alderwood Ave. and Cherrywood Ave.	No	Site 6 is not recommended because of trees, longitudinal slope, street parking, and below-grade adjacent lots.
7	Cottonwood Ave. and Pinewood Ave.	No	Conflicts with driveways, utilities, street parking, sidewalk.
8	Cherrywood Ave., north of Cottonwood Ave.	Yes	Open lawn, no landscaping or driveway conflicts.
9	The 3200 block of Laurelwood Ave.	Yes	ROW facility, west side of Laurelwood Ave. south of Cottonwood Ave. The proposed site spans across several lots, west side of Laurelwood Ave.
10	The 3100 block of Cedarwood Ave.	Yes	ROW facility, north side of road, spans 2 lots.
11	Bill McDonald Pkwy. [a]	Yes	Insert facility into existing conveyance line, include overflow structure to pass high flows. Will require removing SD line and providing traffic control.

a. The Bill McDonald Parkway site is not part of the Birchwood retrofit plan. It was identified by the Padden Creek evaluation.

Sites 4, 6, and 7 are not recommended because of conflicts with mature trees, driveways, adjacent lots being below grade, and utility conflicts. Sites 2 and 3 are marginal sites because of mature trees and other conflicts, but facilities could be arranged to avoid the conflicts. They rank lower in priority. Sites 1, 5, and 7–10 meet standards for ROW bioretention facilities and have a higher ranking. The Bill McDonald Parkway site (Site 11) also met standards.

The ranking criteria are based on recommendations cited in Table 7-2 and facility size because sizing equates to pollutant load reduction. In order of ranked priority the bioretention sites to be considered for the 2020 CIP are:

1. 3200 block of Laurelwood Avenue: A 350-by-16-foot facility along Laurelwood Avenue (Site 9).
2. W Illinois Street east of Nome Street: A 300-by-16-foot facility on both sides of W Illinois Street (Site 1).
3. 3100 block of Cedarwood Avenue: A 300-by-16-foot facility along the north side of the road; spans two lots (Site 10).
4. Cherrywood Avenue: North of Cottonwood Avenue a 116-by-16-foot facility (Site 8).
5. Birchwood Avenue and Firwood Avenue: A 115-by-12-foot walled facility. One mature tree in the corner can be avoided. Place facilities along Birchwood Avenue eastward and Firwood Avenue southward (southeast). West of the intersection on both sides of Birchwood, landscaping and shrubs are prohibitive (Site 5).
6. Bill McDonald Parkway: Place an 84-by-16-foot facility in a planter strip between the roadway and sidewalk. Possible utility conflicts (Site 11).
7. Cedarwood Avenue and Pinewood Avenue: Marginal site because of the presence of mature trees along Cedarwood Avenue (southwest corner), below-grade lot (northwest corner), and sidewalk (southeast). The northeast corner could work, but small (Site 6).
8. Cedarwood Avenue and Firwood Avenue: Marginal site. Landscaping improvements (northwest), mature tree (northeast), trees/shrubs (southeast), and one possible site (southwest) (Site 7).

7.4 Fish Passage Program

The City initiated a culvert improvement program in 2003 to address barriers to fish passage within city limits. The City is committed to stewarding fish and wildlife habitat and has a long history of improving fish passage throughout the city and urban growth area both with independent restoration projects and in conjunction with other capital improvement projects (City 2019).

The Washington Department of Fish and Wildlife (WDFW) uses a Priority Index (PI) to evaluate culverts and takes into account the severity barrier, habitat gain, species mobility, stock status, and projected cost of the project (WDFW 2019). The City uses the WDFW PI scores to create a draft list that goes through a data-driven process to identify the prioritized projects. The full decision-making process used during the 2019 update is shown in Figure 7-7. Barrier improvements are coordinated with other entities when possible to maximize habitat benefits and cost efficiencies, and has been since before requirements were set in place under the 2013 injunction requiring the State of Washington to correct fish barriers.

STEPS 1 -6: Identify Sites

1. Create a Draft Priority List consisting of the top 10 City-owned barriers within City limits identified in the Whatcom County Fish Passage Barrier Inventory (Whatcom County Public Works, 2006), ranked by 2006 PI score and listed by WDFW identifier number.
2. Update PI scores for the 10 barriers identified in 1, above, using the FPDSI database (WDFW, 2019a).
3. Review all City-owned barriers within City limits mapped on the FPDSI database (WDFW, 2019a) and add barriers with PI scores ≥ lowest score identified in 2 (PI score ≥ 15.48).
4. Add barriers to the Draft Priority List if they:
   a. did not have a PI score but were lower in the system than barriers on the Draft Priority List from 3, above and/or
   b. are within 2 miles of a restoration site or barrier removal completed or planned to be complete by 2025. Planned projects are based on the City's adopted Six-Year (2020-2025) Transportation Improvement Program (City of Bellingham, 2019) and the WSDOT 2019 Project Delivery Plan (WSDOT, 2019).
5. Add any top 10 barriers from Anchor 2010 (from PI Ranks for All Barriers list), if not already on Draft Priority List from 4, above.

STEP 6: Refine Site Information

6. Update and add information:
   a. Calculate lineal gain if not provided on WDFW barrier forms by estimating distance in GIS using City of Bellingham stream layer.
   b. Update any data from qualified sources. In 2019, this consisted of updating fish Passability at the City's flood dams based on a habitat assessment conducted by Environmental Science Associates (ESA), Waterfall Engineering, Aspect Consulting, and Wilson Engineering (2019). It also included updating the ESA species presence to include bull trout from WDFW (2019b).

STEP 7: Score and Rank Sites

7. Score and rank all culverts on the Draft Priority List from step 7 using the Prioritization Equation below. The equation uses 12 metrics. These metrics represent key information available for all barriers together with Additional Considerations (species listings, coordination, benefits, juveniles, community support, and funding opportunities) provided in the WDFW *Fish Passage Inventory, Assessment and Prioritization Manual* (WDFW, 2019c, p. 12-5). See the Prioritization Manual for methodologies and descriptions of each of the Additional Considerations.

Prioritization Equation:

SCORE =
Lineal Gain + Passability + ESA + Coord. Barriers + Coord. Other + (Benefits/3) + Juveniles + Comm. Support + Funding Opp. – Cost

Figure 7-7. 2019 fish barrier prioritization methodology

The City provided HDR a list of ranked culverts from the Prioritization Report (City 2010) that included 2019 planning-level construction estimates. These estimates were developed only to determine orders of magnitude for the purposes of prioritizing culvert improvements. The list of ranked culverts are included in Appendix C (C.5 Ranked Fish Passage culverts).

The top five culverts from the City-provided list were selected; their locations are shown in Figure 8-1. The top five culvert projects were included in the 2020–2026 CIP.

7.5 Conveyance Improvements

Operating and maintaining an SSWU requires an intentional program to renew or replace stormwater conveyance lines. The 2007 Stormwater Comprehensive Plan and 2020 SSWCP each have analyses identifying stormwater pipelines in need of renewal or replacement to address deficiencies in condition or capacity. This section describes recommended conveyance improvements for the 2020–2026 CIP, including a marine outfall conveyance improvement plan, a marine outfall basin prioritization, PURC projects, and 2007 CIP conveyance.

7.5.1 Marine Outfall Conveyance Improvement Plan

The Shoreline Management Master Program includes the goal of shoreline protection. Specific shoreline protection policies focus on flood protection through the use of floodplain management. This is done through the use of flood protection and streamway modifications. It is recognized that improper flood control upstream results in increased flood damage downstream. Floodplain management as a means of flood control has advantages of maintaining the natural characteristics of the shoreline while protecting adjacent property without amplifying potential flood damage downstream.

Bellingham Bay contains nine direct discharge outfall systems from various highly developed areas of the city that are a concern for the City regarding upstream flooding and conveyance restrictions that could impact land use development and property values, in addition to impacts to the receiving water body, Bellingham Bay. As part of the 2020 SSWCP update, the City requested an analysis of mainline conveyance pipelines draining directly to Bellingham Bay to identify capacity-constrained sections of pipe. The objective of the analysis was to identify pipe segments to be upgraded and enlarged to meet the City's 25-year conveyance standard in the built future condition.

Hydrologic and hydraulic models were developed and used to conduct detailed analyses to characterize current- and future-conditions flooding in nine direct discharge marine outfall systems in the city of Bellingham. The hydraulic model was then used to develop and evaluate potential flood reduction alternatives with the goal of eliminating flooding during the 25-year full buildout conditions flood event, and evaluate the effect of SLR on the drainage systems. Modeling results show that two of the basins, Bennett Street outfall and Cedar Street outfall, have no flooding. They were removed from consideration in the CIP. The other seven basins have varying improvement needs to meet the objective of conveying the future 25-year flow.

To minimize the cost of the proposed improvements, solutions were sought that required replacing the shortest total length of pipe. In some instances, however, several alternatives were identified to achieve the desired level of flood reduction.

When testing pipe upsizing alternatives, the invert elevations for upsized pipes were kept at the existing invert elevations except in instances where the new pipe would have less than 1 foot of cover over the pipe crown to the ground surface at either end of the pipe. In these cases the invert elevations for the new pipe were lowered such that there would be at least 1 foot of cover. If the cover was less than 2 feet, then ductile-iron pipe (DIP) material was specified for cost implications. City standard pipe material would be assumed for pipes with cover of 2 feet or more. To be conservative for the purposes of setting budgets, some solutions may indicate the replacement of the same size pipe but changing the pipe material to create higher conveyance. During the actual design phase of these projects, a value engineering review should be performed for alternatives such as sliplining or pipe-bursting that may produce lower overall costs and less disruption to traffic and utilities.

A future SLR analysis was also conducted to evaluate the effect of SLR on the proposed conveyance system improvements. Additional information on SLR as a result of climate change is provided in Chapter 4. The scope of this analysis has the time horizon set at 50 years in the future (i.e., 2070). Recent work by the UW CIG estimates that the median value of relative SLR in Bellingham Bay will be between 0.9 foot and 1.1 feet by 2070. The SWMM model of the flood reduction alternatives was run assuming that the tidal boundary condition was raised by 1.1 feet. While the higher tailwater condition results in increased water levels upstream of the outfalls, this analysis found that no additional flooding would result from the predicted SLR. The conclusion is that the proposed conveyance system improvements are robust enough to handle at least 1.1 feet of future SLR. While other SLR studies are looking at greater increases in tidal conditions (resulting from time horizons longer than 50 years), this horizon would be longer than that of the pipe system.

The following prioritization criteria were used to rank the outfall basins:

- Structural flooding risk
- Increase in impervious surface area between existing conditions and future full buildout conditions
- Percent increase in the simulated 25-year flow rate between existing and future land uses
- Number of predicted flooding catch basin structures in the future-conditions scenario
- Roadway classification where proposed improvements are needed
- If the pipe segment is identified as being in poor condition by the City's PURC program
- The type of land conversion between existing and future conditions

Data used in the prioritization are shown in Table 7-3. Point values for each criterion, based on the range of values and distributed evenly without weighting, are shown in Table 7-4. The actual scores and outfall basin rankings are shown in Table 7-5.

Figure 7-8 shows the recommended pipes to be upgraded to eliminate flooding for the 25-year design flood event with full buildout land use. The complete modeling report is included as Appendix C (C.6 Marine Outfall Tech Memo). Brief discussions of the solutions are provided below, organized by the street name where the outfall discharge is located.

Arbutus

Within the Arbutus basin, one hydrologic model node floods during the 25-year flood event. Replacing the existing 12-inch-diameter corrugated metal pipe (CMP) with a 15-inch-diameter RCP pipe or with a 12-inch-diameter smooth bore is recommended. Polyvinyl chloride (PVC) pipe would eliminate predicted flooding. The reduction in roughness between these two pipe materials is sufficient to eliminate flooding at this location. The increase in size would provide additional capacity.

Broadway

The flooding within the Broadway basin is more extensive than any other basin, with flooding along both the Broadway branch and Eldridge branch of the drainage network for the 25-year storm. To eliminate flooding along the Broadway branch (Meridian, Kulshan, and Peabody Streets), 49 pipe segments were identified that need to be upsized (total length 6,575 feet). These modifications also would act to reduce water levels upstream in the drainage network and eliminate the inter-basin flooding at the intersection of H and Jenkins Streets to the Ellsworth basin. DIP is recommended for some of the replacement pipes as they have less than 2 feet of ground cover above the pipe crown. To eliminate flooding along the Eldridge branch, modifications to the main branch beneath Eldridge Street and the smaller branches leading to the main branch are recommended (total length 3,181 feet). However, it should be noted that the City does not own or maintain the stormwater outfall on Port of Bellingham property, as there are no easements or maintenance agreements. Improvements to this component of the system would require coordination with the Port of Bellingham.

C Street

Flooding in the C Street basin can be eliminated by upsizing 13 pipes with a total length of 1,421 feet. A portion of the recommended pipe upgrade in sizing will have to be installed at a lower invert elevation to maintain a minimum of 1 foot of cover (the existing concrete pipes have less than 1 foot of cover at this location). DIP is recommended for these and three other replacement pipes in the basin because they will have less than 2 feet of cover.

Ellsworth

Flooding within the Ellsworth basin can be eliminated by upsizing eight pipes with a total length of 1,509 feet. Currently the Broadway basin overflows into the Ellsworth basin. Modifications made to the Broadway system would eliminate interbasin overflows.

Laurel

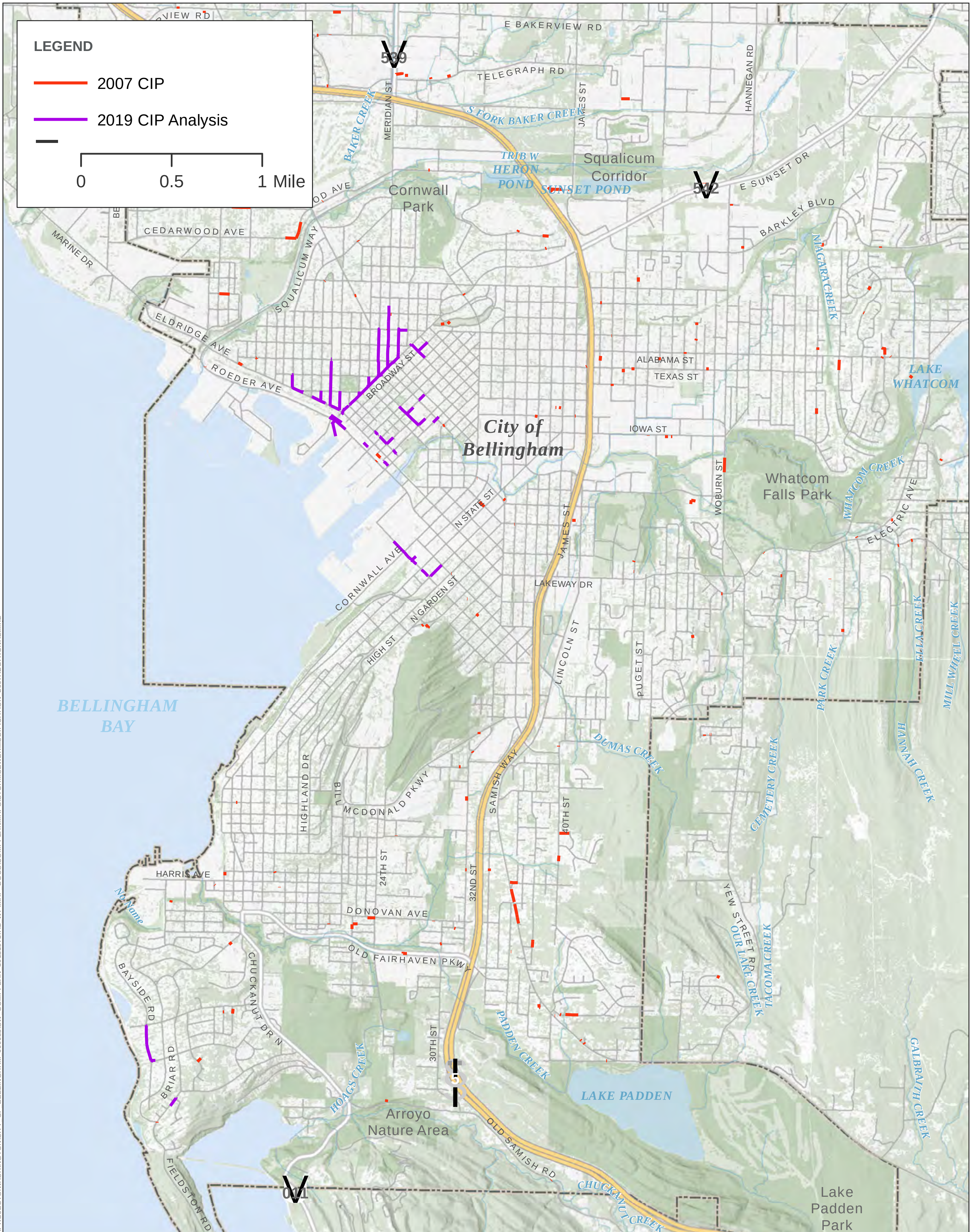
Flooding within the Lauren basin can be eliminated by upsizing 10 pipes and changing the material on 1 pipe, with a total length of 1,162 feet.

Olive

The only simulated flooding in the Olive basin occurs from a manhole east of the railroad, immediately upstream from the outfall. Surface flooding may not be much of a problem at this location, in which case no action would be needed. However, if the City wants to eliminate any flooding, one pipe segment would need to be upsized.

Willow

In the Willow basin, four pipes need to be replaced to eliminate flooding along Bayside Road. Flooding can be eliminated by installing 24-inch-diameter RCP pipes, which have a lower roughness value than the existing CMP. The reduced roughness with concrete pipes is enough to eliminate flooding at this location, while the increase in size would provide additional capacity. An alternative to consider during engineering design of this project would be a sliplining approach. Sliplining has the ability in areas of congested utilities and surface features to be more cost-effective over “cut-and-cover pipe replacement.”



STORM SEWER MODIFICATION

FIGURE 7-8

City of Bellingham

Surface and Stormwater Comprehensive Plan

Source: City of Bellingham (2018)

Table 7-3. Marine outfall prioritization data

Marine outfalls area [a]	Structural flooding risk [b]	Impervious area increase (%)	25-year flow existing (cfs)	25-year flow future (cfs)	Percent increase	Roadway classification [c]	Flooding nodes	PURC list [d]	Type of land conversion
Arbutus	High	13	11	16	45.5	Residential	1	No	SFR to SFR
Bennett	Low	13	19	27	42.1	Principal	0	No	SFR to MFR
Broadway Eldridge branch[a]	Low	15	103	132	28.2	Principal	16	Yes	SFR to MFR
Broadway Main branch[a]	Medium	15	103	132	28.2	Principal	17	No	SFR to MFR
C Street	Low	17	42	50	19.0	NA	11	No	Large conversion of SFR to MFR
Cedar	Low	7	21	28	33.3	Principal	0	Yes	Institutional and public space and parks
Ellsworth	Low	5	32	34	6.3	Other	4	Yes	SFR to MFR
Laurel	High	19	35	50	42.9	Residential	11	No	SFR to MFR
Olive	Low	11	22	32	45.5	Residential	1	No	No appreciable change
Willow	Low	10	17	24	41.2	Residential	4	No	Roadside ditch floods

SFR = single-family residential zoning; MFR = multifamily residential zoning.

a. Broadway Main and Broadway Eldridge are both located in the Broadway basin. Eldridge is left branch. Flows reported at outfall. Because each sub-basin discharges at the same outfall, the flow value for each is equal. Flooding nodes: total is 33 (from Table 6 in Appendix C, Marine Outfalls Technical Memorandum). Fourteen are from Eldridge, per count in Table 7 for Eldridge (Appendix C, Marine Outfalls Technical Memorandum).
b. Desktop review to assess flood risk determined qualitatively using Google street view. High risk: floodwaters could enter structure. Analysis based on Google street view and roadway profile; medium risk: residential flood risk is possible, no business flooding, drainage flows to railroad easement; low risk: floodwaters do not threaten structure and/or flow toward railroad easement.
c. Roadway classification from CityIQ where improvements are identified (Principal, Secondary, Collector, Residential).
d. PURC = Pavement and Utility Rating Committee.

Table 7-4. Marine outfall prioritization points criteria

Flooding risk	Pts. [a]	Impervious area delta (percent)	Pts. [a]	Percent flow increase	Pts. [a]	Flooding nodes	Pts. [a]	Roadway classification	Pts.	PURC list	Pts.	Land conversion type	Pts.
High	3	≥15	3	≥34.5	3	≥ 5	3	Collector	3	Yes	2	Comm, Instit, or Ind.	3
Medium	2	10 to <15	2	23 to <34.5	2	10 to <15	2	Principal	3	No	0	SFR to MFR (larger scale)	2
Low	1	5 to <10	1	11.5 to <23	1	5 to <10	1	Secondary	3	NA	NA	SFR to MFR smaller scale)	1
None	0	<5	0	<11.5	0	<5	0	Residential	0	NA	NA	No change	0

Pts. = points; Comm = commercial zoning; Instit = Institutional zoning; Ind = industrial zoning; SFR = single-family residential zoning; MFR = multifamily residential zoning; NA = not applicable.

Point categories evenly divided based on range of values for each category.

Table 7-5. Marine outfall scores and ranking

Rank	Marine outfall	Structural flooding risk	Impervious area increase	Percent increase in flow	Flooding nodes	Roadway classification	PURC list	Type of land conversion	Score
1	Laurel	3	3	3	2	3	0	2	16
2	Broadway Main branch	2	3	2	3	3	0	1	14
3	Broadway Eldridge branch	1	3	2	3	3	2		14
4	C Street	1	3	1	2	3	0	2	12
5	Arbutus	3	2	3	0	0	0	0	8
6	Ellsworth	1	1	0	0	3	2	1	8
7	Olive	1	2	3	0	0	0	0	6
8	Willow	1	2	3	0	0	0	0	6

7.5.2 Pavement and Utility Rating Committee Projects

The City's PURC uses condition assessments to identify conveyance lines in need of repair or replacement. The PURC pipe list is in part linked with the City's roadway improvement overlay program with the goal of improving subsurface utility conveyance lines (water, sanitary, and storm) ahead of plans to improve the roadway surface. Flood protection is another driver of replacing or renewing stormwater conveyance lines. The PURC list comprises pipe segments inspected by the City's video inspection program and marks the pipes as in "fair" or "poor" condition. For the 2020 SSWCP update, the following poor condition conveyance lines are included the CIP (see Chapter 8).

Valencia Street Conveyance

The Valencia Street Pipeline Repair project is a proposal to replace or repair approximately 1,600 lf of large-diameter storm pipe. A condition assessment report indicates that the pipe varies in diameter from 48 to 54 inches and notes that the bottom is rusted out in places. Because the pipe is located in the public ROW, there is concern of roadway damage if the structural integrity of the pipe were to fail. The pipe segment, constructed in 1984 along Valencia Street, currently conveys water from urban development and a portion of Fever Creek. Its repair will require temporary bypass of Upper Fever Creek to Lower Fever Creek for an approximate 2-week period. Pipe identifiers (IDs) were referenced to City GIS data and analyzed for recent improvements. A cost estimate was prepared for Valencia Street, which is further explained in Chapter 8, Capital Improvement Plan. The City is currently moving this project forward independent of this SSWCP.

North Garden Street

Along N Garden Street between E Pine Street and E Oak Street replace 500 lf of 12-inch-diameter pipe with 12-inch-diameter pipe.

Billy Frank Jr. Way

Between E Ellis Street and E Holly Street replace and enlarge 400 lf of 10-inch-diameter RCP with 12-inch-diameter RCP.

7.5.3 2007 CIP Conveyance

The goals and objectives of the 2007 Stormwater Comprehensive Plan include:

- Analysis of existing stormwater facilities and aquatic resources
- Identification of existing stormwater problems
- Analysis of alternative stormwater solutions
- Documentation of the stormwater plan for implementation by City staff
- Providing City staff a tool to address stormwater and pollutant control obligations, as required by local, state, and federal law

The 2007 Stormwater Comprehensive Plan was an update to the 1995 Watershed Master Plan developed for the City of Bellingham by HDR. The recommendations found in the 2007 document included the use of conveyance system sizing information for future study prior to design and construction. The study areas included portions of six watersheds that flow through the city of Bellingham: Whatcom Creek, Silver Beach Creek, Padden Creek, Chuckanut Creek, Squalicum Creek, and Silver Creek. The study areas within each watershed were selected because of known and/or suspected stormwater problems.

The stormwater drainage analysis was conducted using the SWMM module of the WWHM3 software. The conveyance systems were modeled using the SWMM module. A detailed description of the modeling analysis can be found in the 2007 report. SWMM's automatic pipe resizing routine was used to aid in developing appropriate pipe diameters to meet the required level of service.

The 2007 Stormwater Comprehensive Plan includes a list of pipe deficiencies in basins throughout the city along with associated pipe increase suggestions. The pipes in the 2007 deficiency list were then analyzed in GIS with pipes coded for replacement under the marine outfall conveyance improvements (described in Section 7.5.1 of this chapter). Pipe code numbers that overlapped under the 2007 pipe deficiency list were filtered from the 2007 list. A summary of the 2007 Stormwater Comprehensive Plan pipe list, pipe lengths, and sub-watersheds are shown Table 7-6.

Table 7-6. Summary of conveyance pipes needing improvements from 2007 Stormwater Comprehensive Plan

Sub-basin	Improvement project group	Pipe upgrade quantity (lf)
Whatcom Creek	Ellis Street 1	2,250
	Ellis Street 2	2,050
	King/Virginia/Lincoln	3,400
	Meador Avenue	200
	State Street	900
	Misc. Whatcom outfalls	250
Fever Creek	Kentucky Street	1,050
	Orleans/Nevada	1,600
	Valencia/North/Verona	3,500
	Misc. improvements	700
Cemetery Creek	(Insufficient conveyance system data)	
Hannah Creek	Lakeway Drive	800
	Raymond Street	200
Lincoln Creek	Lincoln Creek	1,050

7.6 Padden Creek Flow Augmentation Project

Several aquatic habitat restoration projects have been built in lower Padden Creek downstream of Lake Padden since the last SSWCP update. Stream flow data collected from the Fairhaven Park flow gage show that during most summer months, the stream runs dry, putting the success of the habitat projects at risk. The analysis reported in this section was requested to provide the City information and data about augmenting flows in Padden Creek. Its purpose was to provide information to support possible future plans. As a possible capital improvement project to mitigate this problem, an analysis to withdraw water from Lake Padden and augment stream flow to the creek was performed. The analysis evaluated the effects on lake levels from two water withdrawal rate proposals.

A water balance model was used to measure the effects on lake levels from a withdrawal rate of 1 cfs and 2 cfs for a few different augmentation periods. The following scenarios were analyzed:

1. Minimum withdraws (1 cfs in summer and fall)
2. Medium withdraws (2 cfs in summer and 1 cfs in the fall)
3. A maximum withdraw (2 cfs in summer and fall)

The results of the analysis showed that:

- Depths up to 0.7 foot in the habitat reach (where a previous daylighting project was installed) were obtained when 2 cfs were added.
- Augmenting stream flow by 2 cfs drops Lake Padden water levels by about 3 feet and produces channel depths of about 0.7 foot.
- Based on flow exceedance calculations, 2 cfs would be a significant flow augmentation rate that would have an impact of sustaining water in the lake (i.e., lake levels would reduce) and deemed by City staff to be unacceptable.
- Augmentation by 1 cfs drops Lake Padden by about 1 foot and produces channel depths of 0.6 foot in the receiving stream.

The findings show that the water level impacts may have effects for the management objectives of the lake, and thus the City should have additional discussion to guide next steps. The technical memorandum describing the water balance model is included in Appendix C, (C.7, Lake Padden Flow Augmentation Technical Memorandum).

7.7 Iowa Street Flooding

During staff interviews, persistent flooding along Iowa Street, just east of I-5, was identified as a problem to investigate. As of 2019, no formal analysis had been completed to identify the cause of the flooding. Because a basin-scale hydrologic analysis was beyond the scope of the SSWCP project, a desktop assessment was performed to investigate Iowa Street flooding and to consider if an end-of-pipe solution should be included in the CIP (e.g., tide gate).

During the staff interview, City personnel stated that about 3 feet of water had been observed in Iowa Street during a recent flooding event (date was unknown) and that Whatcom Creek was flowing during the event. It was speculated that backwater from Whatcom Creek may contribute to the flooding problem. The desktop assessment considered outflow data from Lake Whatcom dam and attribute data from CityIQ of stormwater assets in the surrounding area.

The rim elevation of the stormwater catch basin at the intersection of Iowa Street and Nevada Street is 59.61 feet (asset 8329NW-358), which puts the alleged flooding water surface elevation at about 62.6 feet. The invert elevation of the 60-inch-diameter outfall pipe to Whatcom Creek at Nevada Street is 50.95 feet, which means that if backwater from Whatcom Creek were causing the problem, the water surface in Whatcom Creek at the outfall would have to be at least elevation 60 feet or higher (e.g., 63 feet) to produce the observed flooding water surface elevation. Contour data from CityIQ show that ground elevations on the opposite bank of Whatcom Creek range from 55 feet to 60 feet, suggesting that the south side of Whatcom Creek would flood long before Iowa Street would flood (because Iowa Street is 3 feet higher in elevation).

The conclusions of the desktop assessment were that backwater from Whatcom Creek does not contribute to Iowa Street flooding and an end-of-pipe CIP solution is not warranted. During the course of the desktop assessment, the City completed construction of a large stormwater detention vault in the Iowa Street sub-basin along the south side of the public works facility in Virginia Street. The vault was sized to meet flow control requirements of the redeveloped public works site with extra volume being designed to provide downstream flood relief.

A full-scale hydrologic and hydraulic modeling analysis is recommended for identifying engineered solutions to the Iowa Street flooding. The modeling approach will need to establish a stage-discharge curve for the flow splitting on Fever Creek at Valencia Street to calculate the respective flow values split off into the Valencia Street bypass and how much stays in lower Fever Creek flowing toward Iowa Street. The hydraulic analysis will need to evaluate existing detention volume in the basin as well, like what was recently constructed by the City to capture the effect that facility has on the flooding problem.

Given that this analysis shows downstream tailwater is contributing to the problem, one possible consideration would be that the conveyance system is constrained by pipe size or as a result of pipe failures. Considering how developed the sub-basins draining to the flooding locations are and the size of the existing conveyance network, engineered solutions will likely be centered on providing more detention and volume-reducing bioretention facilities in the upper basin.

As part of the 2020 assessment, eight possible sites (parcels) were identified as locations where flow control facilities could be built. Table 7-7 presents a summary of these sites. Figure 7-9 shows the locations of the potential detention vaults.

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Table 7-7. Fever Creek basin analysis: potential detention sites

Solution #	Parcel #(s)	Total size (ac)	Landowner	Current Land Use	Basin	Drainage to parcel (ac)	Drainage Percentage of Total Fever Creek Basin	Acres impervious roads [b]	Acres impervious roofs [b]	Acres other impervious (driveways, walking paths, patios, etc.) [b]	Impervious total (percentage of drainage to parcel)
1 (vault)	380329329523 380329340519	2.03	Joan's Lane Properties LLC	Partially undeveloped field (land use code 91)	Lower Fever Creek	311	23.5	31 (10%)	40 (13%)	57 (18%)	41
2 (pond)	NA; ROW going south from (intersection of Iowa St. and Nevada St.)	0.98	City of Bellingham: Public Works	Existing LID stormwater BMP (rain garden)	Lower Fever Creek	614	46.3	67 (11%)	103 (17%)	148 (24%)	52%
3 (vault)	380320540078	0.23	Kathleen E. Briscoe	Managed undeveloped field adjacent to Fever Creek	Upper Fever Creek	526	39.7	48 (9%)	70 (13%)	34 (7%)	29
4 (vault)	380329474447	0.67 (additional adjacent parking lot)	Janna L. Palm	Maintained undeveloped field	Upper Fever Creek	706	53.3	69 (10%)	103 (15%)	52 (7%)	32
5 (vault)	380329400543	2.88	City of Bellingham: Finance Dept.	Grassy field within Roosevelt Park	Lower Fever Creek	286	21.6	30 (11%)	35 (12%)	51 (18%)	41
6 (vault)	NA; northern parking lot adjacent to parcel 380329146532	0.67	City of Bellingham: Finance Dept.	Parking lot along Carolina St.	Lower Fever Creek	166	12.5	22 (13%)	31 (19%)	24 (15%)	47
7 (vault)	380329208378	1.04	J&M's LLC	Pacific St. dead end/parking	Lower Fever Creek	480	36.2	50 (10%)	78 (16%)	109 (23%)	49
8 (vault)	NA; ROW between Undine St. and Verona St.	0.52	ROW	PSE transmission line ROW	Lower Fever Creek	243	18.3	25 (10%)	26 (11%)	41 (17%)	38

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8 Capital Improvement Plan

The 2021–2027 CIP will provide the City with funding to support a series of projects and programs that will help achieve the goals and objectives of the SSWU. The exercise to develop a funding level for a CIP is based on development of preferred projects; however, the actual list of projects implemented with CIP funding should be fluid to respond to other City initiatives and priorities that can influence the priority of the stormwater program. The projects listed should be considered for planning purposes only, and should not be construed as a final approved list for design and construction.

The following projects and programs will improve water quality, remove barriers to fish migration, and rehabilitate or replace aged infrastructure. They are the result of the stormwater system analysis described in Chapter 7 and were factored into the SSWU rate study described in Chapter 10. Figure 8-1 is a citywide map showing the locations of the proposed CIP projects.

The CIP comprises projects and programs. CIP projects are discrete, one-time capital improvements that, once completed, are removed from the CIP. By contrast, CIP programs receive annual funding to support projects that are similar in nature and are bundled into a continuous CIP program. The 2021–2027 CIP includes a program for addressing deficiencies, be it capacity or condition, in the stormwater conveyance pipelines. It is anticipated that CIP programs will continue well into the future.

The 2021–2027 CIP is divided into water quality improvement projects (including flow control projects), fish passage improvement projects, and infrastructure renewal projects. CIP project exhibits are included in Appendix D. The exhibits include project descriptions, cost, location maps, and an overall summary of each CIP project.

The following sections describe the CIP projects and programs and the methods used to prioritize them.

8.1 Water Quality Improvement Projects

The following water quality facilities are proposed:

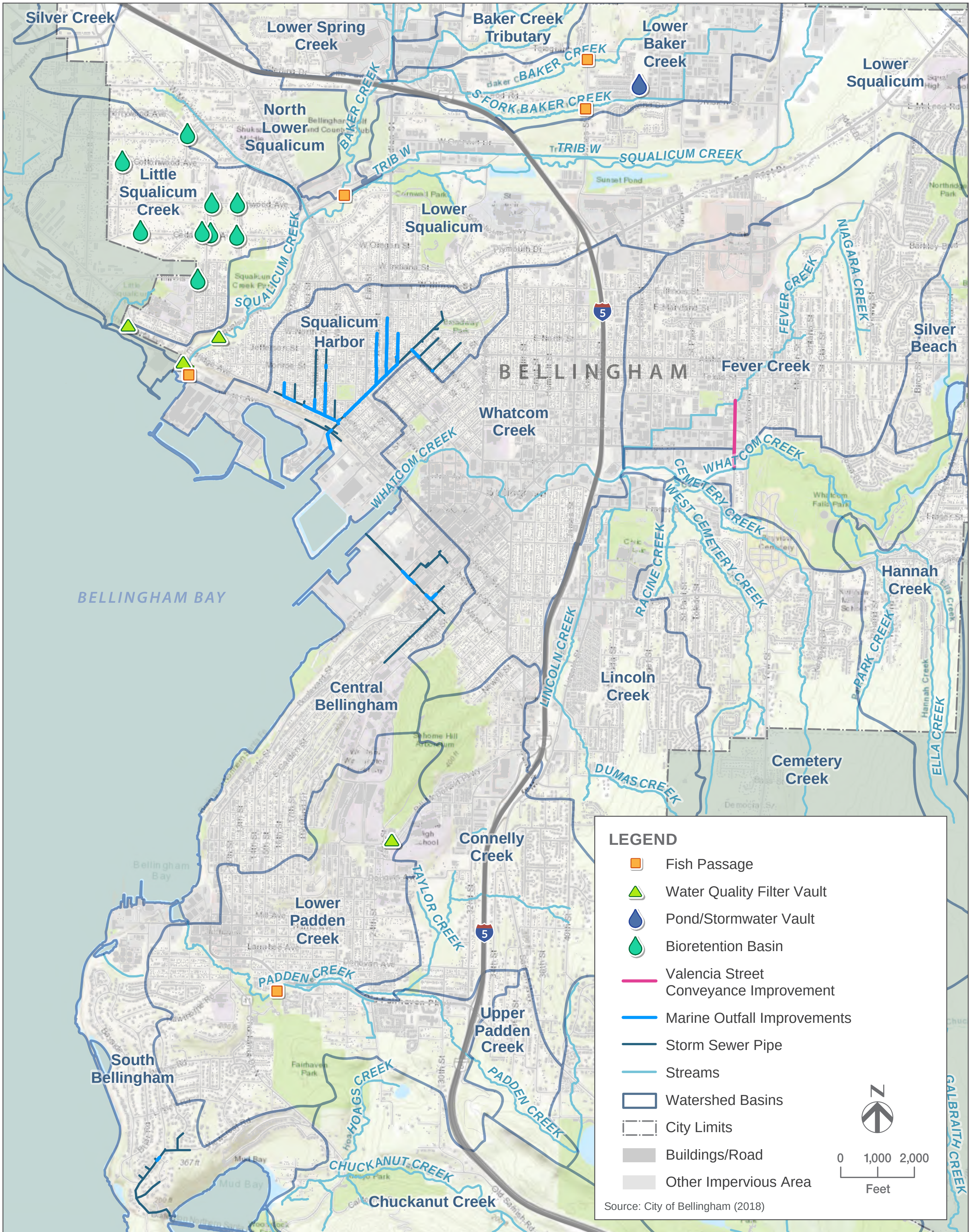
- Two filtration vaults along Squalicum Way in Lower Squalicum Creek
- One bioretention facility along Bill McDonald Parkway in Lower Padden Creek
- A regional water quality treatment facility in the Lower Baker Creek Tributary that detains and treats stormwater runoff from a drainage basin with industrial facilities
- A series of bioretention facilities proposed in the Birchwood neighborhood in Little Squalicum Creek

The City is also implementing water quality improvements in the Lake Whatcom drainage area, funded through the 30 percent of the Lake Whatcom Reservoir Property Acquisition Program revenue that is allowed to be used for stormwater projects within the Lake Whatcom watershed. This report does not include those projects, but they are considered a vital part of the City's overall strategy for stormwater management.

This SSWCP does not contain a Lake Whatcom water quality section because Lake Whatcom has its own set of regulations (TMDLs) that are tied to the City's and Whatcom County's Phase II Permits. The Phase II Permit is renewed every 5 years on a cycle that does not align with the 6-year capital improvement program presented in the Lake Whatcom plan. Additionally, Lake Whatcom represents its own body of work and study and is documented in other materials. Lake Whatcom is managed through the Lake Whatcom Cooperative Management Program, which was established by an Interlocal Agreement in 1998 between the City of Bellingham, Whatcom County, and the Lake Whatcom Water and Sewer District (formerly Water District 10). The goal of the program is to jointly manage and implement programs affecting the Lake Whatcom watershed and to coordinate programs and projects that restore, protect, and preserve Lake Whatcom and its surrounding watershed. An important outcome from the work of the Lake Whatcom Cooperative Management Program is the Lake Whatcom Work Plan. The Lake Whatcom Work Plan, which outlines planned work in the 5-year horizon including stormwater projects, was developed jointly by Whatcom County, the Lake Whatcom Water and Sewer District, and the City of Bellingham. The Lake Whatcom 2020–2024 Work Plan has been approved by each of the three respective jurisdictions. The Lake Whatcom Water and Sewer District approved the plan at its June 10, 2020, Board of Commissioners meeting. The Whatcom County Council approved the plan at its July 7, 2020, council meeting. The Bellingham City Council approved the plan at its July 20, 2020, council meeting.

The adoption and use of the SSWCP is not intended to replace or supersede the comprehensive planning, timeline, and management decisions of the Lake Whatcom Cooperative Management Program, the Lake Whatcom Work Plan, or the approvals of the respective jurisdictions.

A summary of the proposed water quality facilities is shown in Table 8-1. Project costs reported are assumed to include design, permitting, and construction allowances.



BELLINGHAM CIP LOCATIONS

FIGURE 8-1

City of Bellingham

Surface and Stormwater Comprehensive Plan

UPDATED 8/20/2020

Table 8-1. Proposed water quality CIP projects

Project ID	Facility type	Description	Cost (2020 dollars)
D-01	Media-filtration treatment vault	Proprietary facility installed in Squalicum Way connected to asset V0076-CB09. Discharges treated runoff via creek outfall. Treats 1,000 lf of roadway.	$288,000
D-02	Media-filtration treatment vault	Proprietary facility installed in Squalicum Way near intersection of Roeder Ave. Flow splitter catch basin installed in existing drainage line, routes water quality design flow to proprietary facility. Treated water is returned to existing drainage system (asset V0076-CB13). Treats 800 lf of roadway.	$249,000
D-03	Bioretention facility	A bioretention facility located in planter strip receives runoff from Bill McDonald Pkwy., treats and infiltrates runoff. An overflow structure designed to capture excess runoff not able to infiltrate, is connected to the existing drainage line (asset 7306NW-59).	$97,000
D-04	Regional treatment facility	End-of-pipe, regional facility in Baker Creek tributary sub-basin will include detention pond, oil/water separator, and bioretention filtration to treat stormwater runoff. Requires property acquisition.	$3,700,000
D-05	Bioretention	ROW facility installed near intersection of W Illinois St. and Nome St.	$290,000
D-06	Bioretention	ROW facility installed near intersection of Cedarwood Ave. and Pinewood Ave.	$144,000
D-07	Bioretention	Vertical walls required because of limited space. Located at Cedarwood Ave. and Firwood Ave.	$48,000
D-08	Bioretention	Birchwood Ave. and Firwood Ave.	$108,000
D-09	Bioretention	Cherrywood, north of Cottonwood Ave.	$111,000
D-10	Bioretention	3200 block of Laurelwood Ave.	$340,000
D-11	Bioretention	3100 block of Cedarwood Ave.	$288,000

The following sections describe the water quality treatment facilities in more detail.

8.1.1 Filtration Vaults

Two filtration vaults are proposed along Squalicum Way. The filtration vaults are multistage media filtration systems (e.g., Modular Wetlands or Filterra units) to be installed in existing below-grade drainage systems. With a relatively small footprint, filtration vaults work well in existing roadway drainage systems collecting and treating roadway runoff prior to discharge into receiving waters.

Project D-01 treats about 1,000 lf of Squalicum Way collecting stormwater runoff from the driveway entrance to Squalicum Creek Park southwest to the storm drainage outfall to Squalicum Creek (the nearest drainage asset is V0076-CB09). The proposed design intercepts the water quality design flow from the existing conveyance line, routes it through the filter media for treatment, and then discharges the treated flow via a new connection from the filtration vault to the existing outfall pipe to the creek. Only the water quality design flows would be discharged at this outfall. Flows in excess of the water quality design flow would bypass the filtration vault and flow in the existing conveyance line to the next downstream outfall located near Roeder Avenue (see Exhibit D-01).

CIP D-02 treats stormwater runoff originating on Squalicum Way from a point immediately downstream of the D-01 treatment vault to the proposed vault location at the intersection of Squalicum Way and Roeder Avenue. Similar to CIP D-01, the treatment vault splits the water quality design flow off the main line, and routes it through the treatment facility where runoff is filtered and then discharged to the creek (see Exhibit D-02).

8.1.2 Baker Creek Regional Facility

The Baker Creek regional facility is an end-of-pipe water quality treatment and flow control facility collecting and treating stormwater from a 160-acre sub-basin. Stormwater runoff is treated by a series of water quality BMPs that reduce the load of pollutants of concern typical of an industrial drainage basin. The treatment-train design is premised on purchasing undeveloped land adjacent to and north of City-owned property where a detention pond would be sited. The proposed detention pond also serves as a pre-settling facility to remove large sediment particles and lower TSS prior to runoff being routed to and treated by the water quality BMPs. The water quality facility comprises two components: an oil/water separator that removes hydrocarbons and oil residue from the runoff followed by an open-air filtration unit that uses a bioretention soil mix and plants to remove metals from the runoff. From there, the treated stormwater is discharged to Baker Creek.

This regional facility provides water quality treatment and flow control to an area where no stormwater treatment facilities exist, and where a group of properties did not meet the threshold for flow control. The facility will capture runoff from an industrial sub-basin and provide downstream benefits by reducing flood risk, improving water quality in Baker Creek and thereby improved aquatic habitat (see Exhibit D-04).

8.1.3 Bioretention Facilities

Several bioretention facilities are proposed for the Birchwood neighborhood in north Bellingham. This residential neighborhood is situated on moderately well-draining loamy soils (172: Urban land-Whatcom-Labounty complex and 82: Kickerville-Urban land complex, see Appendix E (E.1 Birchwood NRCS soils map) and was built prior to stormwater regulations requiring water quality treatment. It is part of the Little Squalicum Creek sub-watershed.

City staff identified the area as a potential for siting bioretention facilities and provided HDR with 10 proposed locations. Each location was screened for viability using desktop techniques that identified conflicts, such as mature trees, driveways, and parking, that render some sites less effective. Seven facilities are proposed in the CIP (D-05 through D-11). Three sites were not included. See Exhibit D-05 for a typical detail for the bioretention facilities in the Birchwood area.

Unit-price cost estimates per square footage for walled and side-sloped bioretention facilities were developed based on seven potential sites identified throughout the city. The determination of site receiving a walled or side-sloped facility was a function of available width given the nearby constraints. The seven sites were representative of types of sites where bioretention facilities could be built. The cost estimates assume connections to existing storm drainage infrastructure and avoid relocating conflicting utilities. Further, the estimates presume that property acquisition is not required. This metric was then applied to facilities shown in Figure 8-2.

CIP D-03 is a proposed bioretention facility located in the Padden Creek sub-watershed. It treats about 1,000 lf of Bill McDonald Parkway east of 25th Street with a bioretention facility. The proposed online bioretention facility replaces about 125 lf of existing storm drain pipe that will capture and infiltrate runoff. The native soils are mapped by the Natural Resources Conservation Service (NRCS) as Squalicum-Urban land complex described as moderately well-draining gravelly-loamy soils, see Appendix E (E.2 Bill McDonald site NRCS soils map). The online facility infiltrates stormwater runoff to the maximum extent allowed by the native soils. When native soils reach saturation and the facility reaches maximum depth, an overflow structure provides a hydraulic connection to the existing downstream drainage network to provide drainage relief for when the facility is at capacity.

This project provides overall runoff volume reduction to the sub-watershed (see Exhibit D-03).

8.2 Infrastructure Renewal and Replacement

As documented in Chapter 2, the City has more than 280 miles of storm drain pipe to maintain. The City's infrastructure renewal and replacement program targets conveyance pipes in need of replacement because they are either undersized or in poor condition. In the 2020 SSWCP update, the following three sources were used to identify pipe segments to be included in the CIP:

- The 2007 Stormwater Comprehensive Plan update where several capacity-constrained pipe segments were identified by the modeling effort from that plan
- The City's PURC list of pipes identified as conveyance pipes in "poor" condition (the PURC-identified pipes are the product of the City's ongoing, video-based condition assessment program)
- The 2020 marine mainline conveyance hydraulic analysis

Capacity-deficient pipe segments identified in the marine line hydraulic analysis for the Broadway and C Street basins are also coincidentally listed on the PURC list.

HDR

UPDATED 8/20/2020

BIRCHWOOD NEIGHBORHOOD RETENTION SITES

FIGURE 8-2

City of Bellingham

Surface and Stormwater Comprehensive Plan

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The following sections list proposed CIP projects that will replace storm drainage conveyance pipe segments identified in the 2007 Stormwater Comprehensive Plan, the PURC program, and the marine conveyance modeling.

8.2.1 2007 Conveyance Upgrade Pipes

The 2007 Stormwater Comprehensive Plan analyzed conveyance system pipes in the Whatcom, Fever, Cemetery, Hannah, and Lincoln creek basins to identify pipe segments that were capacity constrained. The 2020 CIP proposes an ongoing CIP program (D-27) that will have funds necessary to address the recommendations of the 2007 Stormwater Comprehensive Plan to make improvements to the identified pipes. Table 8-2 shows the pipe segments recommended for renewal and/or replacement, their 2007 cost estimates, and 2020 escalated cost estimates. Details of the cost escalation calculations are included in Appendix F.

Table 8-2. CIP D-27: Program to improve capacity in pipes identified in the 2007 Stormwater Comprehensive Plan

Sub-basin	Improvement project group	Pipe upgrade quantity (lf)	2007 cost opinion [a] (× 1,000)	Construction index [b] %	2019/2020 cost of opinion (× 1,000)
Whatcom	Ellis St. #1	2,250	$1,858	150	$2,787
	Ellis St. #2	2,050	$1,176	150	$1,764
	King/Virginia/Lincoln	3,400	$2,032	150	$3,048
	Meador Ave.	200	$129	150	$194
	State St.	900	$398	150	$597
	Miscellaneous Whatcom outfalls	250	$176	150	$264
Fever	Kentucky St.	1,050	$1,373	150	$2,060
	Orleans/Nevada	1,600	$925	150	$1,388
	Valencia/North/ Verona	3,500	$3,330	150	$4,995
	Miscellaneous improvements	700	$480	150	$720
Cemetery	Insufficient data in 2007 for the analysis				
Hannah		800	$486	150	$729
		200	$185	150	$278
Lincoln		1,050	$813	150	$1,220

a. Cost from 2007 Stormwater Comprehensive Plan (City 2007), p. 92. https://www.cob.org/documents/pw/storm/2007-stormwater-comp-plan.pdf

b. Mortenson construction inflation index, average annual rate of change: 3.14%.

8.2.2 PURC Program

The PURC list of conveyance pipe upgrades is described below. These proposed CIP projects list pipe segments identified as being in poor condition. The PURC infrastructure improvement projects are listed in Table 8-3.

Table 8-3. PURC list of conveyance projects

Project ID	Description	2019/2020 cost estimate
D-24 North Garden Way E. Pine St. to E Oak St.	Replace 500 lf of 12" pipe with 12" pipe	$300,000
D-25 Billy Frank Jr. E. Holly St. to Ellis St.	Replace and enlarge 400 lf of 10" concrete pipe with 12" concrete pipe	$200,000
D 26 Valencia St. Outfall to Whatcom Creek to Fever Creek crossing	Cure in-place 1,600 lf of CMP pipe	$1,028,000

lf = linear feet.
CMP = corrugated metal pipe.

North Garden Street

The North Garden Street conveyance improvement project (D-24) replaces approximately 400 lf of 10-inch-diameter concrete pipe with 12-inch-diameter concrete pipe. The proposed CIP project assumes that existing manhole structures on either end will remain intact. Traffic control, underground utility coordination, and business outreach will be required. See Exhibit D-24 in Appendix D for project details.

Billy Frank Jr. Street

The Billy Frank Jr. Street conveyance improvement project (D-25) replaces approximate 400 lf of 10-inch-diameter concrete pipe with 12-inch-diameter concrete pipe. The proposed CIP project assumes that existing manhole structures on either end will remain intact. Traffic control and utility coordination will be required. Public outreach to nearby business is also advised. See Exhibit D-25 in Appendix D for project details.

Valencia Street

The Valencia Street conveyance improvement project (D-26) replaces approximately 1,600 lf of 42- to 54-inch-diameter CMP between the Whatcom Creek outfall north to where Fever Creek intersects with Valencia Street. The condition assessment program identified sections that have rusted out and there is concern of pipe failure.

The conveyance line doubles as a high-flow bypass pipe conveying high flows from Fever Creek directly to Whatcom Creek. In a 2013 Joint Aquatic Resources Permit Application (JARPA), project implementation plans call for fish exclusion and water quality testing prior to and during construction see Appendix E (E.3 Valencia Street JARPA). In negotiations with WDFW, the City has agreed to provide wetland mitigation in the upper Fever Creek sub-watershed.

The proposed CIP looked at the following two options for replacing five pipe segments and five manholes:

1. **Lining:** Improvements include installation of cured-in-place pipe lining, testing, and preservation of existing manholes.
2. **Replacement:** Improvements include replacement of five segments of pipes and five associated manholes.

Option 1 is proposed for the CIP project because it is more cost-effective and less disruptive to surrounding businesses. See Exhibit D-26 in Appendix D for project details. The City is currently proceeding into preliminary design on this project.

8.2.3 Marine Conveyance

The marine outfall capacity analysis resulted in the identification of capacity-constrained pipe segments in seven of the nine basins analyzed. Consideration was given to the age of the infrastructure as well as pipe material in understanding system performance risk. The Bennett Street and Cedar Street outfall lines were determined to have sufficient capacity; consequently, no CIP projects were identified in those two basins. For the remaining basins, each has capacity-constrained pipes when analyzed for future-conditions flows. Proposed pipe materials and size vary by circumstance. If flooding can be resolved by using a pipe with the same diameter, but with material that has a lower friction factor (e.g., smooth-bore PVC pipe as opposed to concrete pipe), then that arrangement was given priority. If the proposed improvement was for pipe diameters greater than 18 inches, the proposed improvement uses a pipe with a smooth roughness for sizing such as reinforced concrete pipe (RCP). If the proposed improvement has shallow cover, then DIP is proposed. CIP projects for the respective basins are proposed and are summarized in Table 8-4. As these projects advance into preliminary design, the scope of the improvements should be refined to take into account constraints with the proposed system routes (both horizontally and vertically), as surface and subsurface features (e.g., other utilities) may alter the stated improvement. Consideration at that time should consider the merits of sliplining or pipe-bursting over traditional cut-and-cover projects. For the purposes of budgeting, the more conservative approach was shown.

Table 8-4. Marine outfall conveyance projects

CIP ID	Outfall name	Project location	Project description (to eliminate flooding)	Pipe upgrade quantity (lf)	2019/2020 cost [a]
D-17	Arbutus	Fieldston Rd.	Replace 12" CMP with 12" PVC	114	$66,000
D-18	Willow	Bayside Rd.	Replace 18" CMP with 18" PVC	1,024	$565,000
D-20	Laurel	Laurel St. (State St. to Cornwall Ave.)	Increase 30" RCP to 36" RCP	290	$720,000
		Laurel St. (Forest St. to State St.)	Increase 12" RCP to 18" RCP	139	

CIP ID	Outfall name	Project location	Project description (to eliminate flooding)	Pipe upgrade quantity (lf)	2019/2020 cost [a]
		Forest St. (Maple St. to Laurel St.)	Increase 12" PVC to 15" PVC	218	
		East Maple St. to Laurel trunkline	Replace 15" CMP with 15" RCP	515	
D-21	C St.	Astor St. (C St. to D St.)	Increase 15" RCP to 18" RCP and DIP	239	$700,000
		Astor St. (D St. to E St.)	Increase 15" RCP to 18" DIP	253	
		Astor St. (E St. to F St.)	Increase 12" RCP to 15" RCP	261	
		Astor St. (F St. to G St.)	Increase 12" RCP to 15" RCP	222	
		Roeder Avenue N (C St. to D St.)	Increase 18" RCP to 24" RCP	199	
		Roeder Avenue (N) (F St. to G St.)	Increase 12" and 15" RCP to 18" RCP or DIP	247	
D-22	Ellsworth	Girard St. (C St. to D St.)	Increase 15" RCP to 24" RCP	194	$790,000
		Girard St. (F St. to G St.)	Increase 15" RCP to 18" RCP	258	
		Ellsworth St. (D St. to F St.)	Increase 15" RCP to 18" RCP	479	
		Ellsworth St. (F St. to G St.)	Increase pipe size from 12" and 18" RCP to 15" and 24" RCP	578	
D-23	Broadway (Main branch)	Kulshan St. (Broadway to W North Ave.)	Increase 12" and 15" RCP to 24" RCP	1,400	$4.7M
		Peabody St. (Broadway to W North Ave.)	Increase 12" and 15" RCP to 24" RCP	648	
		Meridian St. (Broadway to W Connecticut St.)	Arterial street; increase 12" RCP to 24" and 30" RCP and DIP	1,300	
		Broadway St. (Roeder Ave. to Peabody St.)	Arterial street; increase 30" and 36" RCP to 48" RCP and DIP	2,000	
		Bellwether Way	Increase 36" RCP to 48" RCP	500	

CIP ID	Outfall name	Project location	Project description (to eliminate flooding)	Pipe upgrade quantity (lf)	2019/2020 cost [a]
D-19	Broadway (Eldridge branch)	Williams St. (Jefferson St. to Madison St.)	Increase 12" VIT to 18" RCP	300	$1.9M
		Utter St. (Jefferson St. to Eldridge Ave.)	Increase 8" and 12" RCP to 18" RCP	960	
		Eldridge Ave. (Walnut St. to Victor St.)	Increase 24" RCP to 36" RCP	900	
		Eldridge Ave. (Victor St. to Jaeger St.)	Increase 12" and 18" RCP to 24" RCP	860	
		Eldridge Ave. (Walnut St. to Broadway)	Increase 36" RCP to 42" RCP	60	

a. Detailed cost estimates provided in Appendix F.1.

RCP = reinforced concrete pipe.

CMP = corrugated metal pipe.

PVC = polyvinyl chloride.

DIP = ductile iron pipe.

VIT = vitrified clay pipe.

As is evident in Table 8-4, several alignments in the downtown basins (Broadway-Main, Broadway-Eldridge, C Street, Ellsworth, and Laurel) could on their own be separated into individual CIP projects. For example, in the Broadway-Main basin, the magnitude of the proposed project to replace the main conveyance line from the outfall to Peabody Street (a distance of more than 2,000 lf) is a major undertaking considering the disruptions to traffic, businesses, the size of the proposed pipe, utility conflicts, and other inherent constraints of a capacity improvement project in an urban corridor. If the City chooses to break out the respective alignment improvements into smaller CIP projects for design and bid purposes, the cost estimates prepared for the respective marine outfall alignment, see Appendix F (F.2) improvements can be easily proportioned into the respective sub-projects. Alternatively, cost estimates for the smaller sub-projects could be assessed on a dollars per linear foot ($/lf) unit cost. For purposes of providing CIP costs for the rate study, the aggregate costs were used.

8.3 Fish Passage Projects

The City provided HDR a ranked list of culverts to be included in the 2020 CIP (see Appendix F.3). The list is the product of the 2019 City of Bellingham Fish Barrier Prioritization Update (City 2019). Details for how each culvert was assessed are included in this update. HDR did not reevaluate the culvert rankings for the purposes of preparing the 2020 CIP.

From the list, the top five prioritized culverts are included in the 2020 CIP with associated cost estimates based on City 2019 estimated values. These estimates are for planning purposes only and are not based on an engineer's cost estimate. The locations of the top five culverts are shown in Figure 8-1 above. Project exhibits are included in Appendix D. Table 8-5 lists the top five culverts, their locations, and cost.

Table 8-5. Fish passage culvert projects

CIP ID	Project Title	WDFW Site ID	2019 Cost Estimate
D-12	Squalicum Creek/Baker Creek Confluence	602273	$200,000
D-13	SF Baker Creek/James St.	993881	$1,000,000
D-14	Baker Creek/ James St.	993006	$1,000,000
D-15	Padden Creek/Old Fairhaven Pkwy.16th Street ROW	01.06220.80	$1,000,000
D-16	Squalicum Creek/ Roeder Ave.	991104	$4,000,000

8.3.1 Baker Creek at Squalicum Creek Confluence (D-12)

The fish passage barrier at this location is not the actual culvert; it is the bed-control weir downstream of the culvert that creates the blockage. In the Prioritization Report, the culvert on Baker Creek (culvert B1) is not identified as a barrier (City 2010). The existing site consists of a concrete 29-by-2-foot bed control weir with an embedded timber flashboard riser. To increase fish passage the weir will likely need to be removed and replaced with a roughened channel (WDFW 2020) by placement of large rock and woody debris. This will help to overcome the jump height barrier and maintain hydraulic backwater conditions downstream of the proposed culvert. The proposed improvement will must meet compliance with WDFW standards for slope ratio, floodplain utilization, and bankfull width.

8.3.2 South Fork Baker Creek at James Street (D-13)

The existing site features an 8-inch-diameter concrete culvert. WDFW has indicated that the culvert is undersized. The culvert is identified as South Fork Baker 2 in the Prioritization Report (City 2010). The barrier is identified as a velocity barrier. The proposed improvement will must meet compliance with WDFW standards for slope ratio, floodplain utilization, and bankfull width. Combining this project with D-14 could produce economy-of-scale savings because the projects are both located on James Street. The culverts are about 1,200 feet apart.

8.3.3 Baker Creek at James Street (D-14)

The existing site features an unconfirmed 18-inch-diameter (or possibly a 24-inch-diameter) concrete culvert and is identified as Baker 7 in the Prioritization Report (City 2010). WDFW has indicated a large scour pool at the downstream end of the culvert and note that the culvert may proposes a velocity barrier for fish passage. Proposed improvements will must meet compliance with WDFW standards for slope ratio, floodplain utilization, and bankfull width.

8.3.4 Padden Creek at Old Fairhaven Parkway (D-15)

The existing site features a four-step concrete pool and fishway chute with rock control steps, creating a steep gradient between the mouth of the culvert and the stream channel. The unconfirmed pipe sizes are an 18-inch-diameter concrete culvert with two high flow, 9-inch-diamater concrete culverts on either side of the main culvert. The culvert is identified as Padden 7 in the Prioritization Report (City 2010) and the above-crossing is the former Old Fairhaven Parkway road converted to a gravel path. WDFW has indicated that the culvert proposes a velocity barrier for fish passage. The proposed improvement will meet compliance with WDFW standards for slope ratio, floodplain utilization, and bankfull width.

8.3.5 Squalicum Creek at Roeder Avenue (D-16)

The Squalicum Creek crossing at Roeder Avenue is not identified as a fish passage barrier in the Prioritization Report (City 2010); however, it is included in the City's top-five list because of coordination opportunities with a larger habitat/estuary restoration project at that location.

8.4 CIP Prioritization

The 2020 CIP is arranged into six planning-level prioritization categories in collaboration with City staff, reflecting the City's policies, standards, and service level goals. Each CIP project and/or program was arranged by the prioritization criteria shown in Table 8-6. In summary, most of the proposed CIP projects meet at least three of the prioritization criteria. Exceptions are noted for the PURC conveyance improvement projects and the CIP program (D-27) that will address conveyance issues identified in the 2007 Stormwater Comprehensive Plan. Conveyance improvements projects and/or programs are credited for improving drainage and neighborhoods aesthetics plus asset renewal. Weighting of the six categories was deemed not necessary for the purpose of this planning-level prioritization.

The water quality treatment projects meet objectives to treat stormwater runoff and thereby improve aquatic resources in receiving waters. Additionally, given that the bioretention facilities are located in neighborhoods, they have potential to enhance neighborhood aesthetics, but would not necessarily stimulate economic development.

The fish passage improvement projects meet regulatory requirements to remove barriers to fish passage while also improving access to habitat. Many of the culvert replacement projects also qualify for renewing assets to manage risk.

Many of the infrastructure renewal projects address three or more prioritization criteria. The marine conveyance line improvements meet the standard for improving compliance because the projects bring the City's conveyance lines up to the City's engineering design standard. When these lines are enlarged, it is likely to stimulate redevelopment in the business areas because the enlarged conveyance lines will meet Ecology's standards to exempt property owners from providing flow control because the conveyance lines directly discharge to the flow control exempt water body of Bellingham Bay. This exemption would reduce the cost for redeveloping properties. Redevelopment sites would not need to provide flow control because of downstream pipe capacity limitations, but they would have to treat runoff, which over time provides an improvement to water quality in Bellingham Bay.

Table 8-6. CIP prioritization criteria

CIP	Maintain or improve compliance	Stimulate economic development	Improve water quality	Neighborhood investment	Protect or improve aquatic resources	Renew assets to manage risk
Water quality projects (filtration vaults, bioretention, Baker Creek regional)						
D-01 Squalicum Way Filtration Vault			✓		✓	✓
D-02 Roeder Ave. Filtration Vault			✓		✓	✓
D-03 Bill McDonald Pkwy. Bioretention			✓	✓	✓	
D-04 Baker Creek WQ Facility			✓	✓	✓	
D-05 Birchwood 1			✓	✓	✓	
D-06 Birchwood 2			✓	✓	✓	
D-07 Birchwood 3			✓	✓	✓	
D-08 Birchwood 5			✓	✓	✓	
D-09 Birchwood 8			✓	✓	✓	
D-10 Birchwood 9			✓	✓	✓	
D-11 Birchwood 10			✓	✓	✓	
Fish passage improvement projects						
D-12 Squalicum Creek Baker Creek	✓				✓	✓
D-13 SF Baker Creek at James St.	✓				✓	✓
D-14 Baker Creek at James St.	✓				✓	✓

CIP	Maintain or improve compliance	Stimulate economic development	Improve water quality	Neighborhood investment	Protect or improve aquatic resources	Renew assets to manage risk
D-15 Padden Creek at 16th St.	✓				✓	✓
D-16 Squalicum Creek at Roeder Ave.		✓				
Marine outfall conveyance projects						
D-17 Arbutus Alt. 2	✓	✓	✓			✓
D-18 Willow Alt. 2	✓	✓	✓			✓
D-19 Olive	✓	✓	✓			✓
D-20 Laurel Alt. 1	✓	✓	✓			✓
D-21 C St.	✓	✓	✓			✓
D-22 Ellsworth	✓	✓	✓			✓
D-23 Broadway	✓	✓	✓	✓		✓
PURC projects						
D-24 N Graham Way				✓		✓
D-25 Billy Frank Jr.				✓		✓
D-26 Valencia St.				✓		✓
2007 conveyance improvement program						
D-27 Various Locations				✓		✓

8.4.1 Marine Outfall Conveyance Prioritization

In Chapter 7, Stormwater System Analysis, the analysis of nine separate shoreline outfall pipes, draining directly to Bellingham Bay, is described (please note that the Broadway outfall pipe has two separate conveyance lines analyzed as separate basins). Except for two outfall conveyance lines, hydraulic modeling identified pipe segments in the other outfall conveyances that need upgrades to meet the City's future land use conditions, 25-year flow rate conveyance standard. The Cedar Street and Bennett Street outfalls do not show flooding and were dropped from consideration in the 2020 CIP. Of the remaining outfall conveyance lines analyzed, where flooding was predicted, a prioritization analysis also described in Chapter 7 resulted in the following basin priorities listed from highest priority to lowest:

1. Laurel outfall basin
2. Broadway outfall, the main pipeline branch in Broadway
3. Broadway outfall, the Eldridge Avenue pipeline branch
4. C Street outfall basin
5. Arbutus outfall
6. Ellis Street outfall basin
7. Olive Street outfall basin
8. Willow Street outfall basin

The priorities factor into the four CIP cost scenarios described in Section 8.5.

8.5 CIP Funding Scenarios

The 2020 CIP projects list was divided into four cost scenarios for use in the utility rate study analysis. The rate study evaluation (Chapter 10) analyzes rates using CIP cost categories of high cost, medium cost, and low cost to determine the respective rate increases needed to implement the three CIP scenarios within the 6-year planning horizon. A fourth category, No Rate Increase, determined how much of the proposed CIP could be implemented without increasing utility rates. The strategy in creating the different funding scenarios was built on maintaining a diverse set of project types and treatment strategies recognizing that focusing on one treatment or improvement method would lower the overall program benefit in achieving system-wide and community-wide water quality/quantity and habitat enhancement. The strategy also looks to address those projects in most need/highest benefit, regardless of location. Finally, this strategy preserves the momentum achieved in all of the City's areas of focus from renewal, to replacement, to flow control, to water quality, to habitat enhancement/protection.

The high cost scenario CIP funds all listed projects. The medium and low cost scenarios fund projects from each CIP category (Water Quality Improvement, Fish Passage, and Infrastructure Renewal) to varying degrees. Because the City Council is committed to giving fish passage improvement projects preference, the medium- and low-cost scenarios each have a majority of those projects included. The following sections list the various CIP projects and programs by cost scenario.

All scenarios include $1 million in funding from the City's property acquisition fund to go toward improvements in the Lake Whatcom area.

8.5.1 Large-CIP Funding Scenario

The Large-CIP funding scenario funds all listed projects and assumes the Engineering Group responsible for implementing the CIP with additional FTE positions (see Chapter 9, Recommended Stormwater Management Program and Implementation for details) needed to implement 27 CIP projects/programs. The sum total of all the CIP projects is $45.3 million (2019 dollars).

8.5.2 Medium-CIP Funding Scenario

The Medium-CIP funding scenario is based on projects that meet at least three prioritization category standards and represent the highest-performing projects in certain categories. Therefore, the funding level is equivalent to all filtration vaults, the Baker Creek water quality facility, the top four prioritized bioretention facilities (representing 50 percent of the total bioretention basins), the top three (out of five) fish passage improvement projects, the top three (out of eight) marine conveyance basins, an annual fund of $1 million (or $6 million total) for making upgrades to conveyance pipes identified in the 2007 Stormwater Comprehensive Plan, and all of the PURC projects. This scenario also assumes new FTEs (see Chapter 9, Recommended Stormwater Management Program and Implementation, for details). The sum total of the medium-CIP scenario projects is $23.5 million (2019 dollars).

8.5.3 Small-CIP Funding Scenario

The Small-CIP funding scenario includes all of the filtration vaults, the top four prioritized bioretention facilities, the top two fish passage projects, the top two marine outfall basin priorities (Laurel and Broadway Main), an annual fund of $1 million (or $6 million total) for making upgrades to conveyance pipes identified in the 2007 Stormwater Comprehensive Plan, and all of the PURC projects. No new FTEs are assumed. The sum total of the Small-CIP scenario projects is $13.5 million (2019 dollars).

8.5.4 Baseline Scenario

If utility rates are held steady at 2019 levels, annual increases are based on the Seattle-Tacoma consumer price index, and system development charges (SDCs) are adjusted (increased) as part of this analysis, then about $6 million will be available to implement the CIP provided. In this cost scenario, funding would be available for the equivalent of these following projects: the filtration vaults, the top three bioretention facilities, the top two fish passage projects, the highest-priority marine outfall system (Laurel Street outfall system), an annual fund of $250,000 (or $1.5 million total) for making upgrades to conveyance pipes identified in the 2007 Stormwater Comprehensive Plan, and all of the PURC projects.

Each cost scenario includes the top-tier projects from the CIP categories (Water Quality, Fish Passage, and Infrastructure Renewal).

Table 8-7 presents a summary of CIP costs for each scenario. A detailed representation of how these funding levels were developed can be found in Appendix D.

Table 8-7. CIP scenarios and associated costs

	Large CIP	Medium CIP	Small CIP	No Rate Increase CIP
Water quality improvement projects				
Filtration vaults	$537,000	$537,000	$537,000	$537,000
Baker Creek	$3,700,000	$3,700,000		
Bioretention	$1,500,000	$762,000	$762,000	$762,000
	$5,737,000	$4,999,000	$1,299,000	$1,299,000
Fish passage projects				
Top 5 projects	$7,200,000			
Top 3 projects		$2,200,000		
Top 2 projects			$1,200,000	
Top 2 projects				$2,010,000
Conveyance improvements projects				
Marine outfall lines	$9,470,500	$7,320,000	$5,450,000	$720,000
2007 lines	$20,041,500	$6,000,000	$6,000,000	$1,500,000
PURC lines	$1,528,000	$1,528,000	$1,528,000	$1,528,000
	$31,040,000	$14,848,000	$12,978,000	$2,748,000
Grand total	**$43,977,000**	**$22,047,000**	**$15,477,000**	**$6,034,500**

8.6 Opinions of CIP Cost

As described above some CIP cost estimates were derived by others and by the HDR team and are documented in their respective reports. They represent estimates for design, permitting, and construction. Specifically, the costs for improving the conveyance lines are documented in the 2007 Stormwater Comprehensive Plan and costs for the fish passage culverts are documented in the Prioritization Report (City 2019). The 2020 CIP cost estimates for the regional water quality facility, the bioretention facilities, and the PURC and marine outfall conveyance pipe improvements were derived by HDR as part of the 2020 SSWCP update.

The cost estimates derived by HDR are opinions of cost considered to be “Class IV” estimates. The Association for the Advancement of Cost Engineering (AACE) and the American National Standards Institute (ANSI) both define the expected accuracy of a Class IV estimate to be plus or minus 30 percent. It must be clearly understood that this is a planning-level estimate and has been prepared only for guidance in project evaluation purposes from information presented to the estimator at the time of the estimate.

The opinions of cost (estimates) shown, and any resulting conclusions on project financial or economic feasibility or funding requirements, have been prepared for guidance in project evaluation and implementation based on the information available at the time that the opinion was prepared. The final costs of the projects and resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. As a result, the final project costs will vary from the opinions of cost presented herein.

The detailed cost estimates used to assist in developing funding levels for the 2020 CIP are included in Appendix D.

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9 Recommended Stormwater Management Program and Implementation

The business of managing stormwater runoff is an evolving one requiring a wide range of technical, legal, and political skills. Periodic review of the City's SSWU management program keeps the City in compliance with changing federal, state, and local regulations. Updates to the SSWCP enable the SSWU to meet the community's expectations to preserve and protect the environment and to establish sustainable and affordable utility rates. The purpose of this chapter is to present recommended approaches for addressing identified deficiencies and gaps in the City's SSWU program. The recommendations include capital improvement projects, SWMP adjustments, and a recommendation for future renewal and replacement costs of built stormwater infrastructure. In essence, this chapter presents a summary of recommendations. Supporting details and background information are included in previous chapters and the appendices.

9.1 Drivers for Change

Evolving regulatory standards, increased knowledge and understanding of the condition of the City's stormwater system, water quality research, increased public interest and support for stormwater management, and new flooding problems each create incentives for stormwater management agencies to update their SSWCPs. Furthermore, the Bellingham City Council and its citizens identify themselves as environmentally progressive, and pride themselves on strong environmental protection.

9.1.1 Regulatory Standards

Effective August 1, 2019, the Phase II Permit introduced new regulatory standards for cities in Washington State. With the objective of reducing pollutant loading to receiving waters, Ecology reissues the Phase II Permit every 5 years including new requirements that come recommended by the findings of stormwater research conducted locally and abroad. With the 2019 Phase II Permit, HDR conducted a gap analysis (described in detail in Chapter 6) to identify opportunities for the City to strengthen compliance strategies and prepare for the new requirements. The City has accomplished more than 90 percent of the previous Phase II Permit conditions, and is well on its way to accomplishing the new Phase II Permit requirements over the next 5 years.

9.1.2 Asset Management

In Chapter 5, an approach to asset management is described, one that is based on existing programs at the City but modeled after national standards for inspection, conditions assessment rating, and for making plans based on risk and condition. The City's ongoing video inspection program will continue to evaluate the gray infrastructure condition, and thereby will continue to identify stormwater pipes in poor condition that will feed into the City's renewal program.

9.1.3 Water Quality Sustainability

The Puget Sound Initiative cites stormwater runoff as a major contributor to pollutant loading to Puget Sound. The City's Phase II Permit requires new and redeveloping properties to install water quality and flow control BMPs. Only when development regulations are triggered will the benefits to the receiving waters be realized. However, retrofit planning and retrofit project implementation is a way to achieve improvements in water quality independently of development plans. Often retrofit projects are focused in areas developed prior to stormwater regulations and are an important strategy to include as part of reducing pollutant loading to receiving waters.

9.1.4 Flood Control/Conveyance

As Bellingham's population continues to grow, urban infill and impervious areas increase, and as precipitation intensities change because of shifts in weather patterns, stormwater runoff volumes and localized flooding naturally increase. Pipe capacity today may be sufficient, but will likely be less so in the future. The CIP recommendations for continued pipe replacement projects will address this evolving challenge through appropriate design of system conveyance based on level of service (e.g., design storm frequency, SLR projections, and rainfall pattern changes).

9.2 Implementation Strategies

Multiple implementation components are presented for managing the respective components of the SSWU—the CIP and the SWMP. SWMP implementation, required by the Phase II Permit, leads the City toward a comprehensive implementation strategy. However, efficiencies in program delivery are possible that will create a sustainable and holistic program. Program enhancements focus on MS4 initiatives. The CIP, arranged in four cost tiers, provides the City with a range of implementation options that allow flexibility due to fiscal constraints and/or affordability. Program staffing recommendations guide the City in meeting the administrative needs of the program as Phase II Permit conditions evolve.

9.2.1 Program Enhancements

Like all NPDES permits in western Washington, Bellingham's Phase II Permit is organized into Special Conditions and General Conditions, and with compliance it allows the regulated jurisdiction to discharge stormwater runoff from its MS4 to the waters of the state. As a Phase II Permit condition, each calendar year the City updates and publishes a SWMP that describes the City's programs and documents how it meets the conditions of the Phase II Permit. The City's current SWMP is available on its website: https://www.cob.org/services/planning/environmental/pages/stormwater-program.aspx.

Overall, the City is doing quite well in meeting its obligation toward Phase II Permit compliance. In fact, it is already making strides at completing tasks that are new in the current Phase II Permit. For example, the City has accomplished 80 out of the 89 individual tasks evaluated from the 2015 Phase II Permit, or 90 percent, representing an exceptional track record of performance. Of the nine tasks noted as not accomplished, some are enhancement recommendations only. Also, the City has begun on the new permit conditions found in the 2019 Phase II Permit by initiating or completing four individual tasks, with some progress already made on many of the outstanding items not to be completed for some time. Therefore, the overall strategy going forward should be focused primarily on achieving the new requirements while maintaining the current level of support on previous requirements.

9.2.2 Capital Improvements

Long-term strategies of sustainable stormwater management should always include an element that focuses on the built assets, evaluating improvements and/or enhancements to aid in achieving the SWMP's goals. The 2020 CIP projects list was divided into four cost scenarios (i.e., levels of service) for use in the utility rate study analysis (Section 8.5). The rate study evaluation (Chapter 10) analyzes rates using CIP cost categories of high, medium, and low cost to determine the respective rate increases needed to implement the three CIP scenarios within the 6-year planning horizon. A fourth category, No Rate Increase, determined how much of the proposed CIP could be implemented without increasing utility rates. Projects are identified for developing cost estimates to support a CIP funding level. However, the actual list of projects implemented with CIP funding should be fluid to respond to other City initiatives and priorities that can influence the priority of the stormwater program. Therefore, the projects listed should be considered for planning purposes only, and should not be construed as a final approved list for design and construction. Appendix D provides the background on how the different CIP funding levels were developed, while Appendix E and F provide technical details on the projects for information only.

The strategy in creating the different funding scenarios was built on maintaining a diverse set of project types and treatment strategies, recognizing that focusing on one treatment or improvement method would lower the overall program benefit in achieving system-wide and community-wide water quality/quantity and habitat enhancement. The strategy also looks to address those projects in most need/highest benefit, regardless of location. Finally, this strategy preserves the momentum achieved in all of the City's areas of focus—from renewal, to replacement, to flow control, to water quality, to habitat enhancement/protection. From public input and review of the rate analysis, the City Council should support the CIP that is deemed most appropriate in meeting its goals while being sensitive to affordability and social equity. The four scenarios generated the following CIP funding:

- Large CIP option: $43,997,000
- Medium CIP option: $22,047,000
- Small CIP option: $15,477,000
- No Rate Increase CIP option: $6,034,500

9.2.3 Program Staffing

Proper staffing is critical to administering the program and communicating with City leaders, the public, and other City departments and agencies. Staffing is also needed to manage information and projects associated with implementation of the SWMP and the CIP program. Analysis was performed to understand current levels of staffing against the new Phase II Permit requirements that will be initiated over the next permit cycle of 5 years. Many Phase II Permit gaps exist simply because of new requirements scheduled to take effect on different dates within the Phase II Permit window (2019–2024); therefore, the staffing estimates are also sensitive to the implementation date.

Time estimates used in the analysis are based on the type of program work that is needed. Each Phase II Permit compliance gap was categorized into one of the following four categories:

- Compliance tracking
- SWMP documentation
- Policy development and implementation
- SWMP evaluation

These categories helped to establish basic assumptions describing the work, which became the basis for the estimated number of staffing necessary to fill Phase II Permit activity gaps. The evaluation concluded that the City would need to add up to four additional staff throughout the course of the next 5 years. This gradual increase in staffing was factored into the rate analysis.

9.3 Program Benchmarking

Comparing one stormwater program to another can have its limitations as each municipality has different priorities and objectives. While many communities fall under similar NPDES Phase II Program requirements, they vary on their level of capital improvements and maintenance. Taking a broader approach at benchmarking can provide some insight into how each community charges for its stormwater services. Chapter 10 provides a detailed evaluation on stormwater rates and affordability. Up to 16 communities in the region were evaluated to compare average stormwater rates. The City's current rate of $11.66 per month is below the average of several western Washington communities. The average among the communities surveyed was approximately $15 per month. The Cities of Everett and Tacoma were particularly high when compared to the other cities surveyed. Excluding Everett and Tacoma, the average stormwater rate was $13.34.

An important consideration when setting rates is affordability. The affordability of utility rates has been a subject of increasing importance as utility rates have increased significantly in recent times. While there have been some studies of affordability for other utilities such as water and sewer, stormwater rates have not been included in these studies. One reason for the lack of information on affordability in stormwater rates is that stormwater rates are typically much lower than water or sewer rates and stormwater utilities have become prevalent only in the last 20 to 30 years.

What is considered affordable can be an abstract concept. The most common way of viewing affordability is as a percentage of median household income (MHI). MHI is not a perfect measure of affordability but it does provide some insight. MHI varies widely among the cities studied and Bellingham is on the lower end of the spectrum with an MHI of approximately $51,000 compared to the average of $76,000. Bellingham's stormwater rate as a percentage of MHI is just above the median at 0.28 percent.

The Southeast Stormwater Association publishes a biennial Survey of Southeast Stormwater Utilities. The 2019 survey, which marks the seventh publication, provides results from 103 respondents from 136 jurisdictions. This survey provided the following information that can be used in making program decisions in the future:

- 52 percent of respondents fund their CIP only from their stormwater revenues
- The average 5-year CIP budget is approximately $55 million
- 43 percent of respondents charge for site plan review
- Average current FTE employees funded by stormwater is 20
- 80 percent monitor for improvements in water quality
- 75 percent monitor for improvements in flood protection

9.4 Stormwater Management Program Funding

The financial component of a SWMP is crucial to the successful implementation of the prescribed CIP within the Surface Water Management Plan as well as ongoing operations. A comprehensive financial program provides a detailed account of methods to fund the CIP and demonstrate that the utility operates in a financially sustainable manner over the course of the planning period. The objective of the financial program section of the SSWCP is to identify the total cost of operating and maintaining the City's SSWU and its programs, provide adequate funding to meet the SSWU capital improvement schedule, and assist in establishing cost-based and equitable rates for service.

Rates may be set around several factors, including the cost of service. However, several other factors may also be considered when designing rates. Washington State law gives cities flexibility when setting rates, leaving the City to consider factors other than strictly cost of service. The primary goal the City has indicated for this study is to set the rates at a level sufficient to fund the capital needs, in addition to maintaining compliance with the Phase II Permit and current O&M practices. Four rate alternatives were prepared corresponding to the four levels of capital funding.

The City is using a cost-of-service approach as a foundation for developing rates and keeping rates stable from year to year from the customer's perspective.

To accommodate the goal of stable rates over time, rate designs were developed to phase in over a period of time to transition to cost-based rates.

The City currently provides several credits that can be applied against its monthly stormwater bill. The City proposes making some changes to the credits contained in the BMC and these changes are provided in this SSWCP. These changes are supported by a cost-of-service model approach and are based on the effectiveness of the credits and impact on the City's stormwater system. Eliminating several of the existing credits increases the revenue collected within the large-footprint customer class, resulting in a reduction in the rate impact to that class of service because of the resulting increase in revenue. At present rate levels, the elimination of these credits results in an increase of approximately $500,000 in revenue per year. The City also provides a credit for low-income residents and senior citizens but currently does not have this credit in the BMC. The City intends to maintain this credit and add it to the BMC.

Recently Revised Code of Washington (RCW) Section 90.03.525 was amended, adding additional conditions and restriction to paragraph 2 of that section requiring cities that charge WSDOT for stormwater to report to WSDOT how their funds are linked to WSDOT properties. Therefore, the benefit has diminished to charge either WSDOT or the City's Street fund. See Chapter 10 for additional information. As a result, the SSWU will lose approximately $800,000 of revenue, which is the City's Street fund and WSDOT combined. Losing this $800,000 will require stormwater rates to be increased to offset the loss.

Four rate scenarios were examined to address a baseline condition, and the three CIP levels were presented, to examine the rates and cost from FY 2021 through FY 2026. Within these scenarios, different costs are presented for the different size parcels within the city, and showing the progression of a rate increase over this 6-year period for each parcel classification. In addition to the rate analysis, the current service development charges and permit fees were examined.

9.5 Conclusion

The City's SSWU is responsible for operation of the City's storm drainage system under the regulatory framework of the Phase II Permit. The City carries out this responsibility in part by having a comprehensive SWMP that establishes policy and service level standards, and a CIP designed to meet the goals and objectives of the SSWU. The purpose of this update to the SSWCP is to provide goals, policies, guidance, and planned program activities that will help the City meet regulatory requirements and create funding mechanisms to support a CIP, development permit reviews, and maintenance requirements for the SSWU for the years 2020 to 2026.

The City is expecting, and has budgeted for, ending fund balance to decrease in the last few years because of its expenditures exceeding revenue in those years. This trend will likely continue unless expenditures are reduced significantly or revenue is increased. Revenue increases are the recommended action as reducing expenditures will make it difficult, if not impossible, to meet the requirements of the City's Phase II Permit, support growth within the city, and meet the overall stormwater management goals and objectives.

Regulatory drivers, in addition to community needs, stormwater asset condition, and financial stewardship, help the City define a strategy and priorities that become the framework for a SSWCP. The City finds itself well organized and positioned to continue the success of past accomplishments from previous plans through thoughtful public input, sustainable strategies for Phase II Permit compliance, and a fiscal approach to funding a long-term program that is also sensitive to affordability and social equities. As new regulatory requirements become eligible for completion over the next Phase II Permit cycle, and as the City's system ages, both staffing and CIP needs will drive the need to increase funding to maintain the level of service across the many facets of stormwater management. This SSWCP, when accomplished over this planning horizon, will position the City as a model program that supports regional water quality and system sustainability for the citizens of Bellingham.

10 Financial Program Review

The objective of the financial program chapter is to identify the total cost of operating and maintaining the City's SSWU and its programs, provide adequate funding to meet the stormwater management utility capital improvement schedule, and assist in establishing cost-based and equitable rates for service.

The financial program is crucial to the successful implementation of the prescribed CIP within this SSWCP as well as ongoing operations. A comprehensive financial program provides a detailed account of methods to fund the CIP and demonstrate that the utility operates in a financially sustainable manner over the course of the planning period.

The methods used in this study followed general industry guidelines for developing utility rates. These general industry guidelines outline that rates must generate sufficient revenue to be self-supporting and financially viable, without undue discrimination toward or against any customer. Detailed exhibits provided in Appendix G outline the development of this study.

Legal authority for a city to operate a surface water utility comes from RCW 35.67.025, which states "any public entity and public property, including the state of Washington and state property shall be subject to rates and charge for storm water control facilities to the same extent private persons and private property are subject to such rate and charges." Additionally, RCW 35.67.020 allows for cities "to fix, alter, regulate, and control the rates and charges for their use," which includes surface water management.

10.1 Past and Present Financial Status

The City's SWMP manages the stormwater runoff within the city's boundaries as well as areas outside of city limits that drain into the City's stormwater system. The goals of the SWMP are to adhere to regulatory requirements, protect public health and safety, and be good stewards of the environment. Much like many other cities across the country, the City of Bellingham has been expanding its program to fulfill its goals and objectives and meet state and federal requirements.

The City operates the SSWU as a self-supporting enterprise fund and provides affordable stormwater management to its customers. Table 10-1 provides the City's historical revenue and expenditures over the last 5 years.

Table 10-1. Historical and budgeted revenue and expenditures

Description table values in $1,000s	FY 2014 Actuals	FY 2015 Actuals	FY 2016 Actuals	FY 2017 Actuals	FY 2018 Actuals	FY 2019 Budget	FY 2020 Budget
Beginning fund balance	$4,847	$4,734	$3,866	$3,176	$5,435	$1,500	$930
Revenue							
Surface water rate revenue	$6,090	$6,476	$7,118	$7,491	$7,615	$8,400	$8,532
Other revenue	$2,455	$10,948	$2,167	$2,759	$5,132	$7,831	$3,671
Total revenue	$8,545	$17,424	$9,284	$10,250	$12,747	$16,231	$12,204
Expenditures							
Salaries and benefits	$1,605	$1,812	$1,992	$2,023	$2,069	$2,957	$3,073
Supplies	$159	$209	$217	$170	$237	$262	$264
Tools and equipment	$10	$85	$28	$41	$33	$48	$44
Services	$1,324	$1,436	$1,290	$1,267	$1,256	$2,348	$1,300
Travel	$6	$13	$6	$11	$7	$14	$14
Interfund expenditures	$2,289	$2,324	$2,728	$2,722	$2,914	$2,520	$2,522
Utilities	$15	$15	$52	$15	$15	$19	$19
Repairs and maintenance	$367	$244	$121	$120	$186	$6,317	$2,062
Miscellaneous expenses	$118	$107	$138	$115	$158	$136	$136
Total expenditures	$5,894	$6,246	$6,571	$6,484	$6,876	$14,622	$9,434
Capital costs	$1,750	$11,043	$1,949	$50	$3,171	$180	$100
Debt service	$0	$0	$249	$444	$415	$479	$477
Taxes	$847	$899	$1,009	$1,046	$1,071	$1,119	$1,119
Operating transfers	$0	$104	$87	$60	$285	$400	$100
Ending fund balance	$4,901	$3,866	$3,285	$5,341	$6,365	$930	$1,904

Stormwater management rate revenue is fairly consistent from year to year because the rate is a set, or flat, per month rate with no variable component. Increases in the stormwater management revenue are mainly due to growth in the number of accounts and any change in the rates charged to customers.

The City also receives a variety of other revenue, which has varied since 2014 with a low of $2.1 million in 2015 to a budgeted high of $7.8 million in 2019. A major cause for this fluctuation is due to transfers in from the Watershed reserve fund of $1 million. The Watershed fund is a subfund of the water fund related to the Lake Whatcom watershed. Stormwater improvements within the Lake Whatcom watershed will lead overall water quality improvements. For this reason, 30 percent of the annual Watershed fund revenue can be used on stormwater capital projects. Another significant revenue source is Ecology grants of $1.3 million in the 2020 budget. Grant revenue should be discounted when projecting other revenue forward because these are not revenue sources the City should rely on in the future. Net of transfers and grants the City has consistently received $1.2 million per year in other revenue. The other significant revenue sources are storm drainage fees, storm and vactor charges, and stormwater permits. Storm drainage fees include SDCs, which are charges for new development.

The City's expenditures have increased annually because of inflation of costs and the increased costs to meet regulatory and City goals and objectives. The increase in expenditures does include some expenses that might be considered one time or intermittent such as one-time projects or studies. The City is expecting, and has budgeted for, ending fund balance to decrease in the last few years because of its expenditures exceeding revenue in those years. This trend will likely continue unless expenditures are reduced significantly or revenue is increased. Revenue increases are the recommended action as reducing expenditures will make it difficult, if not impossible, to meet the requirements of the City's Phase II Permit, address TMDLs for Lake Whatcom, support growth within the city, and meet the overall stormwater management goals and objectives.

10.2 Overview of the Rate Study Process

A comprehensive rate study is a series of three interrelated analyses including a revenue requirement analysis, cost-of-service analysis, and rate design analysis. The goal of the analysis is to adequately fund the utility while maintaining equity among customers.

10.2.1 Generally Accepted Rate-Setting Principles

Utilities should set rates around generally accepted or global principles and guidelines. Utility rates should be:

- Cost-based, equitable, and set at a level that meets the utility's full revenue requirement
- Easy to understand and administer
- Designed to conform to "generally accepted" rate-setting techniques
- Stable in their ability to provide adequate revenues for meeting the utility's financial, operating, and regulatory requirements
- Established at a level that is stable from year to year from a customer's perspective
- Meet legal and regulatory requirements

10.2.2 Revenue Requirement

Most public utilities use the "cash basis" [1] approach for establishing the revenue requirement for rate-setting purposes. This approach conforms to most public utility budgetary requirements.

The cash basis revenue requirement analysis is the comparison of projected revenue and expenses to determine if the current level of revenues is sufficient to responsibly manage the utility. The components of a cash basis revenue requirement are available funds such as rate revenue and miscellaneous revenue, compared to operating expenditures or O&M, rate-funded capital, taxes and transfers, and debt service. In place of these non-cash expenditures the cash basis adds rate-funded capital and debt service. The cash basis is used by public utilities because they are not a profit-seeking enterprise but rather a public service. Table 10-2 shows the general breakdown of a cash basis revenue requirement.

Table 10-2. Cash basis revenue requirement

Overview of a cash basis revenue requirement
+ O&M expense
+ Taxes and transfer payments
+ Rate funded capital (≥ depreciation expense)
+ Debt service (principal + interest)
= Revenue requirement

Revenue requirements are often conducted over a projected period similar to financial plans. Projecting the revenue requirement over several years allows for the utility to set rates on a consistent basis or allow the utility to make proactive steps to deal with a future financial hurdle.

10.2.3 Cost of Service

The cost-of-service analysis is conducted after the revenue requirement is determined and uses one year, often the next fiscal year, as the test year. The cost-of-service analysis takes the test year expenses established in the revenue requirement and equitably distributes them to customer classes of service. The City's current customer classes of service include small footprint, medium footprint, and large footprint. These classes of service were not changed for this analysis. The cost-of-service analysis consists of the following three sequential steps:

[1] "Cash basis" as used in the context of rate setting is not the same as the terminology used for accounting purposes and recognition of revenues and expenses. As used for rate setting, "cash basis" simply refers to the specific cost components to be included within the revenue requirement analysis.

1. Costs and assets are functionalized or grouped into the various cost categories related to providing service (conveyance, water quality, etc.). This step is largely accomplished using the City's chart of accounts.
2. The functionalized costs are allocated to specific cost components. Allocation refers to the arrangement of the functionalized data into cost components. For example, a stormwater utility's costs are typically allocated as impervious surface area, pervious surface area, and customer-related costs.
3. Once the costs are allocated into components, they are proportionally distributed to the customer classes of service (e.g., small footprint, medium footprint, and large footprint). The distribution is based on each customer class's relative contribution (proportional share) of each cost component (i.e., benefits received from and burdens placed on the system and its resources). For example, customer-related costs are distributed to each class of service based on the total number of customers in that class of service. Once costs are distributed, the unit costs from each customer class of service required to achieve cost-based rates can be determined.

10.2.4 Rate Design

The rate design analysis is the final step in a comprehensive rate study. Rate design takes the revenue requirement and the cost-of-service data and establishes rates. The rate design process is guided by the previous analysis conducted but also considers the utility's goals and objectives. Rate design also may consider the structure of the rates. Rate structure refers to the means of charging the rates, such as a flat rate, per acre charge, or charge per impervious surface area.

10.3 Financial Policies

Financial policies are an important component of the healthy management of a utility. Financial policies are generally measures meant to provide a framework so that the utility will be managed in a consistent way and avoiding politically expedient decisions. It is important to stay within the bounds of adopted policies when conducting a rate study.

10.3.1 The City's Financial Policies

In 2010 the City adopted Financial Management Guidelines through Resolution 2010-17. The Financial Management Guidelines document is extensive and deals with many aspects of the City' financial management. Strong financial policies are important for continuity of financial management and help City leadership make decisions that are good for the long-term sustainability of the City and not short-sighted, politically expedient decisions. The City's policies are extensive and important but the few that are most relevant for the SWMP are stated below.

General Budget Policy 8: <u>Reserves.</u> The use of reserves as a balancing resource within the proposed budget shall be clearly and specifically identified. Use of reserves is subject to reserve policy standards and limits as presented within this document. When any proposed budget for a fund causes reserves to fall below the minimum reserve target for that fund, the budget document shall include a proposed plan for "replenishing" the reserve to at least the minimum target as stated with the attached fund reserve goal table. (This is text from the financial management guidelines; the table it is referring to is not included in this document.)

Revenue Guideline 2: Charges for Services. Charges for services benefiting specific users should be established at a rate that recovers full costs, including all direct and capital costs. Departments imposing fees or service charges should prepare and periodically update cost-of-service studies for such services. A subsidy of the costs for such services may be considered when the City Council determines it is in the public interest. Any subsidy of service costs shall be specifically identified to the council prior to presentation for approval of fees or service charges.

Revenue Guideline 3: One-time Revenue. The City will not use revenues received that are considered to be available for only a limited period; to fund ongoing employment costs, staff will ensure that the source of revenue is available for at least 3 years.

Reserve Policies

The City will maintain adequate reserves. Reserves shall be sufficient to meet the following needs:

- Provide adequate liquidity
- Provide for unanticipated economic downturns
- Maintain credit ratings
- Provide for services and costs during a declared emergency
- Provide for long-term capital needs
- Meet mandated reserve requirement

Operating Fund 430: Target. Five percent of current year budget operating expenditures plus 10 percent of its total budgeted 5-year capital plan. Minimum of 5 percent of current year budgeted operating expenditures plus $400,000.

10.3.2 Industry Standard Financial Policies

In addition to financial policies identified in the City's Financial Management Guidelines, this analysis used a few generally accepted guidelines used for rate making. The following financial guidelines were observed in the development of this analysis:

- **Enterprise fund:** The Governmental Accounting Standards Board (GASB) defines an enterprise fund as a fund that operates a business-like activity and is funded primarily by user fees, such as stormwater rates. Because of the SSWU's distinction as an enterprise fund, it must be self-sustaining and recover its operating and capital costs. Enterprise funds should not be subsidized or subsidize another fund, including the City's General Fund.

- **Reserve levels:** Reserve balances are necessary to cover current costs and future capital expenditures. Adequate cash reserves help the utility run smoothly and maintain stable rates in the future. There are generally two types of reserve funds, or sub-funds: an operating fund and a capital fund.
  - **Operating reserves** provide day-to-day funding of operations, and the balance must be sufficient to cover the utility's bills, payroll, one-time, and unexpected costs. Healthy operating reserve balances are also useful for smoothing rate adjustments over several years. Common operating reserve targets range between 45 and 90 days of O&M expense or between 12 and 25 percent annual O&M expense.
  - A **capital reserve** holds funds for future capital improvements. The capital reserve commonly contains restricted cash flow as well as current revenue intended for current and future capital expenditures. The City does not currently maintain a separate fund for capital funding. In this case the operating fund acts as both an operating reserve and a capital reserve.
- **Capital funding through rates:** Capital funding through rates is the amount of rate revenue that is dedicated for use on capital projects. The purpose of capital funding through rates is to provide for the replacement of aging system facilities to ensure sustainability of the system for ongoing operations. The current industry standard is to allocate an amount no less than annual depreciation expense from current revenue. The analysis provides for primarily funding capital with current rate revenue and fund balance. This strategy exceeds the depreciation expense minimum standard.
- **Debt service coverage ratio (DSCR):** The industry standard minimum coverage requirement on outstanding revenue bonds is 1.25 times annual revenue bond debt service, using the net revenues of the utility. DSCR is calculated by subtracting operations and maintenance, taxes, and debt payments from revenue then dividing by current annual debt payments. Having a 1.25 DSCR provides that the utility has sufficient revenue to pay its debt service payments on an annual basis.

$$\frac{Revenue - \ expenditures - \ taxes}{Debt\ service} => 1.25$$

Some of the above guidelines are similar to, or complementary of, the City's existing financial policies, while the other guidelines are used as a framework to which the analysis is structured.

10.4 Establishing a Revenue Requirement

As mentioned earlier in this chapter, a revenue requirement is the sum of the utility's O&M expense, taxes and transfer payments, debt service, and rate-funded capital. The revenue requirement is then compared to the revenue at the existing rate plus miscellaneous revenue to determine if the existing rates are sufficient.

10.4.1 Sources of Funds

Sources of funds are simply the revenue available for the utility to fund its operations on an annual basis. Stormwater management revenue is derived from rate revenue and miscellaneous revenues such as SDCs, stormwater permit review fees, developer contributions, bank earnings, and grants. Figure 10-1 below shows that the vast majority of the operating fund's revenue is received through rate revenue collections.

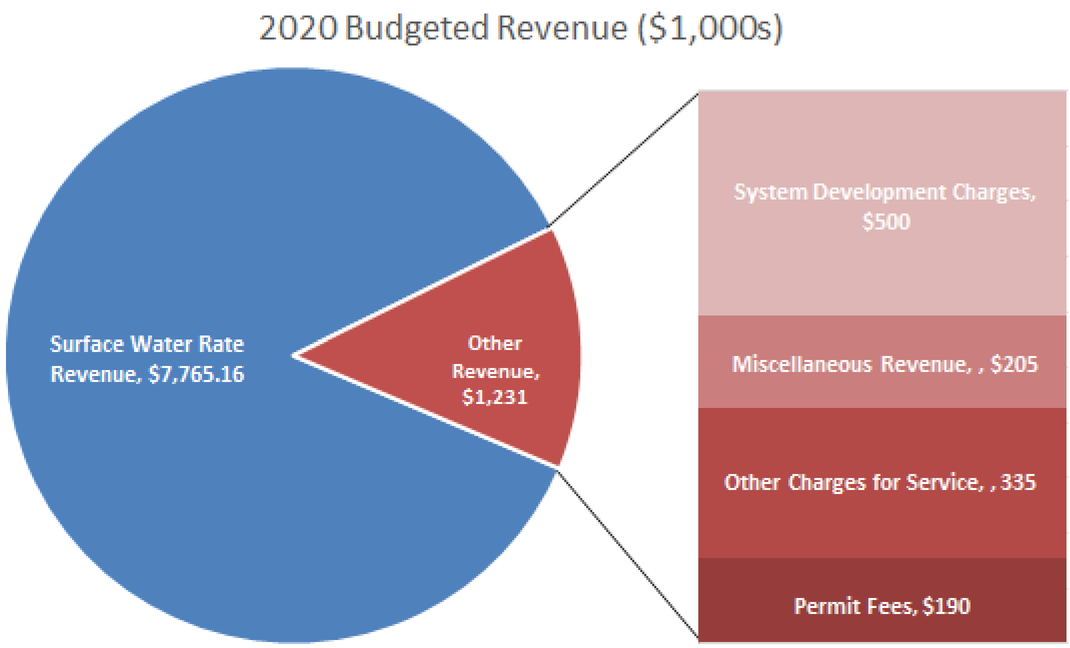

Figure 10-1. Revenue sources 2020 budget

10.4.2 Application of Funds

Application of funds refers to the various components that make up the revenue requirement. O&M expenses comprise a variety of costs associated with the day-to-day operation and maintenance of the SSWU. Salaries, benefits, supplies, inter-fund payments, and utilities are a few of the largest O&M expenses. Growth rates for these expenditures vary widely. Total salaries, the largest component of O&M, generally can be reduced only by reducing staff, as individual salaries generally rise with an index such as the Consumer Price Index (CPI) or similar index, often negotiated with union contract terms. Benefits comprise a wide range of items such as health insurance and pensions. Historically, health benefits have been growing at a rate significantly higher than inflation. As part of the plan a personnel gap analysis was conducted to analyze if the SSWU had sufficient personnel to accomplish the tasks associated with the Phase II Permit. The analysis determined that four additional FTEs would be needed to adequately perform the necessary Phase II Permit activities. The costs of the additional FTEs was added to the forecasted expenditures. The timing for the new FTE costs was spread out with one FTE added in 2020, another in 2021, and then the two added in 2023 for a total of four FTEs.

Figure 10-2 shows the City's expected O&M expenditures for the 2020 budget year.

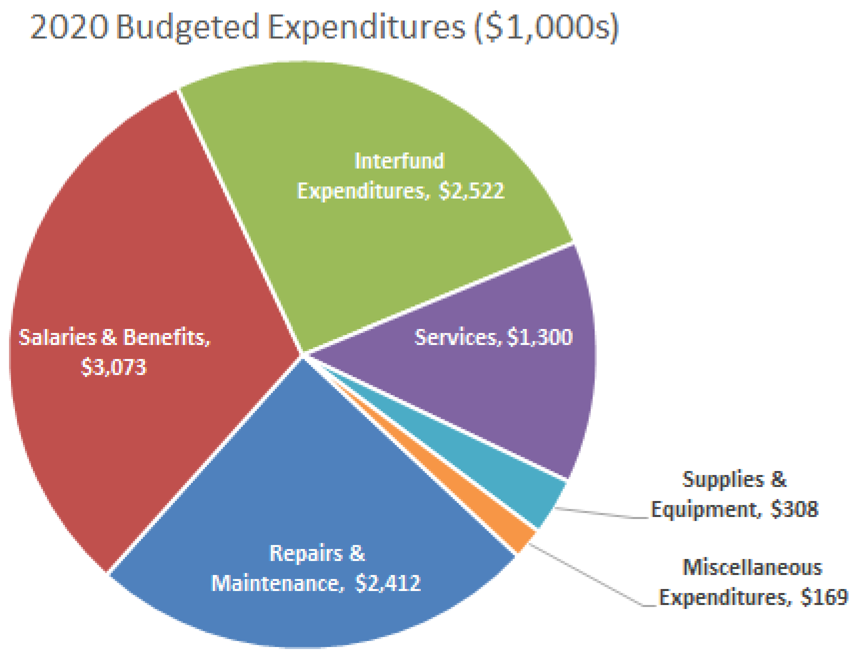

Figure 10-2. 2020 budgeted expenditure by type

Taxes

The SSWU pays a state tax of 1.5 percent, which is charged to all surface water sales. The City also pays a utility tax to the City's general fund of 11.5 percent. The City and State tax is calculated as a percentage of revenue; when rates are increased, additional City and State taxes are incurred.

Capital Funding

Utilities fund capital improvements in many ways—through rate revenues, SDCs, reserves, or long-term debt in the form of loans or bonds. Often utilities employ several means of funding capital projects and for a variety of reasons.

Rate-Funded Capital. Rate-funded capital is an allocation of current rate revenue dedicated to fund capital projects. Some utilities choose to fund their capital plan entirely through current revenue and reserve funds. However, most utilities use a mix of capital funding mechanisms such as rate revenue and long-term debt. As it happens, the amount of rate-funded capital is indicative of the financial health of the utility. Rate-funded capital is intended to represent an average of capital expense on an annual basis. Excess rate-funded capital in one year is intended to be saved for times when capital expenses exceed rate-funded capital allocation. This is sometimes called a "pay as you go" approach, thereby initiating a project only when the funds have accumulated to pay for the project.

Debt Service. Debt service is the payment of principal and interest on debt issued by the utility, generally when a utility desires to initiate capital projects ahead of having the funds available. Often when a utility issues debt, the issuer imposes covenants on the utility to ensure that the utility is financially sound to be able to repay the debt.

Reserves. Utilities commonly use reserve funds to fund capital. Using reserve funds allows utilities to save excess funds in one year and use them in another year for capital costs that exceed their current revenue funding.

System Development Charges. SDCs or connection charges are a one-time charge to new development. These charges are essentially buy-in to the system. SDCs are a commonly used source of capital funding.

10.4.3 Projected Revenue and Expenditures

For this analysis, the City's 2020 budget was used as a starting point for projecting the revenue requirement. Beyond 2020, escalation factors were used to project both revenue and expenditures. The escalation factors used for rate revenue and SDCs were projected at the expected average annual growth rate. Escalation factors for expenditures ranged from 0 percent to 6 percent, depending on the particular type of expense. These escalation factors were based on a conservative interpretation of historical trends in the Seattle-Tacoma-Bremerton CPI and recent trends witnessed among other utilities. Table 10-3 provides the escalation factors used in the financial plan.

Table 10-3. Escalation factors

Average annual escalation factors	2021–2030
Revenue	
Customer growth	1.50%
Connection charges	1.50%
Miscellaneous revenue	0.50%
Expenditures	
Labor	3.75%
Materials and supplies	3.00%
Equipment	3.75%
Professional services	3.50%
Medical benefits	6.00%
Utilities	2.00%
Miscellaneous	2.50%
Repairs and maintenance	3.25%

10.4.4 Capital Plan Scenarios

The City requested that multiple levels of capital projects be explored for its consideration. Essentially, four cost-of-service studies were prepared to provide rates based on the four capital improvement project levels. The capital projects proposed for the CIP scenarios are to be constructed over a 6-year period, 2021 through 2026. The variables that change depending on the capital level are the assumed capital funding levels from rate-funded capital, use of reserve funds, staffing levels, and the changes to rates. In addition to these variables, there are also financial constraints. The primary constraint that was impacting the development of the analysis was reserve fund balance. Reserve fund balance is the cash on hand to fund the utility's operating and capital expenses. As mentioned in the financial policy discussion, the City has a target ending fund balance of 5 percent of current budgeted operating expenditures plus 10 percent of the 5-year CIP and a minimum ending fund balance, which is 5 percent of current operating expenditures plus $400,000. The SSWU fund's operating balance is currently at the low end of the spectrum with a beginning fund balance for 2019 of $930,037. Because the current fund balance is so close to the minimum of $898,000 for 2019, the ability to float or phase in rate adjustments is minimal. While the Stormwater Management Fund has issued debt in the past, the City has decided to cash fund the CIP going forward; therefore, no new debt was assumed for any of the four scenarios.

The capital options developed for the City were as follows:

- **Baseline:** Rates are adjusted at an inflationary level throughout the analysis period (2021–2026). Funds available for capital were essentially the remaining funds after subtracting operating costs from revenue. The available funds under the Baseline scenario starting in 2021 is $1.1 million growing to $1.3 million in 2026 totaling approximately $6 million over the duration of the CIP. The funds available for the Baseline capital scenario are derived primarily from the SDCs and contingent on the implementation of the maximum allowable SDCs as presented in Section 10.7 of this chapter. Any reduction in the level of SDC will also reduce the potential funding available for capital.
- **Small CIP:** CIP consists of only the highest-priority capital projects.
- **Medium CIP:** CIP consists of the highest-priority capital projects plus a second tier of projects deemed medium priority.
- **Large CIP:** CIP consists of all of the recommended projects, including high, medium, and low priority.

To incorporate the CIPs into the rate study, the annual amount of assumed capital funding was set at the one-sixth of the plan costs per year. After establishing the annual funding level the annual capital costs were escalated annually to account for inflation of the construction costs. Table 10-4 presents the Small, Medium, and Large CIPs. It should be noted that Table 10-4 also includes a vactor truck that was not included in the projects in Chapter 8.

Table 10-4. CIP scenarios

Project title	Scenario		
Table values in $1,000s	Small	Medium	Large
Filtration treatment vaults			
Filtration Treatment Vaults	$537	$537	$537
Baker Creek Regional Water Quality	0	3,700	3,700
Bioretention	762	762	1,500
Fish Passage	1,200	2,200	7,200
Conveyance Improvements	5,450	7,320	9,471
Pipe Upsizing	6,000	6,000	20,042
PURC/Condition	1,528	1,528	1,528
Vactor Truck	600	600	600
	$16,077	$22,647	$44,577

Numbers do not always sum exactly to annual totals because of rounding.

Another aspect of the capital scenarios is there was also an analysis of the level of capital spending and number of projects that would require additional personnel. To establish a basis for how many FTEs would be needed to support the proposed CIPs, past capital spending and FTEs that supported that effort was reviewed. At a high level, it was found that on average one engineering staff member supported approximately $5 million in capital spending per year. Note, these FTEs are in addition to the FTEs identified in the gap analysis for the Phase II Permit compliance. Table 10-5 shows the projected additional total FTEs for the period.

Table 10-5. New FTEs to support CIP

CIP	2020	2021	2022	2023	2024	2025	2026	Total
Baseline	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small CIP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Medium CIP	0.0	**0.5**	0.0	0.0	0.0	**0.5**	0.0	**1.0**
Large CIP	0.0	**1.0**	0.0	0.0	0.0	**1.0**	0.0	**2.0**

The Baseline and Small CIP scenarios assumed no new FTEs while the Medium CIP scenario added one FTE and the Large CIP scenario assumed two FTEs. For modeling purposes the new FTEs were spread out over the CIP planning period. In practice the City should add actual FTEs as the workload would require to allow for completion of planned projects.

Given all of the preceding data and assumptions, the revenue requirement analysis was developed for each of the four CIP alternatives. The revenue requirement was designed to minimize rates to the extent possible, maintain target reserve balances through 2026, and fund the identified capital for each scenario. Beyond 2026 the fund balance rises above the minimum because a lower level of capital projects was assumed in the final years of the revenue requirement. Table 10-6, Table 10-7, Table 10-8, and Table 10-9 provide the result of the revenue requirement for the Baseline, Small, Medium, and Large CIP scenarios, respectively.

Table 10-6. Baseline CIP revenue requirement analysis

	Forecast									
Table values in $1,000s	FY 2020	FY 2021	FY 2022	FY 2023	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030
Revenue										
Surface water rate revenue at current rates	$8,561	$7,886	$8,004	$8,123	$8,367	$8,492	$8,618	$8,746	$8,877	$9,009
Non-rate revenue	$3,571	$1,963	$2,006	$2,051	$2,150	$2,201	$2,253	$2,306	$2,361	$2,418
Total revenue	$12,132	$9,849	$10,010	$10,174	$10,517	$10,693	$10,871	$11,053	$11,237	$11,427
Expenditures										
Operating expenses	$9,784	$7,849	$8,110	$8,379	$8,946	$9,245	$9,553	$9,872	$10,203	$10,544
Capital funded through rates	$500	$400	$400	$700	$1,000	$1,200	$1,400	$1,500	$1,500	$1,500
Taxes and transfers	$1,219	$1,108	$1,124	$1,141	$1,174	$1,191	$1,209	$1,226	$1,244	$1,262
Debt service	$477	$742	$761	$349	$185	$176	$166	$166	$166	$166
Total expenditures	**$11,980**	**$10,099**	**$10,395**	**$10,569**	**$11,306**	**$11,811**	**$12,328**	**$12,765**	**$13,113**	**$13,472**
Cumulative balance (deficiency) of funds	$152	($250)	($386)	($395)	($789)	($1,119)	($1,456)	($1,712)	($1,875)	($2,045)
Cumulative deficiency (balance) as a percentage of rates	-1.8%	3.2%	4.8%	4.9%	9.4%	13.2%	16.9%	19.6%	21.1%	22.7%
Proposed rate adjustment	**0.0%**	**2.5%**	**2.5%**	**2.5%**	**2.5%**	**2.5%**	**2.5%**	**2.5%**	**2.5%**	**2.5%**
Rate revenue after adjustment	$0	$197	$405	$625	$1,099	$1,356	$1,626	$1,910	$2,209	$2,523

Table 10-7. Small CIP revenue requirement analysis

Table values in $1,000s	Forecast									
	FY 2020	FY 2021	FY 2022	FY 2023	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030
Revenue										
Surface water rate revenue at current rates	$8,561	$7,886	$8,004	$8,123	$8,367	$8,492	$8,618	$8,746	$8,877	$9,009
Non-rate revenue	$3,571	$1,961	$2,005	$2,051	$2,150	$2,203	$2,258	$2,316	$2,377	$2,440
Total revenue	$12,132	$9,847	$10,009	$10,174	$10,516	$10,694	$10,876	$11,063	$11,254	$11,449
Expenditures										
Operating expenses	$9,970	$8,235	$8,511	$9,211	$9,842	$10,174	$10,517	$10,872	$11,240	$11,621
Capital funded through rates	$500	$1,312	$1,352	$1,394	$1,582	$1,628	$1,677	$1,727	$1,778	$1,932
Taxes and transfers	$1,219	$1,108	$1,124	$1,141	$1,174	$1,191	$1,209	$1,226	$1,244	$1,262
Debt service	$477	$742	$761	$349	$185	$176	$166	$166	$166	$166
Total expenditures	$12,166	$11,397	$11,748	$12,094	$12,783	$13,169	$13,568	$13,991	$14,428	$14,980
Cumulative balance (deficiency) of funds	($34)	($1,550)	($1,739)	($1,921)	($2,267)	($2,474)	($2,692)	($2,928)	($3,175)	($3,531)
Cumulative deficiency (balance) as a percentage of rates	0.4%	19.7%	21.7%	23.6%	27.1%	29.1%	31.2%	33.5%	35.8%	39.2%
Proposed rate adjustment	0.0%	21.0%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Rate revenue after adjustment	$0	$1,656	$1,923	$2,203	$2,808	$3,133	$3,475	$3,834	$4,210	$4,605

Table 10-8. Medium CIP revenue requirement analysis

	Forecast									
Table values in $1,000s	FY 2020	FY 2021	FY 2022	FY 2023	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030
Revenue										
Surface water rate revenue at current rates	$8,561	$7,886	$8,004	$8,123	$8,367	$8,492	$8,618	$8,746	$8,877	$9,009
Non-rate revenue	$3,571	$1,961	$2,005	$2,052	$2,153	$2,207	$2,264	$2,323	$2,385	$2,449
Total revenue	$12,132	$9,847	$10,009	$10,175	$10,520	$10,699	$10,882	$11,069	$11,261	$11,459
Expenditures										
Operating expenses	$9,970	$8,332	$8,611	$9,315	$10,065	$10,406	$10,758	$11,122	$11,499	$11,890
Capital funded through rates	$500	$2,412	$2,552	$2,594	$2,782	$2,828	$2,977	$3,027	$3,178	$3,232
Taxes and transfers	$1,219	$1,108	$1,124	$1,141	$1,174	$1,191	$1,209	$1,226	$1,244	$1,262
Debt service	$477	$742	$761	$349	$185	$176	$166	$166	$166	$166
Total expenditures	$12,166	$12,594	$13,048	$13,398	$14,207	$14,601	$15,109	$15,541	$16,088	$16,550
Cumulative balance (deficiency) of funds	($34)	($2,747)	($3,039)	($3,223)	($3,687)	($3,902)	($4,227)	($4,472)	($4,826)	($5,091)
Cumulative deficiency (balance) as a percentage of rates	0.4%	34.8%	38.0%	39.7%	44.1%	46.0%	49.1%	51.1%	54.4%	56.5%
Proposed rate adjustment	0.0%	40.0%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Rate revenue after adjustment	$0	$3,155	$3,482	$3,825	$4,563	$4,959	$5,374	$5,809	$6,265	$6,743

Table 10-9. Large CIP revenue requirement analysis

Table values in $1,000s	Forecast									
	FY 2020	FY 2021	FY 2022	FY 2023	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030
Revenue										
Surface water rate revenue at current rates	$8,561	$7,886	$8,004	$8,123	$8,367	$8,492	$8,618	$8,746	$8,877	$9,009
Non-rate revenue	$3,571	$1,961	$2,006	$2,053	$2,159	$2,216	$2,276	$2,340	$2,408	$2,480
Total revenue	$12,132	$9,847	$10,010	$10,176	$10,526	$10,708	$10,894	$11,087	$11,285	$11,489
Expenditures										
Operating expenses	$9,970	$8,429	$8,711	$9,419	$10,289	$10,638	$10,999	$11,372	$11,759	$12,159
Capital funded through rates	$500	$6,212	$6,352	$6,494	$6,882	$7,028	$7,177	$7,327	$7,578	$7,732
Taxes and transfers	$1,219	$1,108	$1,124	$1,141	$1,174	$1,191	$1,209	$1,226	$1,244	$1,262
Debt service	$477	$742	$761	$349	$185	$176	$166	$166	$166	$166
Total expenditures	$12,166	$16,490	$16,949	$17,402	$18,531	$19,033	$19,550	$20,091	$20,747	$21,319
Cumulative balance (deficiency) of funds	($34)	($6,643)	($6,939)	($7,226)	($8,004)	($8,326)	($8,656)	($9,004)	($9,462)	($9,830)
Cumulative balance (deficiency) as a percentage of rates	0.4%	84.2%	86.7%	89.0%	95.7%	98.0%	100.4%	102.9%	106.6%	109.1%
Proposed rate adjustment	0.0%	98.0%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Rate revenue after adjustment	$0	$7,729	$8,240	$8,775	$9,919	$10,531	$11,171	$11,839	$12,538	$13,268

Figure 10-3 illustrates the Baseline, Small, Medium, and Large CIP scenario revenue requirement from FY 2020 to FY 2030.

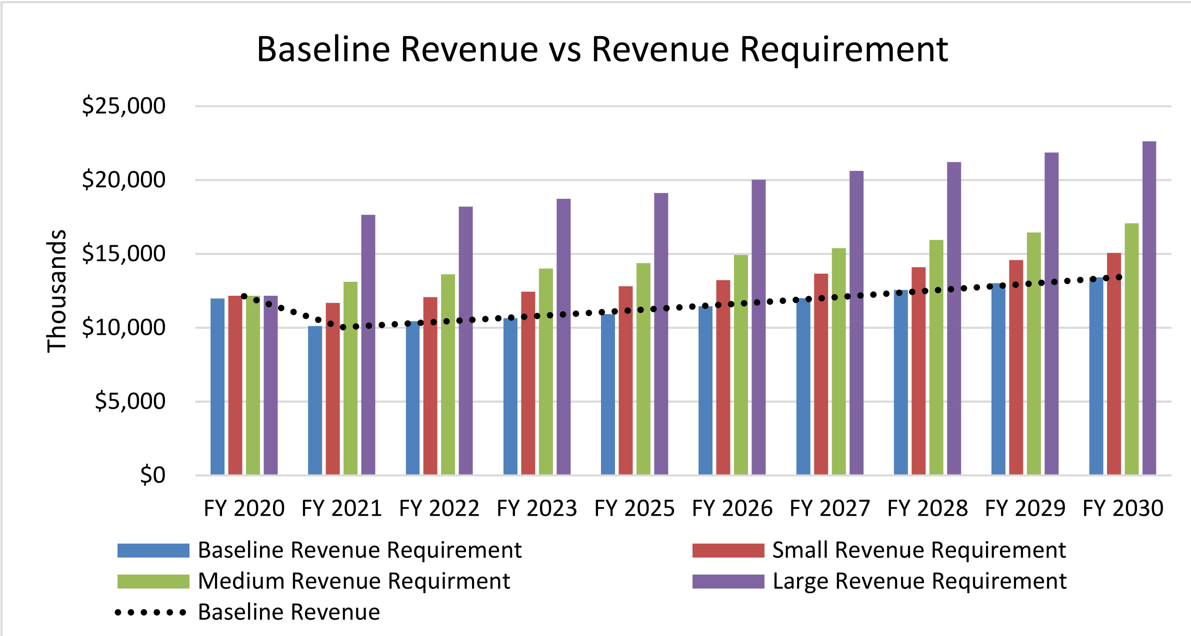

Figure 10-3. Baseline revenue versus revenue needs

The Baseline scenario assumes rate increases equal to what is likely to be implemented based on the City's current policy on rates. As can be expected, the differences in the percentage change in rates between the Baseline and each of the Small, Medium, and Large scenarios is due to the increased CIP expenditures. Other alternative funding sources like grants were not assumed during the analysis period for any of the scenarios as they are not guaranteed in the future. If other alternative funding sources were identified and successfully awarded it could reduce future overall rate adjustments. Table 10-10 shows the revenue adjustment for each CIP scenario as a percentage of rate revenue.

Table 10-10. Revenue adjustment as a percentage of rates

CIP scenario	2021	2022	2023	2024	2025	2026
Baseline	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Small	21.0%	2.5%	2.5%	2.5%	2.5%	2.5%
Medium	40.0%	2.5%	2.5%	2.5%	2.5%	2.5%
Large	98.0%	2.5%	2.5%	2.5%	2.5%	2.5%

10.5 Cost of Service

A cost-of-service analysis determines the equity between a utility's customer classes of service. While the revenue requirement is a projection over several future years, a cost-of-service analysis is a snapshot in a point of time, for the cost-of-service test period. The test period is a single period chosen from one of the years from the previously developed revenue requirement. The test year for the cost-of-service analysis was chosen to be 2021. Additional assumptions used for the development of a cost-of-service analysis are assumptions related to the design of the stormwater system and customer characteristics.

10.5.1 Customer Characteristics

The first step of a cost-of-service analysis is to determine the customer classes of service, or rate schedules, for the analysis. To do this an analysis of the City's customers was conducted to determine if the current customer classes of service are appropriate for the cost-of-service analysis. The current classes of service are small footprint, medium footprint, and large footprint.

The small footprint customer class comprises 13 percent of the total number of customers and 1.6 percent of the total square feet of hard surface. The medium footprint customer class is the largest customer class by number of customers, totaling 70 percent of all customers but only comprises 18.6 percent of the total square footage of hard surface.

The medium footprint customer class includes the majority of single family customers given the range of impervious areas that the medium footprint includes. Figure 10-4 shows the historical medium footprint rates.

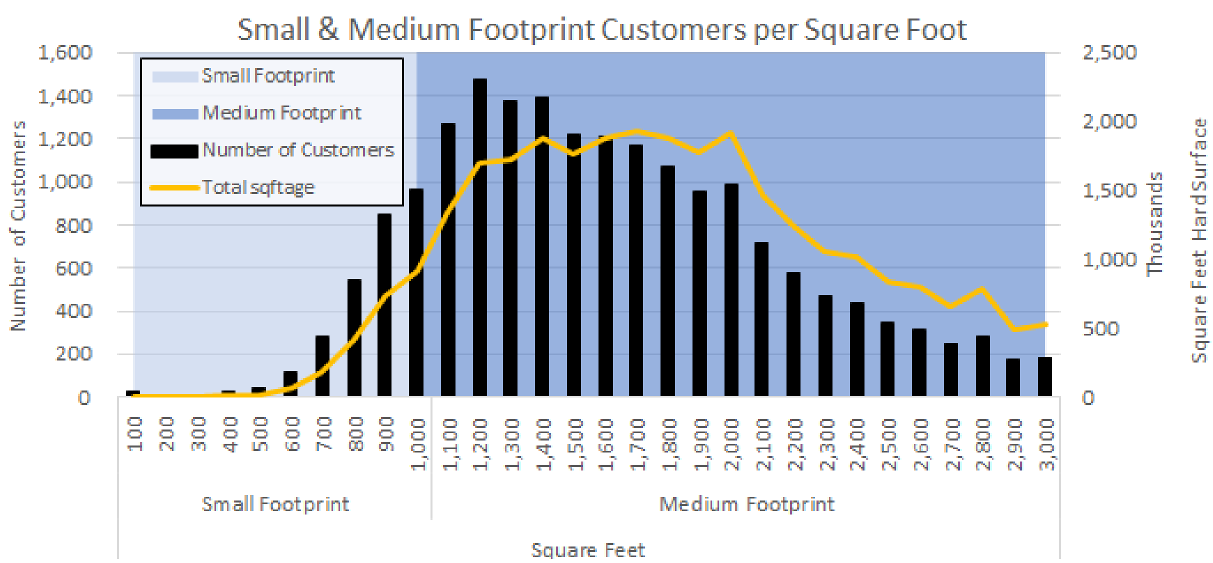

Figure 10-4. Historical medium footprint (single-family) monthly rates

Figure 10-4 shows how small and medium footprint customer classes compare by number of customers and the square footage of hard surface.

Large footprint customers include all customers with 3,000 ft^2 of hard surface and greater. The large footprint customer class differs from the small and medium footprint customer classes by charging each customer by square footage of hard surface rather than a flat rate per customer. The large footprint customer class comprises 17.3 percent of total customer accounts and nearly 80 percent of total square footage of hard surface. Figure 10-5 shows the large footprint customer data for 3,000 to 25,000 ft^2.

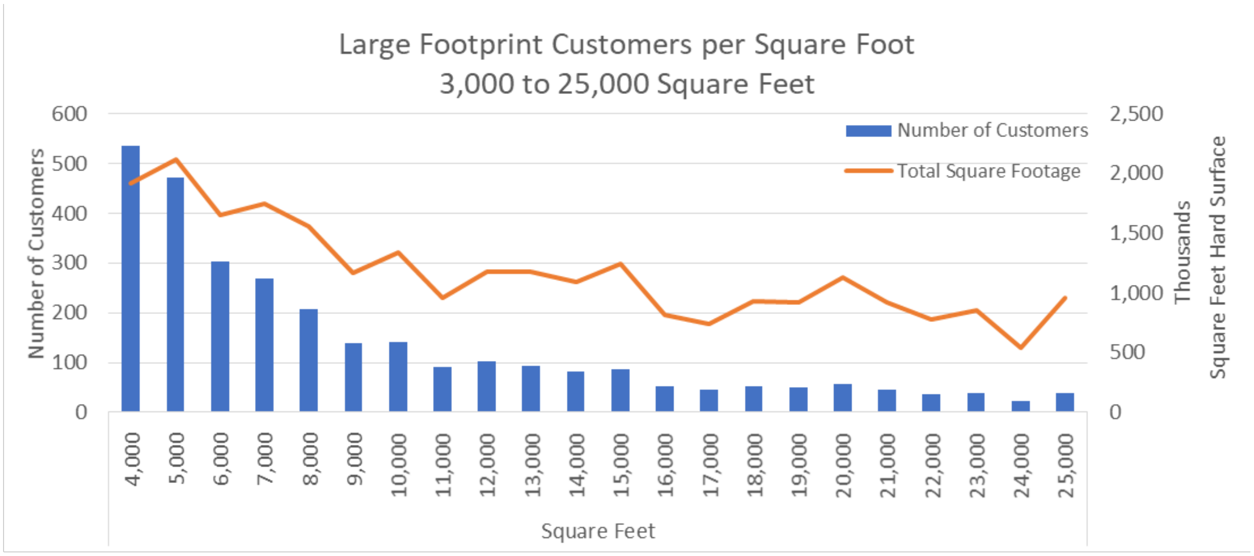

Figure 10-5. Historical large footprint (single-family) monthly rates

Figure 10-5 shows both the number of customers per size of hard surface and the total square feet per customer size. Figure 10-6 shows the large footprint customer data for greater than 30,000 ft^2.

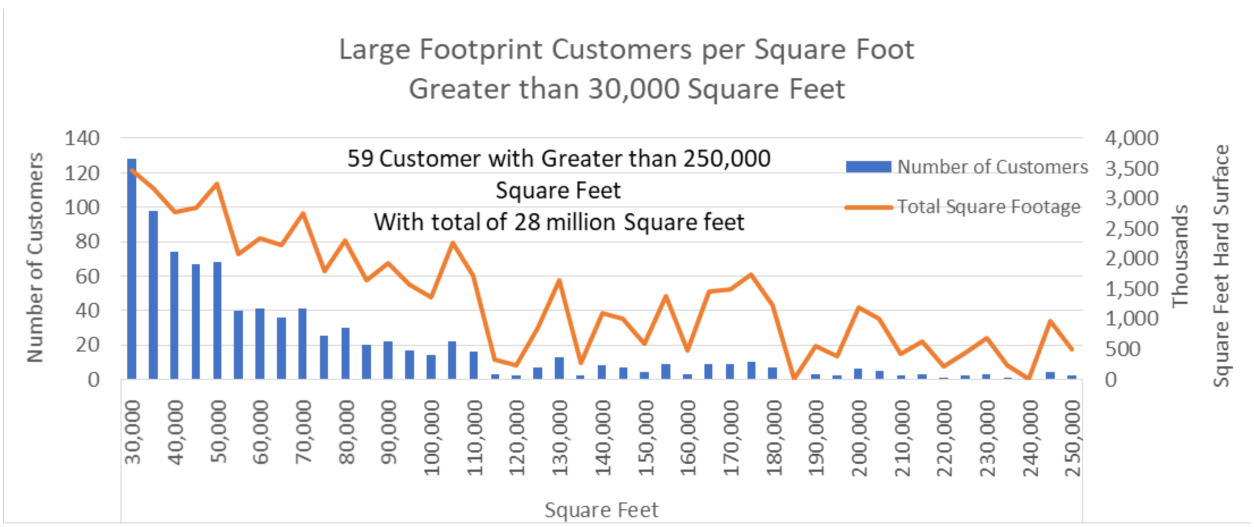

Figure 10-6. Historical large footprint (single-family) monthly rates

Figure 10-6 shows the customer characteristics for customers between 30,000 and 250,000 ft^2 of hard surface. There are 59 customers more with impervious surface area above 250,000 ft^2 not shown in the above figure.

10.5.2 Conducting a Cost-of-Service Analysis

A cost-of-service analysis consists of the three steps: functionalization, allocation, and distribution of costs.

Functionalization

The first analytical step in the cost-of-service process is called functionalization. Functionalization is the arrangement of expenses and asset (e.g., wells, distribution system) data by major operating functions (e.g., conveyance, retention, etc.).

Allocation

The second analytical task performed in a cost-of-service analysis is the allocation of the costs. The allocation of costs examines why the expenses were incurred or what type of need is being met. The allocation of costs is a critical step in developing cost-based and proportional rates for each customer class of service as utilities do not track costs by customer type. The following cost allocators were used to develop the cost-of-service analysis:

- **Impervious surface area:** Impervious surface area costs are the costs associated with the amount of impervious area associated with each customer class. Impervious surfaces are the main driver behind the overall volume of stormwater that ultimately flows through the City's stormwater system.
- **Customer-related:** Some costs associated with the surface water utility may vary with the number of customers within the stormwater system. They do not vary with system output or volume levels. An example of customer-related costs are the costs related to producing customer bills.
- **Revenue-related:** Some costs associated with the surface water utility vary with the amount of revenue-related costs. An example of this is state utility taxes, which are calculated based on gross revenue.

Table 10-11 provides the allocation of costs for each of the scenarios.

Table 10-11. Allocation of costs by scenario

Classification ($1,000s)	Impervious area	Customer-related	Revenue-related
Baseline CIP			
Small footprint	$117	$48	$0
Medium footprint	1,315	268	0
Large footprint	6,055	71	0
Publicly funded educational institutions	208	0	0
Total	**$7,696**	**$388**	**$0**
Small CIP			
Small footprint	$139	$49	$0
Medium footprint	1,563	272	0
Large footprint	7,199	72	0
Publicly funded educational institutions	247	0	0
Total	$9,148	$394	$0
Medium CIP			
Small footprint	$162	$50	$0
Medium footprint	1,818	278	0
Large footprint	8,371	74	0
Publicly funded educational institutions	288	0	0
Total	$10,639	$402	$0
Large CIP			
Small footprint	$231	$53	$0
Medium footprint	2,595	295	0
Large footprint	11,951	78	0
Publicly funded educational institutions	411	0	0
Total	$15,188	$427	$0

Publicly funded educational institutions is not a separate class of service but was analyzed separately to assess their cost of service in light of the publicly funded institution credit provided.

Distribution of Costs

Once the allocation process is complete, and the customer groups have been defined, the various allocated costs were distributed to each customer group. The City's allocated costs were allocated to the previously identified customer groups using the following distribution factors.

Impervious Surface Area Distribution Factor. To establish the impervious surface factor, each customer class's impervious surface area is added up and compared to the impervious surface as a whole. The result is a percentage that can be applied to the allocated costs. Table 10-12 provides the breakdown of the impervious surface area distribution factor by customer class.

Table 10-12. Impervious surface area distribution factor

Classification ($1,000s)	Square feet of impervious surface	Percentage of impervious surface
Small footprint	2,489,218	1.5%
Medium footprint	27,950,036	17.1%
Large footprint	128,700,724	78.7%
Publicly funded educational institutions	4,421,630	2.7%
Total	163,561,607	100.0%

Customer-Related Factor. The customer-related factor is used to distribute costs that have been allocated as customer costs to individual customer classes of service. Table 10-13 provides the breakdown by customer class of the customer distribution factor.

Table 10-13. Customer distribution factor

Classification ($1,000s)	Number of customers	Percentage of customers
Small footprint	3,016	12.5%
Medium footprint	16,665	69.1%
Large footprint	4,426	18.3%
Publicly funded educational institutions	25	0.1%
Total	24,132	100.0%

Revenue-Related Factor. The revenue-related factor is another factor commonly used to distribute costs to customer classes. This factor is based on the amount of revenue generated for each customer class. Table 10-14 shows revenue-related distribution factor.

Table 10-14. Revenue-related distribution factor

Classification ($1,000s)	Revenue	Percentage of revenue
Small footprint	$246	3.1%
Medium footprint	2,294	29.1%
Large footprint	5,290	67.1%
Publicly funded educational institutions	56	0.7%
Total	$7,886	100.0%

Table 10-15 provides the results of the allocation and distribution of those costs to each customer class for the impervious surface costs. The majority of costs were allocated as impervious area, which is very common among surface water cost-of-service studies. The logic behind this method for cost allocation is that if not for impervious surfaces the “urban” surface water drainage structures would not be necessary. While this may not be completely the case for every surface water system, it is an industry standard approach to quantify customers’ impact on the surface water system. Customer- and revenue-related allocated costs made up a much smaller portion of the total system costs. Table 10-16 shows distribution of the allocated customer-related costs.

Table 10-15. Distribution of impervious area among customer classes by scenario

Classification ($1,000s)	Percent impervious	Baseline	Small CIP	Medium CIP	Large CIP
Small footprint	1.5%	$117	$139	$162	$231
Medium footprint	17.1%	1,315	1,563	1,818	2,595
Large footprint	78.7%	6,055	7,199	8,371	11,951
Publicly funded educational institutions	2.7%	208	247	288	411
Total	100.0%	$7,696	$9,148	$10,639	$15,188

Table 10-16. Distribution of the allocated customer-related costs

Classification ($1,000s)	Percentage of customers	Baseline	Small CIP	Medium CIP	Large CIP
Small footprint	12.5%	$48	$49	$50	$53
Medium footprint	69.1%	268	272	278	295
Large footprint	18.3%	71	72	74	78
Publicly funded educational institutions	0.1%	0	0	0	0
Total	100.0%	$388	$394	$402	$427

Table 10-17 provides the results of the cost-of-service analysis. The table compares the customer current revenue to the allocated revenue and provides the percent change in rate needed to bring the rate up to their cost of service. It is generally believed that if a customer class is within 5 percent of the overall rate adjustment, it is within an acceptable range to be considered at the cost of service.

Table 10-17. Cost-of-service analysis results

Cost-of-service summary	Small footprint	Medium footprint	Large footprint	Publicly funded educational institutions	Total
Revenues at present rates	$246	$2,294	$5,290	$56	$7,886
Baseline					
Allocated costs	$166	$1,583	$6,126	$208	$8,084
$ change	($81)	($711)	$837	$152	$197
Percent change	-32.8%	-31.0%	15.8%	271.9%	2.5%
Small					
Allocated costs	$188	$1,835	$7,271	$248	$9,542
$ change	($58)	($459)	$1,981	$192	$1,656
Percent change	-23.5%	-20.0%	37.5%	342.0%	21.0%
Medium					
Allocated costs	$212	$2,096	$8,445	$288	$11,041
$ change	($34)	($199)	$3,155	$232	$3,155
Percent change	-13.9%	-8.7%	59.7%	413.9%	40.0%

Cost-of-service summary	Small footprint	Medium footprint	Large footprint	Publicly funded educational institutions	Total
Large					
Allocated costs	$285	$2,890	$12,029	$411	$15,615
$ change	$38	$596	$6,739	$355	$7,729
Percent change	15.4%	26.0%	127.4%	633.4%	98.0%

Note: Table values in $1,000s.

The final component of a cost-of-service study is the development of unit costs. Table 10-18 provides the unit costs for the cost-of-service results and is useful for comparing customer classes to each other on a common basis, such as their cost per acre of impervious surface area or their cost per acre in total.

Table 10-18. Cost-of-service unit costs: Small CIP scenario

Unit cost summary	Current revenue per unit		Cost-of-service results per unit		
	Current revenue/ft²	Current revenue/ customer	Impervious area cost/ft² impervious	Customer- and revenue-related cost/ customer	Total cost/ customer
Small footprint	$0.83	$6.81	$0.47	$1.36	$5.21
Medium footprint	$0.68	$11.47	$0.47	$1.36	$9.18
Large footprint	$0.34	$99.59	$0.47	$1.36	$136.90
Publicly funded educational institutions	$0.11	$186.81	$0.47	$1.36	$825.73

10.6 Stormwater Rates

The City's current rate structure is based on size of hard surface and consists of three rate categories of small, medium, and large footprint. Small and medium footprint customers are charged a flat rate bimonthly, per parcel, per customer depending on the size of the square footage of hard surface. Large footprint is also charged bimonthly but charged per square foot of impervious surface.

10.6.1 Current Rates

Small footprint customers are charged $14 per 2-month period for square footage up to 1,000 ft^2. Medium footprint charges $23.32 for a 2-month period for square footage of hard surface between 1,001 and 2,999 ft^2. Large footprint customers pay $0.00778 per 1 ft^2 of hard surface per 2 months. Table 10-19 provides the current rates with their defined ranges of impervious surface if applicable. Publicly funded educational institutions are contained within the large footprint class of service but receive a 70 percent credit from the City.

Table 10-19. Current (2020) rates

Rate category	Rate description	Rate	Rate type
Small footprint	Impervious surface less than 1,000 ft^2	$14.00	Per parcel/bimonthly
Medium footprint	Impervious Surface 1,001–2,999 ft^2	$23.32	Per parcel/bimonthly
Large footprint	Impervious surface greater than 3,000 ft^2	$0.00778	Per ft^2/bimonthly

10.6.2 Historical Rates

Over the past 8 years the City has adjusted its rates annually. The rate increases have varied in size over the 8-year period ranging from $0.53 to $2.94 bimonthly and averaging an increase of $1.33 per billing period (bimonthly) for medium footprint. As rates have been increased over the last 8 years the proportional relationship between the small, medium, and large footprint stormwater rates has not changed. The lack of a change in proportionality between customer classes is indicative that there have been no adjustments to account for the cost of service among the City's customer classes. Figure 10-7 shows the rates from 2012 to 2020.

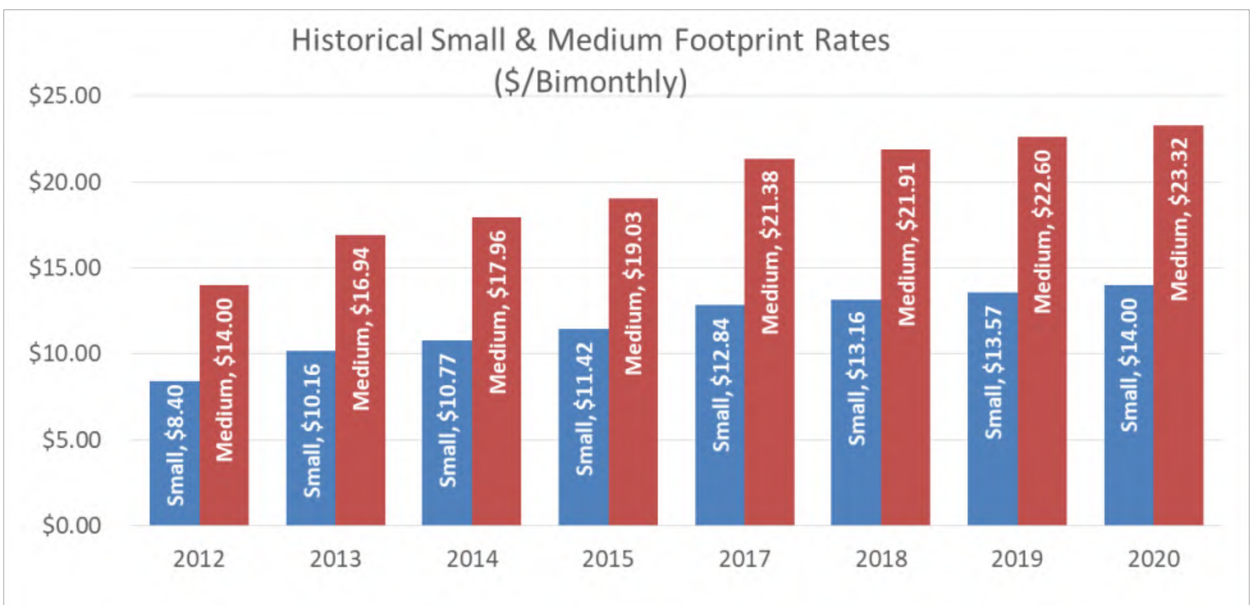

Figure 10-7. Historical small and medium footprint (single-family) monthly rates

Figure 10-8 shows the large footprint bimonthly rates from 2012 to 2020.

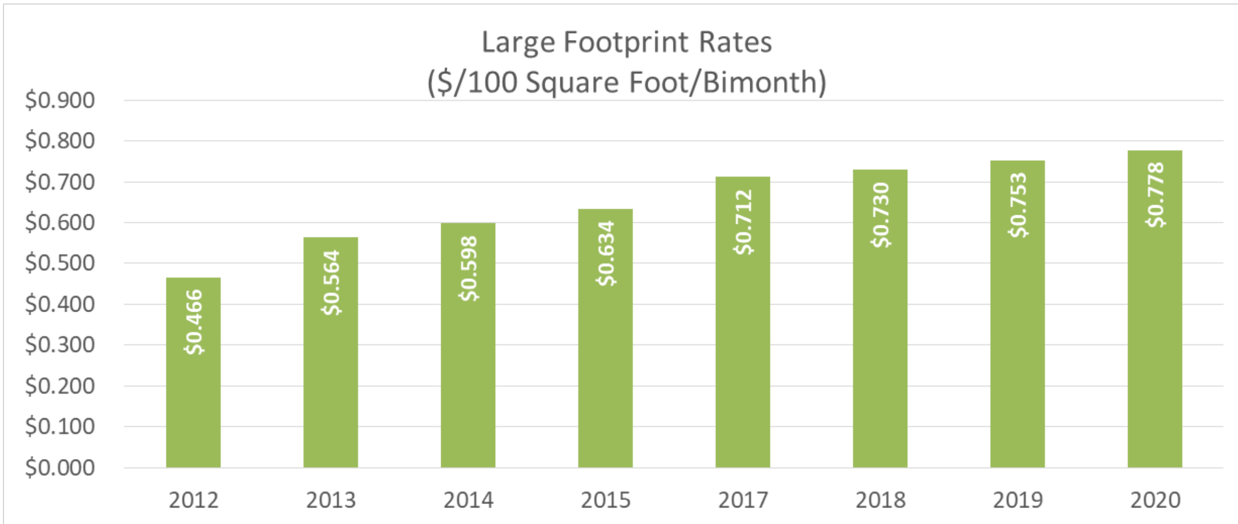

Figure 10-8. Historical large footprint bimonthly rates

10.7 Development of Rate Design

There are several factors around which rates may be set. The cost-of-service analysis provides cost-based rates through the development of unit costs. However, several other factors may be considered when designing rates. Washington State law gives cities flexibility when setting rates, leaving the City to consider factors other than strictly cost of service. The primary goal the City has indicated for this study is to set the rates at a level sufficient to fund the capital needs, in addition to maintaining compliance with the Phase II Permit and current O&M practices. Four rate alternatives have been prepared corresponding to the four levels of capital funding. The City has indicated that one principle it would like to pursue when designing rates is keeping rates stable from year to year from the customer's perspective.

To accommodate the goal of stable rates over time rate designs were developed to phase in over a period of time to transition to more cost-based rates. As shown in the cost-of-service analysis small and medium footprint customer class rates are greater than their cost of service while large footprint customer class rates are less than their cost of service. Rather than reducing small and medium rates, small and medium rates were held flat over a period until their rate would be greater than their current rate. Conversely, large footprint rates would be increased at a slower rate than indicated by the cost of service until small and medium footprint rates catch up with their cost of service.

10.7.1 Exemption, Credits, and Adjustments

The City currently provides several credits that can be applied against customers' bimonthly stormwater bills. The City proposes making some changes to the credits contained in the BMC, which are provided in Table 10-20. Table 10-20 shows existing stormwater rate credits and whether the credits should be maintained or eliminated.

Table 10-20. Rate credits

Credit	Maintain	Eliminate
B Credits for qualified existing stormwater facilities, which includes:		
1. Any property with properly maintained water quality and quality facility that meets or exceeds the design requirements of the 1992 Department of Ecology Stormwater Technical Manual		✓
2. Any property that has an active and valid NPDES permit		✓
C Credits for qualified existing stormwater facilities with special discharge limits		
1. Discharge directly into marine waters or waters under tidal influence with no connection to the city systems	✓	
2. Discharge of stormwater is to an infiltration facility meeting the requirements of Ecology for stormwater treatment and groundwater protection	✓	
D Public education credits. Credit is provided a reimbursement of the cost of environmental science curriculum.		✓
E Special credits for partially gravel or approved pervious surfacing.		
1. The customer has at least 6,000 ft^2 of gravel for the 20% credits.		✓
2. Pervious surfaces meeting infiltration standards receive a credit 50% on the pervious surface square footage.		✓

Table 10-20 shows which credits it intends to maintain and which it intends to eliminate. These changes to the credits were decided based on a variety of reasons including the effectiveness of the credits, impact on the City's stormwater system, and because the initial purpose of the credit was to encourage stormwater mitigation facilities now required by Ecology's current recommendations and requirements in the Phase II Permit. The City also provides a credit for lower-income and senior citizens but currently does not have this credit in the BMC. The City intends to maintain this credit and add it to the BMC. Eliminating the proposed credits increases the revenue collected within the large footprint customer class, resulting in a reduction in the rate impact to that class of service due to the resulting increase in revenue. At present rate levels, the elimination of these credits results in an increase of approximately $500,000 in revenue per year.

Another change to the credits provided in the BMC is to address RCW 35.67.020 Section 3. This section states:

> The rate a city or town may charge under this section for storm or surface water sewer systems or the portion of the rate allocable to the storm or surface water sewer system of combined sanitary sewage and storm or surface water sewer systems shall be reduced by a minimum of ten percent for any new or remodeled commercial building that utilizes a permissive rainwater harvesting system. Rainwater harvesting systems shall be properly sized to utilize the available

roof surface of the building. The jurisdiction shall consider rate reductions in excess of ten percent dependent upon the amount of rainwater harvested.

The City interprets the above RCW as meaning that the rainwater harvesting system is to be an offset to potable water use. The credits to be eliminated do not apply to this RCW.

Publicly Funded Primary and Secondary Educational Institution Credits

The City has a Public Education Credit up to 70 percent available to the school district provided that the school district's curriculum includes environmental science. The credit is essentially a reimbursement of costs incurred by the school district providing an environmental science curriculum and specifically the cause and effect of stormwater pollution. This credit is provided in BMC 15.16.040. Eliminating this credit would require council action to change the municipal code. The BMC states that the amount of the credit is established by a contract between the City and the school.

The contract that is currently active became effective in 2001 through 2003 with automatic extensions each year following 2003. Per Section VI of the contract, the contract can be terminated by either party with or without cause upon 30 days' written notice to the other party. This credit is not provided to the school district because it has a lower cost of service but rather was a policy decision to provide the credit to encourage curriculum for environmental science. Prior to the credit the school district pays approximately $200,000. The school district then applies for reimbursement of approximately $140,000 showing the costs it wishes to be reimbursed.

This analysis leaves publicly funded primary and secondary education institutions in the large footprint class of service and phases out the credit over a 4-year period. Table 10-21 shows the publicly funded primary and secondary educational institution credit phase-out schedule.

Table 10-21. Publicly funded primary and secondary educational institution credit phase-out schedule

2020 (current)	2021	2022	2023	2024
70%	53%	35%	18%	0%

10.7.2 Charges for Streets and Highways

The City currently charges WSDOT for the areas within the city. Washington State law, RCW 90.03.525, stipulates that WSDOT properties including state highway ROW or any section of state highway ROW for the construction, operation, and maintenance of stormwater control facilities be charged 30 percent of the comparable rate and further stipulates that if WSDOT is charged for stormwater, the City must also charge City streets. Some cities choose to charge WSDOT and by extension their own streets while others do not. WSDOT revenue was approximately $73,000 while the City's street department pays approximately $718,000 annually at its current rate out of the street fund, which is funded from general taxes originating from the City's General Fund. If the street department is not charged for stormwater, the City's General Fund will benefit from the reduction in charges. Recently RCW

90.03.525 was amended, adding conditions and restriction to paragraph 2 of that section requiring cities that charge WSDOT for stormwater to use that revenue for stormwater control facilities that directly reduce state highway runoff impacts or implementation of BMPs that will reduce the need for such facilities and, in coordination with WSDOT, develop a plan for the expenditure of the charges for that calendar year. Because the requirements have become more onerous to continue to charge WSDOT the City no longer is required to charge the City's streets department for stormwater. For this analysis, the City would no longer charge either WSDOT or the City's street department. As a result, the stormwater department will lose approximately $800,000, which is the City street department and WSDOT revenue combined. Losing the $800,000 will require stormwater rates to be increased to offset the loss.

10.7.3 Rate Scenarios

The scenarios for Baseline, Small CIP, Medium CIP, and Large CIP were reviewed for both the cost of service rate design results and the phase-in approach for rate designs. Table 10-22 through Table 10-25 show the rates for each of the scenarios.

Table 10-22. Baseline rate design

Rate class	Current	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
Baseline							
Small footprint (0–1,000 ft^2)/month							
Cost of service	$14.00	$9.41	$9.64	$9.88	$10.13	$10.38	$10.64
Phase-in approach	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00
Medium footprint (1,001–2,999 ft^2)/month							
Cost of service	$23.32	$16.09	$16.49	$16.91	$17.33	$17.76	$18.21
Phase-in approach	$23.32	$23.32	$23.32	$23.32	$23.32	$23.32	$23.32
Large footprint (greater than 3,000 ft^2)/month							
Cost of service	$0.778	$0.857	$0.874	$0.896	$0.917	$0.939	$0.963
Phase-in approach	$0.778	$0.778	$0.778	$0.805	$0.830	$0.858	$0.888

The City currently has a policy to adjust rates annually at the same rate as CPI. The Baseline scenario assumes that overall, revenue will increase at CPI in line with the City's policy but individual customer classes will adjust based on cost-of-service results. With that, small and medium footprint customer class rates would decrease while large footprint rates would increase, resulting in an overall increase in rate revenue equal to CPI. The phase-in approach shown on Table 10-22 differs on the implementation of the cost of service by leaving small and medium footprint steady while increasing large footprint rates to a lesser extent than the pure cost-of-service rate scenario while still increasing revenue at CPI.

Table 10-23. Small CIP rates design

Customer class	Current	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
Small CIP							
Small footprint (0–1,000 ft²)/month							
Cost of service	$14.00	$10.71	$10.97	$11.25	$11.53	$11.82	$12.11
Phase-in approach	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00
Medium footprint (1,001–2,999 ft²)/month							
Cost of service	$23.32	$18.66	$19.12	$19.60	$20.09	$20.59	$21.11
Phase-in approach	$23.32	$23.32	$23.32	$23.32	$23.32	$23.32	$23.32
Large footprint (greater than 3,000 ft²)/month							
Cost of service	$0.778	$1.017	$1.037	$1.063	$1.088	$1.115	$1.143
Phase-in approach	$0.778	$0.947	$0.980	$1.011	$1.041	$1.074	$1.109

Table 10-23 shows the two rate scenarios for the Small CIP scenario, one that aligns rates with the cost-of-service results in the first year and another where rates for small and medium footprint remain the same, phasing in the rate adjustments over time so that the rate impacts are brought into line with the cost of service over the 6-year period.

Table 10-24. Medium CIP rate design

Customer class	Current	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
Medium CIP							
Small footprint (0–1,000 ft²)/month							
Cost of service	$14.00	$12.05	$12.35	$12.66	$12.98	$13.30	$13.63
Phase-in approach	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.03
Medium footprint (1,001–2,999 ft²)/month							
Cost of service	$23.32	$21.30	$21.83	$22.38	$22.94	$23.51	$24.10
Phase-in approach	$23.32	$23.32	$23.32	$23.32	$23.32	$23.51	$24.10
Large footprint (greater than 3,000 ft²)/month							
Cost of service	$0.778	$1.182	$1.205	$1.235	$1.263	$1.295	$1.327
Phase-in approach	$0.778	$1.150	$1.188	$1.224	$1.258	$1.293	$1.327

Table 10-24 shows the rate scenarios similar to the Medium CIP scenario, with a scenario that follows the cost-of-service results and another that phases in the cost-of-service results over the 6-year period.

Table 10-25. Large CIP rate design

Customer class	Current	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
Large CIP							
Small footprint (0–1,000 ft²)/month							
Cost of service	$14.00	$16.16	$16.56	$16.98	$17.40	$17.84	$18.28
Phase-in approach	$14.00	$16.16	$16.56	$16.98	$17.40	$17.84	$18.28
Medium footprint (1,001–2,999 ft²)/month							
Cost of service	$23.32	$29.38	$30.11	$30.87	$31.64	$32.43	$33.24
Phase-in approach	$23.32	$29.38	$30.11	$30.87	$31.64	$32.43	$33.24
Large footprint (greater than 3,000 ft²)/month							
Cost of service	$0.778	$1.683	$1.717	$1.759	$1.800	$1.845	$1.891
Phase-in approach	$0.778	$1.683	$1.717	$1.720	$1.803	$1.845	$1.835

Table 10-25 shows the rate scenarios for the Large CIP scenario similar to the Small and Medium CIP scenarios, with both a cost-of-service and a phased-in approach. The results of the Large CIP scenario do differ from the Small and Medium CIP rate scenarios because each class of service requires a rate increase, whereas the Small and Medium CIP scenarios did not.

The Baseline scenario is the lowest overall rate adjustment and the impact of the phase-in approach to the rates is the most pronounced. The small and medium footprint rates do not catch up over the 6-year period to the cost of service.

10.7.4 Comparisons with Other Cities

Several western Washington cities' stormwater rates were compiled to compare how Bellingham's stormwater current and proposed rates compare. Figure 10-9 shows a survey of monthly stormwater rates for single-family or moderately developed or medium footprint as a comparison to the City's current rates.

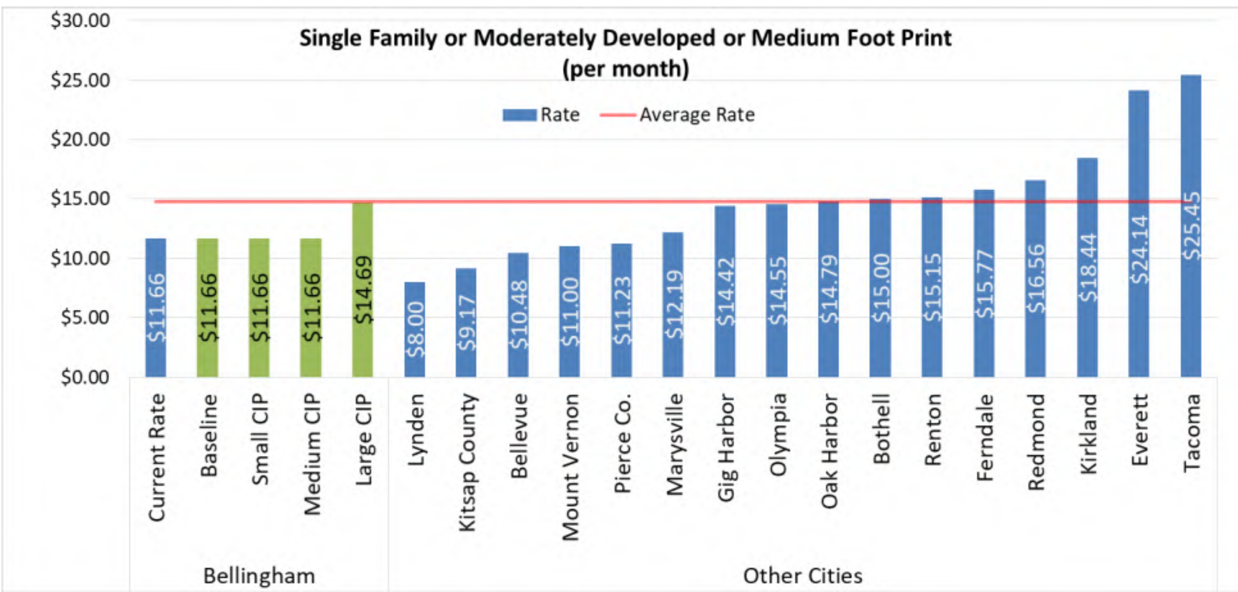

Figure 10-9. Survey of single-family or moderately developed or medium footprint (per month)

The City's rates in Figure 10-9 are provided on a monthly basis for comparison purposes.

The City's current and proposed stormwater rates are at or below the average of several western Washington communities. The average among the communities surveyed was approximately $15 per month. The Cities of Everett and Tacoma were particularly high when compared to the other cities surveyed. Excluding Everett and Tacoma, the average stormwater rate was $13.34. It should be noted that comparing rates with other cities gives some context, but it ignores underlying factors that dictate the level at which the rates are set. Factors that may play a significant factor in the level at which stormwater rates are set include geology, topography, age of the system, how well the system has been maintained, and to what degree the city goes to manage its stormwater system.

An important consideration when setting rates is affordability. The affordability of utility rates has been a subject of increasing importance as utility rates have increased significantly in recent times. While there have been some studies of affordability for other utilities such as water and sewer, the stormwater rates have not been included in these studies. One reason for the lack of information on affordability in stormwater rates is that stormwater rates are typically much lower than water or sewer rates and stormwater utilities have become prevalent only in the last 20 to 30 years.

What is considered affordable can be an abstract concept. The most common way of viewing affordability is as a percentage of MHI. MHI is not a perfect measure of affordability but it does provide some insight. According to the American Water Works Association (AWWA), water and sewer rates are assumed to be affordable below 4.0 percent of MHI. A similar measure of affordability has not been established for stormwater rates. There is still value in incorporating MHI when comparing rates among other cities. Figure 10-10 shows how other western Washington cities compare when factoring in MHI. Figure 10-10 shows the stormwater rates for the City and other cities as a percentage of MHI as a comparison.

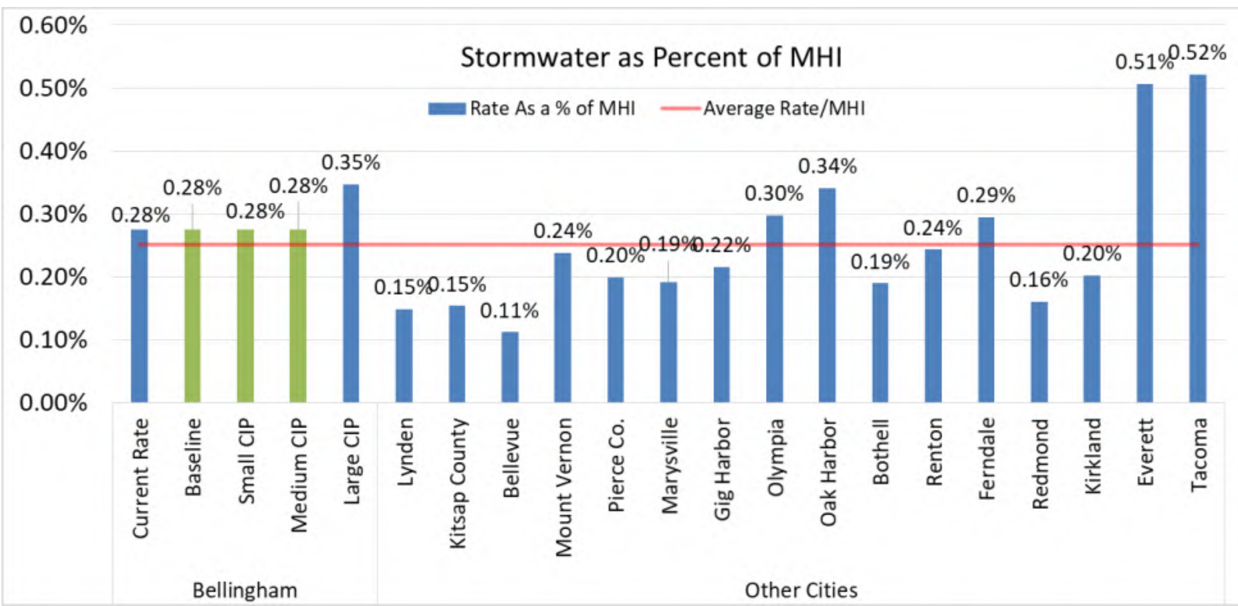

Figure 10-10. Stormwater as a percentage of median household income

Figure 10-10 does not say what is affordable but rather gives a sense of where Bellingham's stormwater rates are compared to other cities when incorporating MHI. MHI varies widely among the cities studied and Bellingham is on the lower end of the spectrum with an MHI of approximately $51,000 compared to the average of $76,000. To help get a sense of context it is helpful to consider other customer bills as a percentage of MHI. As a percentage of MHI, wireless phone is 2.5 percent, cable/satellite television is 1.5 percent, and general utilities and public transportation are 7.7 percent according to expenditures from the U.S. Bureau of Labor

Statistics (U.S. Bureau of Labor Statistics 2019) and MHI from the U.S. Census Bureau (U.S. Census Bureau 2019).

10.8 System Development Charges

An important part of the City's CIP is how the City intends to fund the needed projects. One funding source that many utilities employ is through SDCs. SDCs are a one-time charge for new developments or connections to the system. An SDC is intended to accomplish two things: pay back existing customers' investment for excess capacity in the system and create a funding source for future capital projects that increase system capacity.

10.8.1 Defining System Development Charges

The first step in establishing cost-based SDCs is to gain a better understanding of what they are and what they are not. An SDC is defined as follows:

> System development charge are one-time charges paid by new development to finance construction of public facilities needed to serve them (Nelson 1995)

Put another way, SDCs are contributed capital to either reimburse existing customers for the available capacity in the existing system, or help finance planned future growth-related capital projects. An SDC is not a revenue source for the utility to fund ongoing operations and maintenance. Not charging an SDC or charging an outdated fee puts the burden of development on ratepayers and not on those who are causing the need for expansion.

10.8.2 Economic Theory and System Development Charges

SDCs are generally imposed as a condition of service. The objective of SDCs is not to generate revenue for the utility, but to create fiscal balance between existing customers and new customers so that all customers seeking to connect to the utility's system bear an equitable share of the cost of capacity that is invested in both the existing and any future growth-related expansion. Through the implementation of equitable SDCs, existing customers will not be unduly burdened with the cost of new development. By updating the SDC, the City continues an important step in providing adequate infrastructure to meet growth-related needs while providing the infrastructure to new customers in a cost-based and equitable manner.

10.8.3 System Development Charge Criteria

Several criteria are considered when determining an SDC, including the following:

- State/local laws
- System planning criteria
- Financing criteria
- Customer understanding

Many state and local communities have enacted laws that govern the calculation and imposition of SDCs. These laws must be followed in the development of SDCs. For utilities in Washington, RCW 35.92.025 provides the approach to establishing SDCs. Washington State law allows historical asset costs to include 10 years' worth of interest. This calculation is done to reflect the fact that existing customers have provided for excess capacity in the system and hence need to be reimbursed for not only their initial investment, but also the "carrying cost" on that investment. The reimbursement to existing customers is accomplished by the fact that without SDCs, rates would otherwise be higher than they would be with SDCs. Inclusion of interest in future capital costs reflects the method used to finance the plant and hence the "true cost" to construct future infrastructure. The basic principle that needs to be followed under Washington State law is that the charge be based on a proportionate share of the costs of the system required to provide service and that adoption of charges and accounting be in compliance with State of Washington law.

The use of system planning criteria is an important aspect in calculating SDCs. System planning documents provide the criteria basis for the rational nexus between the amount of infrastructure necessary to provide service and the charge to the customer. The rational nexus test requires that there be a connection (nexus) established between new development and the new or expanded facilities required to accommodate new development, and appropriate apportionment of the cost to the new development in relation to benefits reasonably received.

The financing criteria for establishing SDCs relates to the method used to finance infrastructure on the system and ensures that customers are not paying twice for infrastructure—once through SDCs and again through rates (i.e., debt service on the financed infrastructure). The financing criteria also contemplate contributed capital and ensure that the customer is not charged for infrastructure that was provided (contributed) by developers.

10.8.4 Existing System Development Charge

The City's SDC currently is $678 for a single-family home and $0.226/ft^2 for other customer types and has remained unchanged since 2005. Under this SDC cost structure it can be implied that a single-family charge is equal to 3,000 ft^2; the charge divided by 3,000 ft^2 equals the per square-foot charge. The current SDC does not match up to the classes of service for usage rates. Missing from the SDC charge is a small footprint rate representing impervious surface with less than 1,000 ft^2.

10.8.5 Calculating the New System Development Charge

The calculation of an SDC is based on a four-step process, summarized as follows:

1. Determine system planning criteria
2. Determine impervious units
3. Calculate system component costs
4. Determine any SDC credits

The City's asset records were used to develop the cost basis to calculate the buy-in component of the SDC. The cost basis is the current value of the City's stormwater system. This value includes all of the assets that make up the stormwater system such as the culverts, catch basin, detention facilities, outfalls, and other components of the stormwater system. The next step is to identify and remove contributed assets donated by developers. After the contributed or donated assets are removed a maximum of 10 years of interest is applied to the remaining original value of the assets. The interest adjusted asset value is $77.7 million.

The capital program developed in this document was used to establish the cost basis for the incremental method for calculating SDCs. Each capital project is examined to determine if and to what extent the project will benefit new development. The capital projects identified as beneficial for new development were determined to be only 13 percent growth-related, so only 13 percent of the capital project cost were included in the SDC calculation.

The final step in calculating the stormwater SDC was to determine if a credit for payment on debt service is applicable for the utility's outstanding and future planned loans and bonds. Credits for debt service payments paid through customer rate revenue are determined to prevent charging the customer twice for debt, once through rates and once through SDCs. Customers pay for debt-financed infrastructure through their monthly utility rates and those costs are removed from the SDC calculation. Total debt is compared with projected annual ERUs to show a dollar per ERU each year.

Based on the sum of the component costs calculated above, the net allowable stormwater SDC can be determined. "Net" refers to the "gross" SDC, net of any debt service credits. "Allowable" refers to the concept that the calculated SDC is the City's cost-based SDC. The City, as a matter of policy, may charge any amount up to the allowable SDC, but not over that amount. Charging an amount greater than the allowable SDC would not meet the nexus test of a cost-based SDC related to the benefit derived by the customer.

Based on City records, there are approximately 154 million ft^2 of hard surface in the city. The net value eligible for SDC is divided by the total impervious surface equaling the SDC by 100 ft^2. Table 10-26 provides the breakdown of the SDC calculation by the four CIP levels.

Table 10-26. SDC calculation

SDC component	Baseline	Small CIP	Medium CIP	Large CIP
Collection system value	$77,766	$77,766	$77,766	$77,766
Eligible capital	0	1,765	2,019	4,221
Outstanding principal	(4,749)	(4,749)	(4,749)	(4,749)
Net allowable SDC asset value	$73,017	$74,782	$75,036	$77,238
Impervious surface (100 ft^2)	154,462,096	154,462,096	154,462,096	154,462,096
SDC per 100 ft^2 of impervious surface	$0.473	$0.484	$0.486	$0.500

With the establishment of the SDC per square feet a small and medium footprint rate can be calculated. The existing single-family SDC is the square footage charge times 3,000. The 3,000 ft^2 is the same impervious area used for the medium footprint customer rate. However, there is not an equivalent SDC for the small footprint customer class. If a small footprint equivalent were to be developed it would be calculated as 1,000 ft^2 times the per square foot SDC charge. Table 10-27 contains the maximum allowable SDC charges for the four CIP scenarios plus a new charge for the small footprint.

Table 10-27. Maximum allowable SDC charges by CIP scenario

Customer class	Current charge	Baseline	Small	Medium	Large
Small footprint	$678.00	$472.71	$484.14	$485.79	$500.04
Medium footprint	$678.00	$1,418.14	$1,452.42	$1,457.36	$1,500.13
Per square foot	0.226	$0.473	$0.484	$0.486	$0.500

There is not a broad difference between SDCs for the four CIP scenarios. In round terms each of the new SDCs by CIP scenario is more than double the existing SDC with the exception of the newly calculated small footprint SDC. The difference in the SDC lies with the amount of eligible capital. Table 10-28 shows SDC charges by CIP scenario reduced by 25 percent.

Table 10-28. SDC charges by CIP scenario reduced by 25 percent

Customer class	Current charge	Baseline	Small	Medium	Large
Small footprint	$678.00	$354.54	$363.11	$364.34	$375.03
Medium footprint	$678.00	$1,063.61	$1,089.32	$1,093.02	$1,125.10
Per square foot	0.226	$0.355	$0.363	$0.364	$0.375

Table 10-29 provides a more modest increase at 50 percent of the maximum allowable SDC.

Table 10-29. SDC Charges by CIP scenario reduced by 50 percent

Customer class	Current charge	Baseline	Small	Medium	Large
Small footprint	$678.00	$236.36	$242.07	$242.89	$250.02
Medium footprint	$678.00	$709.07	$726.21	$728.68	$750.07
Per square foot	0.226	$0.236	$0.242	$0.243	$0.250

The City can choose a level of subsidy or phase in the full SDC over a few years. As an example, the City can choose to implement the 50 percent subsidy for 2021, then 25 percent for 2022, and then no subsidy for 2023, or any variation as long as the fee does not exceed the maximum allowable fee. Many states including Washington allow cities to update their SDCs annually to reflect the increase in construction costs. Many cities use the Construction Cost Index (CCI) published by the *Engineering News-Record*. It is recommended that a full SDC study be performed when the system or CIP is changed significantly, or in 5 to 10 years.

The City currently has a credit for its SDC available for lower-income housing developments. No change to this credit is proposed. The lower-income SDC credit provides no more than 80 percent of the applicable SDC. This credit is conditioned on the development's housing expenses charged to tenants and can be no more than 30 percent of 80 percent of the median family income adjusted for family size. This credit is provided to developers as an incentive to build lower-income housing. Providing incentives is intended to spur development of lower-income housing, which is in support of the City's Legacies and Strategic Commitments statement under the heading "Equity and Social Justice," where it is stated that the City "supports safe, affordable housing" and "support services for lower income residents." This credit has been used several times in past years helping to provide affordable housing.

10.9 Permit Fees

As part of the cost-of-service analysis the City requested additional assistance with updating its permit fees. Permit fees are customer charges for inspection and plan review of construction activities to ensure that the developer or contractor is adhering to City regulations and standards when impacting the stormwater system. There are general principles for establishing charges:

- The beneficiary of a service should pay for the service
- Services provided for benefit of specific individuals or groups should not be paid with general utility revenue
- Services provided to a person or entity that are not customers of the utility should not be paid for by general utility revenue
- Services for where there are charges are generally voluntary
- The price of a service may be used to change user behavior and demand for the good or service
- The level-of-service charges should be related to the cost of providing the service
- The cost of administering the charge should not exceed the revenue

The above are general principles for setting fees or charges, but there is not a legal requirement to adhere to any of them. There are a number of ways utilities set permit fees such as establishing an average hourly cost and then the cost per permit, using an allocation factor to establish the fee, applying a percentage of the value, or by arbitrarily picking a number. None of these are inherently wrong as long as the method fulfills the City's goals and objectives. Permit fees receive much less attention than rates and are often overlooked or not updated for several years because of the relatively small amount of revenue generated for the utility.

10.9.1 Permit Fee Structures

The fee structure is a means by which the utility collects revenue to support permit fee activity. A common goal is to set fees in a way that reflects the effort to issue the permit. This can be accomplished in a few different ways. Below are a few ways that cities charge permit fees:

- **Hourly rates:** Hourly rates are based on a calculated composite cost per hour to issue a permit. The benefit of this method for charging a permit fee is that it recognizes that each situation is different and potentially the complexity of the site may require more time than another of a similar size.

  - **Hourly rate with a minimum charge:** Some utilities charge a set minimum number of hours up front and then send a bill for each additional hour.
- **Surface area of disturbed surface:** This fee type is set by calculating cost per surface area of disturbed surface area. The benefit of this method is that the cost is easily anticipated by the customer.
- **Volume of earth moved:** This method is similar to the surface area method but takes into account the volume of earth that is moved. The fee structure is often expressed in cubic feet. This method could better reflect the increased complexity of a job site where the slope is more or less than the average.

Despite the way a city charges for a permit the intent is to recover some level of cost to issue the permit. Some cities charge an hourly rate, some charge based on the area of disturbed surface area, and others are based on the volume of earth moved. The City currently charges a flat rate based on the amount of area disturbed or area of new or hard surface. The City has said that it wants its fees to be easily anticipated by permittees and consistent. The City's current structure is likely the best structure for consistency because it is easy to establish what the area pertaining to the permits is and the corresponding fee.

10.9.2 Current Permit Fee Methodology

The City's current permit fees were adopted after a Permit Fee Study was conducted in 2005. Prior to the 2005 study, at that time, the City had two levels of permits, small parcel and large parcel. The 2005 study indicated that the existing fees were collecting only approximately 7 percent of the cost to issue permits. The 2005 study suggested a much higher level of cost recovery from the permit fees.

The 2005 study describes a process of accumulating the complete cost to issue permits in three components: direct service costs, indirect costs, and overhead costs. The estimated full cost of issuing permits was $297,085. The next step in the process was to estimate the number of hours spent on issuing the permits. It was estimated that the total hours spent working on issuing permits was 4,224. To arrive at an hourly cost the cost to issue the permit, the cost per hour was calculated by dividing $297,085 by the hours to issue the permit of 4,225, equaling $70.32 per hour.

The fees proposed in the 2005 study were changed to be based on the amount of impervious surface and the square feet of clearing and grading to be done as well as increasing the number of levels to four. The next step in the 2005 study was to establish the average number of hours spent on issuing the four new permit levels. An important point to note is that permit fees 1 and 2 were set to recover their full cost but levels 3 and 4 were set below the estimated cost of issuance. The 2005 report states that data were not detailed enough to accurately establish full cost recovery for levels 3 and 4. Table 10-30 provides the number of hours upon which the permit fee was based. As mentioned previously, level 3 and 4 hours are lower than would be assuming full cost recovery.

Table 10-30. 2005 permit fee hour basis

Permit level	Hours to complete permit
Level 1 permit (fee per site)	1.6
Level 2 permit (fee per site)	4.5
Level 3 permit (fee per site)	9.0
Level 4 permit (fee per acre)	12.0

The calculated hourly rate was multiplied by the hours to complete to establish the permit fees for the four permit levels. Table 10-31 provides the permit fees resulting from the 2005 study.

Table 10-31. Current permit fees (2005 study)

Permit level	Amount of impervious surface	Amount of clearing and grading	Current fee
Level 1 permit (fee per site)	300–1,000 ft^2	500–5,000 ft^2	$113.00
Level 2 permit (fee per site)	1,000–5,000 ft^2	5,000–30,000 ft^2	316.00
Level 3 permit (fee per site)	5,000 ft^2–1 acre	More than 30,000 ft^2	633.00
Level 4 permit (fee per acre)	More than 1 acre	NA	844.00

HDR's opinion is that the 2005 study calculated the permit fees using generally accepted methods. Levels 3 and 4 were not set at a level to achieve full cost recovery, which left approximately $90,000 to be recovered from general rate revenue.

10.9.3 Proposed Permit Fee Methodology

HDR's proposed method is similar to the 2005 study but has grouped costs and arrived at the number of hours per permit in a slightly different way. The 2005 study was helpful in establishing the new fees as it gave a means of comparison. Steps used to accumulated costs for the permit fee calculation are provided below:

1. Identify capital investment made to provide service
2. Estimate direct labor costs, including salary, benefits, sick and vacation leave, and training
3. Determine other direct costs such as vehicles, fuel, and maintenance of equipment
4. Determine indirect costs such as other department support services, finance, legal, and human resources

No capital costs were associated with permit fee issuance. Two FTEs are allocated to perform permits for the stormwater utility, one engineer and one inspector. Salaries for the engineer and inspector staff were assumed to be approximately $95,000 and $75,000, respectively. Benefits were assumed to be approximately 55 percent of each FTE's salary. These benefits include health and dental insurance and retirement. The percentage for benefits was calculated by comparing budgeted salaries to budgeted benefits for the Public Works department. Also included in the costs was 41 percent of salary to account for indirect costs such as rent paid to the general fund for office space, transportation costs, equipment, and other general government costs charged to the utility like purchasing, legal, and information technology costs. Table 10-32 lists the estimated permit costs based on salary, 55 percent benefits, and 41 percent overhead.

Table 10-32. Estimated permit costs

Cost component	Engineer	Inspection	Total
Salary	$95,228	$74,725	$169,952
Benefits (55% of salary)	52,375	41,099	93,474
Overhead (41% of salary)	39,043	30,637	69,680
Total permit costs per FTE	$186,646	$146,460	$333,106

Establishing the Weighted Average Hourly Cost

The next step in the process is to establish the hours of working time for the two FTEs. FTEs are paid for 2,080 hours per year. However, the FTE does not have all of those hours available to devote to permitting activities because he/she also has paid time off for holidays, sick leave, and vacation. An average number of days of paid leave per FTE was assumed to be 28 days total. Deducting paid time off, 1,856 hours remained per FTE, equaling 3,712 hours for two FTEs.

Dividing the total permit costs by the total available hours for permit issuance, an average cost per hour was calculated to be $89.74.

Five years of permit history was reviewed to establish an average number of permits per year. The assumed number of permits per permit level is an important factor in establishing the new fees. Table 10-33 contains the 5 years of stormwater permit data.

Table 10-33. 5-year historical stormwater permits

Permit level	2015	2016	2017	2018	2019	5-year average
Level 1	352	260	260	469	409	350
Level 2	178	224	265	214	171	210
Level 3	18	28	36	35	36	31
Level 4 (acres)	7	12	38	12	22	18
Total # of permits	555	524	599	730	638	609

Establishing the Hours to Issue Permits

The next step in the fee calculation was to determine the average time spent on each level of permit. There are a few ways of determining hours per permit, including surveying staff to get an opinion of the time spent on each type of permit, which was done in 2005, and establishing allocation factors. The new calculation for the permit fees was done using the allocation factor method. The two variables used to calculate allocation factors were number of permits and area of impervious surface. The principle behind this method is similar to the process used in the cost-of-service analysis performed to establish stormwater rates. It was assumed that 25 percent of the cost to issue permits was simply a function of the number of permits, while 75 percent of the cost of permit issuance was related to the size of the impervious area. These two allocation factors are provided in Table 10-34 below.

Table 10-34. Allocation factors

Permit level	Number of permits	Percent of permits	Impervious ft^2/permit level	Percent ft^2
Level 1	350	57%	227,500	10%
Level 2	210	34%	630,000	26%
Level 3	31	5%	752,680	31%
Level 4	18	3%	784,080	33%
Total	609	100%	2,394,260	100%

The allocation percentages from the table above are then multiplied by the allocation weighting and then again by the total number of permit hours. Table 10-35 below shows the hours allocated to each level of permits as well as the two allocation factors.

Table 10-35. Distribution of allocated costs

Permit level	Hours based on number of permits	Hours based on ft^2 of permits	Total permit hours
Percent allocation weighting	25%	75%	
Level 1	533	265	798
Level 2	320	733	1,053
Level 3	47	875	922
Level 4	27	912	939
Total hours	928	2,784	3,712

Once total hours are allocated to the different levels of permits, they are divided by the number of permits to arrive at the average hours per permit level. The hours per permit are then multiplied by the average cost per hour to arrive at the new fee. Table 10-36 provides the assumed hours per permit level and the new fees at three levels: full cost recovery, the fee with 25 percent subsidy (75 percent of full cost recovery), and the fee with a 50 percent subsidy (50 percent of full cost recovery).

Table 10-36. Proposed permit fee

Permit level	Hours/permit	New fee: full cost recovery	New fee: 25% subsidy	New fee: 50% subsidy
Level 1	2.3	$205	$153	$102
Level 2	5.0	$450	$337	$225
Level 3	29.8	$2,670	$2,003	$1,335
Level 4	52.2	$4,682	$3,512	$2,341

Now that the fees have been recalculated and are set to recover the full cost of permit issuance, it is important that the fees be updated so that the fee revenue keep up with the cost. Eighty percent of the cost of permit issuance is for salary and benefits. It is recommended that the fee be updated annually by increasing the fee by either the CPI published by the U.S. Bureau of Labor and Statistics for the Seattle/Tacoma/Bellevue metropolitan statistical area, or a weighted average of salaries and benefits with the weighting of 65 percent and 35 percent, respectively. The City's budget office would likely have calculated an assumed increase in salary and benefits as a part of the budget process.

10.9.4 Conclusion

The City's stormwater management system is operated as an enterprise fund, which means that it is a self-sustaining entity. As a self-sustaining entity rates and fees are the sole source of funding and are critical to the effectiveness and efficiency of utility operation.

The stormwater management system must fund two key functions, operating the utility on a day-to-day basis and constructing and expanding the system to meet the goals and objectives of the City and utility. Sufficient rates are necessary to fund these key functions.

A major consideration with the level of rates proposed was to provide sufficient revenue to meet the requirements of the City's Phase II Permit addressing TMDL limits for Lake Whatcom and support the City's goals and objectives for the stormwater management system. To address this issue additional personnel have been proposed for the Small, Medium, and Large CIP scenarios to fill resource gaps identified for the City's Phase II Permit program.

In addition to the City's Phase II Permit program, capital funding was a concern for the City. The City recognizes that maintaining its current infrastructure is an effective cost-saving activity that prevents catastrophic system failures in the future. Much of the capital projects proposed in the three capital scenarios are intended to repair deficiencies that hinder the operation of the system and to make improvements to the system so that it meets the City's high standard of stewardship of the environment. The City has undoubtedly avoided higher costs by keeping its stormwater system in good working order. It is strongly recommended the City continue to invest in its stormwater system to prevent possible future system failures and the subsequent higher cost.

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Appendix A. Hydrologic Model Review Technical Memorandum

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Memorandum

To: Brian Ward, HDR

From: Larry Karpack, PE; Colin Butler, EIT

Date: July 31, 2019

Re: Comprehensive Stormwater Plan Update, Task 300 - Hydrologic Model Assessment

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INTRODUCTION

Watershed Science and Engineering (WSE) obtained and reviewed existing hydrologic and hydraulic models developed for the City of Bellingham (City) as part of the City's 2007 Stormwater Comprehensive Plan Update (CCS, 2007). Model input and output files, available documentation, and supporting data were provided to WSE by the City. The objective of this task was to provide an assessment of the City's existing hydrologic and hydraulic models and determine their potential for use in completing the modeling and analyses needed to support Task 400 of the current Comprehensive Stormwater Plan Update, specifically for analysis of Lower Padden Creek, Lower Squalicum Creek, Lower Baker Creek, Lower Spring Creek, and Baker Creek Tributary. WSE's assessment identifies issues and data gaps with the existing models and provides a recommendation for developing updated hydrologic and hydraulic modeling to support Task 400. A scope and budget for that work is also provided.

MODEL ARCHIVE

The City provided WSE with a CD containing archived hydrologic and hydraulic models and data from the 2007 Comp Plan Update (CCS, 2007). The archive generally contains: Western Washington Hydrology Models (WWHM) and supporting data for many of the basins, stormwater infrastructure data (nodes and connectors) files in PCSWMM format for stormwater conveyance systems in most sub-basins, and corresponding GIS data layers for many of the sub-basins. The archive does not contain input files that can be directly run in current versions of PCSWMM or EPA-SWMM, and the process for opening the model files in WWHM3 as described in the 2007 report was not successful.

The model files and supporting data vary by sub-basin. Below is a summary of the data included on the CD provided to WSE:

- WWHM folders
  - Chuckanut Creek (PreChuck.uci – WWHM User Control Input file)
  - Padden Lower (PrePadden.uci – WWHM User Control Input file, includes Padden Upper)
  - Silver (PreSilver.uci – WWHM User Control Input file)
  - Silver Beach Creek (PreSilver Beach Creek.uci – WWHM User Control Input file for calibration only)
  - Squalicum (no WWHM User Control Input file)
  - Whatcom (no WWHM User Control Input file)

- Soils Data
    - Whatcom Soils – includes GIS and assorted other mapping files. This directory also includes apparently misplaced files such as cross section data (Station-Elevation) and a model calibration report for Whatcom Creek.
- Land Use sub-folders containing GIS data
    - Chuckanut Creek
    - Padden
    - Silver
    - Squalicum
    - Whatcom
- Stormwater system data consisting of nodes and arcs (Shapefiles)
    - Padden (Lower and Upper)
    - Silver Creek
    - Squalicum (& Baker)
    - Whatcom
- HY-8 (culvert analysis) files/models corresponding to culverts in the WWHM model
    - Chuckanut Creek (12 total input files)
- SWMM files - SWMM directories with data but not model input files
    - Chuckanut Creek
    - Padden (Upper and Lower)
    - Silver Creek
    - Silver Beach Creek Calibration (plus many other SWMM files that have no useful identifiers)
    - Squalicum (& Baker, & Spring)
    - Whatcom (& Cemetery, & Fever, & Hannah)
- PCSWMM 2005 Profiles (cannot be opened in the current version of PCSWMM; it is not clear what these are)
    - Baker1
    - Cemetery
    - Fever Creek
    - Hannah
    - Padden
    - Squal
    - Whatcom
- PCSWMM 2005 Views (cannot be opened in the current version of PCSWMM; it is not clear what these are)
    - Baker
    - Cemetery Creek
    - Fever Creek
    - Hannah
    - Padden Lower
    - Padden Upper

- Silver
- Squal-Rest
- Whatcom Main

MODEL REVIEW

The models contained in the archive were reviewed with respect to the objectives of this task. The following summarizes that review:

WWHM Hydrologic Models – WWHM input files are available for the following basins: Chuckanut Creek, Padden Creek (Lower and Upper), Silver Creek, Silver Beach Creek. These models are assumed to use land cover data corresponding to the existing conditions development at the time of the 2007 study. Models for these sub-basins could be run to generate existing conditions (2007) inflows to the stormwater system. The models could be modified to use future conditions (full build out) land cover assumptions.

For the other sub-basins, specifically Whatcom Creek and Squalicum Creek (including Baker and Spring Creeks), the archive included WWHM folders and *.whm files that could be opened but WSE was not able to get these to run in WWHM2012 no working WWHM models were found in the archive. Soils and land-use information in various formats was found in the archive, but it is not clear whether these data could be used directly to develop a WWHM model or not.

The 2007 Comp Plan Report described calibration of the WWHM models for Silver Beach Creek and Whatcom Creek. Only the Silver Beach Creek WWHM model files were found in the archive. The Whatcom Creek calibration may have been performed in a separate, earlier study (2006). That study was not obtained or reviewed as part of this task.

The 2007 Comp Plan report provides summary tables listing sub-basin acreages and pervious and impervious area breakdowns for the Silver Creek, Squalicum Creek, Baker Creek, Silver Beach Creek, Whatcom Creek, Padden Creek (upper and lower), Chuckanut Creek basins. The report does not provide any additional description of the existing conditions hydrology.

SWMM Hydraulic Models –no valid PCSWMM or EPA-SWMM model input files were found in the archive for any of the basins. The model archive included the following SWMM directories with various data files: Chuckanut Creek, Padden (Upper and Lower), Silver Creek, Silver Beach Creek Calibration, Squalicum (& Baker, & Spring), and Whatcom (& Cemetary, & Fever, & Hannah). It is possible that some of the files included in the archive can be run using customized and/or proprietary versions of SWMM. WSE attempted to open many of the files using the latest versions of EPA –SWMM and PCSWMM. WSE also attempted to convert the files from earlier versions of SWMM to the newer versions. None of these attempts were successful.

RECOMMENDATION FOR USE OF THE 2007 HYDOLOGIC AND HYDRAULIC MODELS

WWHM hydrologic models of existing (2007) conditions for the Chuckanut Creek, Padden Creek (Lower and Upper), Silver Creek, Silver Beach Creek basins are available. These could be used to develop hydrologic inputs for stormwater modeling of those systems under 2007 land-use conditions. Note, however, that the 2019 Comprehensive Stormwater Plan Update is evaluating system capacity under future (full build-out) conditions. It is anticipated that updates to the models of the four basins listed above to simulate full build-out conditions would be relatively straightforward. Updating the WWHM models of the Whatcom Creek and/or Squalicum Creek basins would be more difficult and would rely on being able to locate the actual WWHM models for those basins or all of the necessary input data. Given this, it might be simpler to set up new WWHM models from scratch to estimate runoff from those basins consistent with the work currently being done under Task 500 of the 2019 Comprehensive Plan Update.

As noted previously the model archive provided to WSE does not include any SWMM model input files that can be directly used in current versions of SWMM. Furthermore the 2007 Comp Plan report provides limited detail on how the data for the SWMM models were derived. Some of the data apparently came from the City's GIS system but other data was obtained from an earlier 1995 study. The 2007 report also states that "Missing or incomplete GIS conveyance system data were filled based on adjacent data." It is not clear what this statement means or how adjacent system data were used to establish conveyance system characteristics (pipe sizes, materials, invert elevations, etc.). The 2007 report also states the following:

> As discussed in the computer model methodology section, GIS data were most readily available for the Whatcom Creek Basin, but not available for much of the drainage area outside of that basin. Therefore, model results identifying system deficiencies are more reliable for the Whatcom Creek Basin than for the other basins. However, even within the Whatcom Creek Basin, GIS data were not available for portions of the existing conveyance system and had to be interpolated as discussed earlier in this report. With the available conveyance system data, model results in other basins are considered conceptual and intended for planning-level decision-making only. These results for the other basins are not considered detailed enough to generate reliable cost opinions at this time.

Given the lack of useable SWMM model input files, the lack of clear documentation on how the SWMM model input data were derived, and the statement that the 2007 models were only "conceptual and intended for planning-level decision-making," it is WSE's opinion that creating new SWMM models would be more efficient and cost effective than spending any additional effort to locate or use the earlier SWMM models. Therefore a draft scope and budget to develop PCSWMM models for the Lower Padden Creek, Lower Squalicum Creek, Lower Baker Creek, Lower Spring Creek, and Baker Creek Tributaries is provided below.

DRAFT SCOPE FOR ADDITIONAL HYDROLOGIC AND HYDRAULIC MODELING

Objective

The objective of this work is to evaluate the conveyance capacity of the Lower Padden Creek, Lower Squalicum Creek, Lower Baker Creek, Lower Spring Creek, and Baker Creek Tributary systems. Hydrologic and hydraulic models will be developed and used to evaluate current and full build out conditions capacity of each of the conveyance systems and conceptually size conveyance improvements needed to adequately convey full build out flows.

Sub-Tasks

1. WSE will develop WWHM2012 hydrologic models for each of the drainage basins. A reasonable number of sub-basins will be delineated within each direct discharge basin to adequately

represent inflows to key points in the main storm trunk lines. WWHM models will be developed for existing conditions and full build out land-use conditions assuming no onsite stormwater quantity control.

2. Design flow hydrographs from each drainage sub-basin will be developed for the 2-, 10-, 25-, and 100-year events for existing and full buildout land-use conditions.

3. A list of data to be collected by City On-Call survey provider (if survey-grade data is required) or by city operations and maintenance personnel will be prepared and a schedule communicated. Guidance related to data collection will be provided as needed. Data needs will likely include:
    a. The distance from the catch basin or manhole rim to the invert of each pipe connected to the structure (measure-down) to the 1/10th of a foot accuracy in stormwater catch basins
    b. Pipe diameter
    c. Pipe material connected to the structure
    d. Identification of any damage within the structure

4. A PCSWMM hydraulic model will be developed for each storm drain trunk line and lateral lines down to 12 inches in diameter. Data from the City's GIS system will be used to define pipe sizes, materials, and invert elevations.

5. PCSWMM models will be run with the flow hydrographs described in bullet 2 to determine locations of flooding under existing and full buildout conditions. Flooding data for the 25-year future conditions flood will be summarized in a table and GIS shape files.

6. Pipe upgrades needed to eliminate flooding for events up to and including the 25-year full buildout conditions discharge will be determined. Potential flow paths for any overflows in the 100-year event will be delineated.

7. Model development, application, and results including data gaps and uncertainties, will be summarized in a technical memorandum. Deliverable will include:
    a. Excel spreadsheet highlighting pipe segments that are capacity constrained.
    b. GIS maps of each system highlighting pipe segments that are capacity constrained.

Assumptions

1. The City will provide the following data for use in this work:
    a. Topographic data and pipe network data at a scale as needed to delineate drainage basins and sub-basins
    b. Aerial photographs for use in delineating land-cover
    c. Soils data for the area of interest
    d. Impervious area coverages
    e. Pipe invert, material, size, and condition information for all pipes to be included in the storm trunk line model
    f. Full buildout land-use assumptions for use in the modeling (e.g. zoning or other information).

2. If pipe invert elevation data do not exist, the City will obtain these data or it will be assumed that all pipes are installed with 2 feet of cover to the ground surface (as determined from the topographic map). If pipe size and material information do not exist, the City will obtain and provide these. If pipe condition information does not exist, all pipes will be assumed to be in fair condition.
3. Conceptual designs will assume that the same pipe material is used as the pipe that is being upsized. All conceptual designs will assume circular pipes with inverts set such that there is a minimum of 18 inches of cover over the pipe.

Deliverables

- Excel spreadsheet highlighting pipe segments that are capacity constrained
- Maps of each basin highlight pipe segments that are capacity constrained
- Modeling report describing the approach and findings of the conveyance system modeling

DRAFT BUDGET FOR ADDITIONAL HYDROLOGIC AND HYDRAULIC MODELING

The scope of work described above can be completed for an estimated cost of $90,000 to $250,000. This budget estimate was developed based on WSE's experience modeling the nine marine outfalls under Task 500. If the City prefers a different level of analysis or additional deliverables, the scope and budget would need to be adjusted accordingly.

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Appendix B. Phase II Permit Gap Analysis

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Key		Acronyms & Abbreviations
Existing Requirement	This permit condition was present in the 2015 NPDES Permit.	BMP = best management practice COB = City of Bellingham DCD = Department of Community Development Ecology = Washington State Department of Ecology IDDE = illicit discharge detection and elimination LID = low impact development MOU = memorandum of understanding MS4 = municipal separate sewer storm system NOI = Notice of Intent NPDES = National Pollutant Discharge Elimination System PIC = Pollution Identification and Correction Program SMAP = Stormwater Action Management Plan SWMMWW = Stormwater Management manual for Western Washington SWMP = Stormwater Management Program SWPPP = stormwater pollution prevention plan TDML = total maximum daily load
New Requirement	This permit condition was not present in the 2015 NPDES Permit, and is new for the 2019 NPDES Permit.	
☐	This permit condition was not found during Gap Analysis. See descriptions of **Gap** and **Recommendation** for further actions.	
✓	This permit condition is met. No further action required.	
Compliance Improvement	Generally the permit condition is met; however modifications will improve COB's reporting and demonstration of compliance.	
Agenda item with COB to discuss New Requirement.	This terminology pertains to New Requirements for the 2019 NPDES Permit. HDR and COB to develop recommendations for meeting new Permit requirement.	

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S1 PERMIT COVERAGE AREA AND PERMITTEES			
S1.D.2	February 1, 2018	Application	✓ (a). Operators of regulated small municipal separate sewer storm systems (MS4s) have submitted or shall submit to Washington Department of Ecology (Ecology) either a Notice of Intent (NOI) for Coverage under National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater General Permit or a Duty to Reapply – NOI.
S2 AUTHORIZED DISCHARGES			
			This section describes the variety of discharges that are covered under the Permit, and the discharges that may travel to surface waters and to ground waters of the state. No documentation required.
S3 RESPONSIBILITIES OF PERMITTEES			
			This section describes how Permittees are responsible for compliance with the Permit. No documentation required.
S4 COMPLIANCE WITH STANDARDS			
S4.F	Immediate	Documentation	✓ Section F describes the actions to take if a discharge occurs in non-compliance with the Permit. **Citation:** A stormwater hotline number is posted on the City's website (https://www.cob.org/contacts/Pages/pw.aspx) and also publicized on the newer storm drain markers throughout the City. **Compliance Improvement:** Formal documentation of how the City responds to discharges is not available. **Recommendation**: Formal documentation in the form of a standard operating procedure or similar would demonstrate the City's compliance with the defined actions.

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S5 STORMWATER MANAGEMENT PROGRAM FOR CITIES, TOWNS, AND COUNTIES			
S5.A STORMWATER MANAGEMENT PROGRAM PLAN			
S5.A.1	Immediate	Documentation	Stormwater Management Program (SWMP) – Geographic Area. **(Existing Requirement)** ✓ COB's SWMP applies to the geographical incorporated area of the city. **Citation**: 2018 City of Bellingham COB. BMC 15.42 **Gap**: None. **Recommendation**: None.
S5.A.2	Annually	Documentation	SWMP – Documentation. **(Existing Requirement)** (a) Include description of planned activities for each program component in S5.C. [See S5.C of this document for documentation compliance with each Section.] ✓ (b) Include description of any additional planned actions to meet the requirements of applicable total maximum daily loads (TMDLs) pursuant to S7 *Compliance with Total Maximum Daily Load Requirements.* [See S7 of this document for documentation compliance with this Section.] ✓ (c) Include description of any additional planned actions to meet the requirements of S8 *Monitoring and Assessment*. **Citation:** https://www.cob.org/services/planning/environmental/pages/stormwater-program.aspx . **Compliance Improvement:** Effective August 1, 2019, several new permit requirement take effect; consequently the SWMP will need to be updated accordingly. **Recommendation**: Recommend COB to conduct an independent review of the draft 2019 SWMP to verify it captures all of the new requirements.
S5.A.3	a. Immediate b. August 1, 2019	Record Keeping	SWMP – Information Management. **(Existing Requirement with new condition)** ☐ (a) Each permittee shall track the cost or estimated cost of development and implementation of each component of the SWMP. This information shall be provided to Ecology upon request. **Citation:** None. **Gap:** COB does not track all related costs or estimate the costs of Stormwater Management Program. **Recommendation**: Recommend COB develop a system for tracking all related costs and estimated costs related to the SWMP ☐ (b) Each Permittee shall track the number of inspection, follow-up actions as a result of inspections, official enforcement actions and types of public education activities as required by the respective program component. This information shall be included in the annual report. **Citation:** Unable to locate in 2018 NPDES Annual Report. COB uses a Stormwater Hotline to report pollution. COB inspects stormwater lines with video and collects data of all assets. The process is repeated every 7 years. Based on these inspections, each pipe segment is assigned a point-value that is entered into the Pavement & Utility Replacement database to determine what storm drain system should be prioritized for retrofits. **Gap:** The SWMP Annual Report aggregates and describes some inspections, enforcement actions, and public education activities; however it does not track each of these items individually as required by the permit, nor is it tracking follow-up actions. (Effective August 1, 2019, COB must also track follow-up actions as well.) **Recommendation**: Recommend COB to disaggregate the respective records from the TrakIT software program, begin tracking follow-up actions as a result of inspections, and include in the SWMP Annual Report.
S5.A.4	Immediate	Record Keeping	SWMP – Implementation. **(Existing Requirement)** ✓ The City continues to implement the SWMP until the updated version is implemented. **Citation**: BMC 1.01.080 **Gap**: None. **Recommendation**: None.

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S5.A.5	a. Immediate b. March 31, 2021	Documentation	SWMP – Coordination among agencies. **(Existing Requirement)** a. Coordination among entities covered under municipal stormwater NPDES permit, including: ✓ i. Coordination mechanisms clarifying roles and responsibilities for the control of pollutants between physically interconnected MS4s covered by a municipal stormwater permit. **Citation:** NA; COB does not have interconnected MS4s. **Gap:** None. **Recommendation:** None. SWMP – Coordination among agencies. **(Existing Requirement)** ✓ ii. Coordinating stormwater management activities for shared water bodies, or watersheds among Permittees to avoid conflicting plans, policies, and regulations. **Citation:** COB participates in the Lake Whatcom Management Program with Whatcom County and Lake Whatcom Water and Sewer District to protect Lake Whatcom as a drinking water source. Collaboration includes purchasing a high-efficiency street sweeper that is shared between four NPDES Phase II permit holders in Whatcom County. **Gap:** None. **Recommendation**: None. SWMP – Interdepartmental coordination. **(New Requirement)** ☐ b. Coordination mechanisms among departments within each jurisdiction to eliminate barriers to compliance with the terms of this permit. Permittees shall include a written description of internal coordination mechanisms in the Annual Report. **Citation:** None. Should be included in the SWMP **Gap:** This is a new requirement for the 2019 permit. **Recommendation**: Beginning in 2021 or sooner, include in the Annual report to Ecology meeting minutes and decision logs demonstrating cross-departmental coordination.
S5.B DISCHARGE REDUCTION			
			This section describes how the SWMP shall be designed to reduce pollutant discharge. No documentation required.
S5.C.1 COMPREHENSIVE STORMWATER PLANNING			
S5.C.1.a	August 1, 2020	Policy Development and Implementation	Stormwater planning interdisciplinary team. **(New Requirement)** ☐ Convene an interdisciplinary team to inform and assist in the development, progress, and influence of this program. **Citation:** None. Should be included in the SWMP **Gap:** No team has yet formed. **Recommendation:** Convene a team, establish a meeting frequency, roles and responsibilities, etc. (create a team charter).
S5.C.1.b.i.	(a) March 31, 2021 (b) January 1, 2023	Documentation	Coordination with long-range plan updates. (**New Requirement)**. ☐ (a) The Permittee shall respond to the series of Stormwater Planning Annual Report questions to describe how anticipated stormwater impacts on water quality were addressed, if at all, during the 2013–2019 permit term **Citation:** None. Should be included in the SWMP **Gap:** This is a new requirement for the 2019 permit. **Recommendation:** Include responses to questions in the permit. ☐ (b) The Permittee shall submit a report responding to the same questions included in (a), above, to describe how water quality is being addressed, if at all, during this permit term in updates to the Comprehensive Plan (or equivalent) and in other locally initiated or state-mandated, long-range land use plans that are used to accommodate growth or transportation. **Citation:** None. **Gap:** This is a new requirement for the 2019 permit. **Recommendation:** Include the findings and recommendations from the city-wide Water Quality Prioritization project.

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S5.C.1.c	i. Immediate ii. December 31, 2023	i. Documentation ii. Policy Development and Implementation	Low impact development (LID) code-related requirements **(New Requirement)**. i. By updating, revising and developing new local development related codes, rules, standards or other documents, LID principles and LID best management practices (BMPs) will become the preferred and commonly-used approach for site development focusing on minimizing impervious surfaces, native vegetation loss, and stormwater runoff. ☐ (a) Annually, assess and document any newly identified administrative or regulatory barriers to implementation of LID principles or LID BMPs, and the measures developed to address the barriers. If applicable, the report shall describe mechanisms adopted to encourage or require implementation of LID principles or LID BMPs. **Citation:** None. **Gap:** This is a new requirement for the 2019 permit. **Recommendation:** In the annual report, describe code review methods. ☐ ii. Review, revise, and make effective codes, rules, standards, or other enforceable documents to incorporate and require LID principles and LID BMPs. A summary of results must be submitted with the annual report no later than March 31, 2024, and list participants, codes, rules, standards, and other enforceable documents revisions and existing requirements that incorporate and require LID principles and BMPs, organized as follows: (a) Measures to minimize impervious surfaces. (b) Measures to minimize loss of native vegetation. (c) Other measures to minimize stormwater runoff. **Citation:** None. **Gap:** This is a new requirement for the 2019 permit. **Recommendation:** In the annual report, describe code review methods.

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S5.C.1.d	i. March 31, 2022 ii. June 30, 2022 iii. March 31, 2023	Record Keeping	Stormwater Management Action Planning. **(New Requirement)** ☐ (i) *Receiving water basin assessment.* Permittees shall document and assess existing information related to local receiving waters and contributing area conditions to identify receiving waters that will benefit from stormwater management planning. Submit a watershed inventory and include a brief description of the relative conditions of the receiving waters and the contributing areas. **Citation**: None. **Gap**: This is a new requirement for the 2019 permit. **Recommendation**: Include the findings and recommendations from the city-wide Water Quality Prioritization project. ☐ (ii) *Receiving water basin prioritization.* Prioritize and rank identified water basins that would benefit from implementation of stormwater facility retrofits and management actions to reduce pollutant loading and address hydrologic impacts from existing development. **Citation**: None. **Gap**: This is a new requirement for the 2019 permit. **Recommendation**: Include the findings and recommendations from the city-wide Water Quality Prioritization project. ☐ (iii) *Stormwater Management Action Plan* (SMAP). Develop a SMAP for at least one high priority area that identifies the following: (a) A description of the stormwater facility retrofits needed for the area, including the BMP types and preferred locations. (b) Land management/development strategies and/or actions identified for water quality management. (c) Targeted, enhanced, or customized implementation of stormwater management actions related to permit sections within S5, including: • IDDE field screening, • Prioritization of Source Control inspections, • Operations & Maintenance (O&M) inspections or enhanced maintenance, or • Public Education and Outreach behavior change programs. Identified actions shall support other specifically identified stormwater management strategies and actions for the basin overall, or for the catchment area in particular. (d) If applicable, identification of changes needed to local long-range plans, to address SMAP priorities. (e) A proposed implementation schedule and budget sources for: • Short-term actions (*i.e.*, actions to be accomplished within 6 years), and • Long-term actions (*i.e.*, actions to be accomplished within 7 to 20 years). (f) A process and schedule to provide future assessment and feedback to improve the planning process and implementation of procedures or projects. **Citation**: None. **Gap**: This is a new requirement for the 2019 permit. **Recommendation**: Include the findings and recommendations from the city-wide Water Quality Prioritization project.
S5.C.2 PUBLIC EDUCATION AND OUTREACH			
S5.C.2.a.i	Immediate	Documentation	Education and outreach program – General Awareness. (**Existing Requirement**, a few revisions to it including the ongoing/strategic schedule requirement) ✓ General awareness. To build general awareness, Permittees shall annually select at a minimum one target audience and one subject area. Permittees shall provide subject area information to the target audience on an ongoing or strategic schedule. **Citation**: https://www.cob.org/Documents/pw/environment/water-quality/Report%20and%20SWMP.pdf (pgs. 5-11). **Gap:** None. **Recommendation:** None.

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S5.C.2.a.ii	(a) Immediate	Documentation	Education and outreach program – Behavior Change. (**Existing Requirement**) ✓ (a) Target Audiences and BMPs. To affect behavior change, Permittees shall select, at a minimum, one target audience and one BMP: **Citation**: https://www.cob.org/Documents/pw/environment/water-quality/Report%20and%20SWMP.pdf (pgs. 5-11) **Gap**: None. **Recommendation**: None.
	(b) July 1, 2020	Evaluation	Education and outreach program – Behavior Change. (**New Requirement**) ✓ (b) Each permittee shall conduct a new evaluation of the effectiveness of the ongoing behavior change program. This evaluation may not be required if COB selects option S5.C.2.a.ii.(c)3 and it will not add value to the overall behavior change program. **Citation:** None. **Gap**: This is a new requirement for the 2019 permit. **Recommendation**: Develop and implement an annual survey that measures the effectiveness of the city's education and outreach campaigns.
	(c) February 1, 2021	Documentation (program and program evaluation plan)	Education and outreach program – Behavior Change. (**New Requirement**) ✓ (c) Each permittee shall: 1. Develop a strategy and schedule to more effectively implement the existing behavior change program; or 2. Develop a strategy and schedule to expand the existing program to a new target audience or BMPs; or 3. Develop a strategy and schedule for a new target audience and BMP behavior change campaign. **Citation:** Bellingham Outreach team is developing the program. **Gap**: None. **Recommendation**:
	(d) April 1, 2021		Education and outreach program – Behavior Change. (**New Requirement**) ☐ (d) Begin to implement the strategy developed in c. **Citation:** None **Gap**: This is a new requirement for the 2019 permit. **Recommendation:** Update the annual report with details about the Education and Outreach program survey.
	(e-f) March 31, 2024		Education and outreach program – Behavior Change. (**New Requirement**) ☐ (e) Evaluate and report on the changes in understanding and adoption of targeted behaviors resulting from the implementation of the strategy and any planned or recommended changes to the program in order to be more effective; describe the strategies and process to achieve the results. ☐ (f) Use results of the evaluation to continue to direct effective methods and implementation of the ongoing behavior change program. **Citation:** None. **Gap**: This is a new requirement for the 2019 permit. **Recommendation**: By the effective date, update the annual report that describes how the city is adapting its program based on survey results.
S5.C.2.a.iii	Immediate	Documentation	Education and outreach program – Stewardship. (**Existing Requirement**) ✓ Stewardship: Each Permittee shall create and advertise stewardship opportunities and/or partner with existing organizations to encourage residents to participate in activities or events planned and organized within the community, such as: stream teams, storm drain marking, volunteer monitoring, riparian plantings, and education activities. **Citation**: https://www.cob.org/Documents/pw/environment/water-quality/Report%20and%20SWMP.pdf (pg. 15) **Gap**: None. **Recommendation**: None.

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S5.C.3 PUBLIC INVOLVEMENT AND PARTICIPATION			
S5.C.3.a	Immediate	Policy Development and Implementation	**(Existing Requirement)** ✓ Opportunities for the public, including over-burdened communities, to participate in the decision-making processes involving the development, implementation and update of the SWMP. **Citation**: https://www.cob.org/Documents/pw/environment/water-quality/Report%20and%20SWMP.pdf (pg. 15) **Gap**: None. **Recommendation**: None.
S5.C.3.b	Immediate	Documentation	**(Existing Requirement)** ✓ The SWMP and annual report are to be posted on the website by May 31 each year. **Citation**: https://www.cob.org/services/planning/environmental/Pages/stormwater-program.aspx **Gap**: None. **Recommendation**: None.
S5.C.4 MS4 MAPPING AND DOCUMENTATION			
S5.C.4.a	Immediate	Record Keeping	**(Existing Requirement)** ✓ Ongoing mapping: Each Permittee shall maintain mapping data for the features listed below: i. Known MS4 outfalls and known MS4 discharge points. ii. Receiving waters, other than groundwater. iii. Stormwater treatment and flow control BMPs/facilities owned or operated by the Permittee. iv. Geographic areas served by the Permittee's MS4 that do not discharge stormwater to surface waters. v. Tributary conveyances to all known outfalls and discharge points with a 24-inch nominal diameter or larger, or an equivalent cross-sectional area for non-pipe systems. vi. Connections between the MS4 owned or operated by the Permittee and other municipalities or public entities. vii. All connections to the MS4 authorized or allowed by the Permittee after February 16, 2007. **Citation:** BMC 15.42.060 **Gap**: None. **Recommendation**: None.
S5.C.4.b	i. January 1, 2020 ii. August 1, 2023	Record Keeping	New mapping. **(New Requirement)** Each Permittee shall: ✓ i. Beginning on January 1, 2020, where known, map size and material for all known MS4 outfalls. **Citation:** City IQ Stormwater Utilities. **Gap:** This is a new requirement for the 2019 permit. **Recommendation**: Add a layer to City IQ explicitly identify pipe ends at creeks, lakes, or Bellingham Bay as outfalls. ✓ ii. No later than August, 1, 2021, complete mapping of all known connections from the MS4 to a privately owned stormwater system. **Citation:** None. **Gap:** This is a new requirement for the 2019 permit. **Recommendation**: Recommend COB to map MS4-private connections.

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S5.C.4.c	August 1, 2021	Record Keeping	Electronic mapping. **(New Requirement)** ✓ Beginning August 1, 2021, the required format for mapping is electronic, with fully described mapping standards. **Citation:** Maps are housed in the COB's geographic information system. **Gap**: None. **Recommendation**: None.
S5.C.4.d	Immediate	Record Keeping	**(Existing Requirement)** ✓ To the extent consistent with national security laws and directives, each Permittee shall make available to Ecology, upon request, available maps depicting the information required in S5.C.4.a through c, above. **Citation:** City IQ **Gap**: None. **Recommendation:** None.
S5.C.4.e	Immediate	Record Keeping	**(Existing Requirement)** ✓ Upon request, and to the extent appropriate, Permittees shall provide mapping information to federally recognized Indian tribes, municipalities, and other Permittees. This permit does not preclude Permittees from recovering reasonable costs associated with fulfilling mapping information requests by federally recognized Indian tribes, municipalities, and other Permittees. **Citation:** City IQ. **Gap**: None. **Recommendation:** None.
S5.C.5 ILLICIT DISCHARGE DETECTION AND ELIMINATION			
S5.C.5.a	Immediate	Documentation	**(New Requirement)** ✓ Procedures for reporting and correcting or removing illicit connections, spills and other illicit discharges when they are suspected or identified. **Citation:** COB performs outfall monitoring, internal camera investigation, employee trainings, citizen information, stream monitoring, and source tracking. 100% of the MS4 has been reviewed and are starting a second run through at an average of 13.5% screened each year. **Compliance Improvement**: Documentation for reporting and auditing purposes is not available. **Recommendation**: Establish defensible documentation to meet this requirement.
S5.C.5.b	Immediate	Documentation	**(Existing Requirement)** ✓ Permittees shall inform public employees, businesses, and the general public of hazards associated with illicit discharges and improper disposal of waste **Citation:** Information regarding the hazards associated with illicit discharges readily found on website for businesses here**:** https://www.cob.org/services/environment/source-control and for residents here: https://www.cob.org/services/environment/stormwater/pages/reduce-pollution.aspx **Gap**: None. **Recommendation**: None.

<table>
<tr><th>Permit Section</th><th>Compliance Date</th><th>Requirement Type</th><th>Description of Permit Condition</th></tr>
<tr><td rowspan="4">S5.C.5.c</td><td rowspan="4">Immediate</td><td rowspan="4">Policy Development and Implementation</td><td>(Existing Requirement)
✓ Each Permittee shall implement an ordinance or other regulatory mechanism to effectively prohibit non-stormwater, illicit discharges in the Permittee’s MS4 to the maximum extent allowable under state and federal law.
✓ (i) Allowable discharges.
Citation: Title 15 prohibits illicit discharge to the MS4. The code was last updated in 2017 (15.42.050). COB performs outfall monitoring, internal camera investigation, employee trainings, citizen information, stream monitoring, and source tracking. 100% of the MS4 has been reviewed and are starting a second run through at an average of 13.5% screened each year.
Gap: None.
Recommendation: None.</td></tr>
<tr><td>✓ (ii) Conditionally allowable discharges
Citation: Title 15 prohibits illicit discharge to the MS4. The code was last updated in 2017 (15.42.050).
Gap: None.
Recommendation: None.</td></tr>
<tr><td>✓ (iii) Discharges identified as significant sources of pollutants
Citation: Title 15 prohibits illicit discharge to the MS4. The code was last updated in 2017 (15.42.050).
Gap: None.
Recommendation: None.</td></tr>
<tr><td>✓ (iv) Escalating enforcement procedures and actions
Citation: Title 15 prohibits illicit discharge to the MS4. The code was last updated in 2017 (15.42.050).
Gap: None.
Recommendation: None.</td></tr>
<tr><td>S5.C.5.d</td><td>Immediate</td><td>Policy Development and Implementation</td><td>(Existing Requirement)
✓ Each Permittee shall implement an ongoing program designed to detect and identify non-stormwater discharges and illicit connections in the Permittee’s MS4. Program will include:
(i). Procedures for conducting investigations of the Permittee’s MS4, including field screening and methods for identifying potential sources. Procedures may also include source control inspections.
☐ (a) Complete field screening for an average of 12% of the MS4 per year. Track total percentage annually beginning August 1, 2019. (New requirement)
(ii). A publicly listed and publicized hotline or other telephone number for public reporting of spills and other illicit discharges.
(iii). An ongoing training program for all municipal field staff, who, as part of their normal job responsibilities, might come into contact with or otherwise observe an illicit discharge and/or illicit connection to the MS4, on the identification of an illicit discharge and/or connection, and on the proper procedures for reporting and responding to the illicit discharge and/or connection. Follow-up training shall be provided as needed to address changes in procedures, techniques, requirements, or staffing. Permittees shall document and maintain records of the trainings provided and the staff trained.
Citation: 2018 SWMP annual report.
Compliance Improvement: Formal documentation of how the City responds to discharges is not available
Gap: A new requirement for the 2019 Permit is that on average, 12% of the MS4 should be field screened each year and these percentages must be tracked annually.
Recommendation: Develop standard operating procedures explicitly describing how outfall field screening occur and include in the annual report a copy of the tracking data.</td></tr>
</table>

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S5.C.5.e	Immediate	Record Keeping	**(Existing Requirement)** Each Permittee shall implement an ongoing program designed to address illicit discharges, including spills and illicit connections, into the Permittee's MS4. Program will include: ☐ (i). Procedures for characterizing the nature of, and potential public or environmental threat posed by, any illicit discharges found by or reported to the Permittee. Procedures shall address the evaluation of whether the discharge must be immediately contained and steps to be taken for containment of the discharge. ☐ (ii). Procedures for tracing the source of an illicit discharge, including visual inspections, and, when necessary, opening manholes, using mobile cameras, collecting and analyzing water samples, and/or other detailed inspection procedures. ☐ (iii). Procedures for eliminating the discharge, including notification of appropriate authorities (as well as owners or operators of interconnected MS4s); notification of the property owner; technical assistance; follow-up inspections; and use of the compliance strategy developed pursuant to S5.C.3.b.v5.c.iv, including escalating enforcement and legal actions if the discharge is not eliminated. ☐ (iv). In the case of illicit discharge, compliance with the provisions in (i), (ii), and (iii), above, shall be achieved by meeting established timelines **Citation:** None. **Compliance Improvement:** Formal documentation does not exist. **Recommendation:** Develop Standard Operating Procedures for each sub-task.
S5.C.5.f	Immediate	Record Keeping	**(Existing Requirement)** ✓ Permittees shall train staff who are responsible for identification, investigation, termination, cleanup, and reporting of illicit discharges, including spills, and illicit connections, to conduct these activities. Follow-up training shall be provided as needed to address changes in procedures, techniques, requirements or staffing. Permittees shall document and maintain records of the training provided and the staff trained. **Citation:** COB requires biannual IDDE (Illicit Discharge Detection and Elimination) training for all municipal field staff. Public Works inspectors and supervisors have also been trained on illicit discharge identification and procedures. 65 employees are trained CESCLs (Certified Erosion and Sediment Control Lead). **Gap:** None. **Recommendation:** None.
S5.C.5.g	Immediate	Record Keeping	Record keeping. **(New Requirement)** ☐ In the annual report permittees will submit data for all illicit discharges investigated during the previous calendar year. The data will include information specified in Appendix 12 and the WQWebIDDE. **Citation:** None. **Compliance Improvement:** This is a new requirement from the 2019 permit. **Recommendation:** Recommend COB to develop Standard Operating Procedures for timing and protocols for uploading IDDE data to Ecology's WQWebIDDE database.
S5.C.6 CONTROLLING RUNOFF FROM NEW DEVELOPMENT, REDEVELOPMENT, AND CONSTRUCTION SITES			
S5.C.6.a	June 30, 2022	Policy Development and Implementation	**(Existing Requirement)** ✓ Implement an ordinance or other enforceable mechanism that addresses runoff from new development, redevelopment, and construction site projects. **Citation**: BMC 15.42.060 **Gap**: None. **Recommendation**: None.

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S5.C.6.b	June 30, 2022	Record Keeping	**(Existing Requirement)** The ordinance or other enforceable mechanism shall include, at a minimum: ✓ (i). The Minimum Requirements in Appendix 1, or the 2013 Appendix 1 amended to include the changes identified in Appendix 10, or a program approved by Ecology under the *2013 NPDES Phase I Municipal Stormwater Permit* and amended to include Appendix 10. **Citation:** BMC 15.42.070.A.3 **Gap:** None. **Recommendation:** None. ✓ (ii). The local requirements shall include the following: (a) Site planning requirements (b) BMP selection criteria (c) BMP design criteria (d) BMP infeasibility criteria (e) LID competing needs criteria (f) BMP limitations **Citation:** BMC 15.42.070.A.3 **Gap:** None. **Recommendation:** None. ✓ (iii). The legal authority to inspect and enforce maintenance standards for private facilities that discharge to the MS4. **Citation:** BMC 15.42.070.A.3 **Gap:** None. **Recommendation:** None.

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S5.C.6.c	Immediate	Record Keeping	**(Existing Requirement)** ✓ The program shall include a permitting process with site plan review, inspection and enforcement capability to the following standards: (i). Site plan review. (ii). Pre-clearing/construction inspection. (iii). Inspection of sites during construction. (iv). Inspection of treatment and flow control facilities during construction. (v). Inspection upon completion. (vi). Compliance determined by achieving 80% of required inspections during permit term. (vii). Procedures for record keeping. (viii). Enforcement strategy for issues of non-compliance. **Citation:** BMC 15.42.060.F.1 and 15.42.070.D. Qualified Public Works Department Inspectors visit the site prior to, during, and after construction. City also tracks inspections with permitting software, TrakIT. **Gap:** None. **Recommendation:** None.
S5.C.6.d	Immediate	Record Keeping	**(New Requirement)** ☐ The program shall make available, as applicable, the link to the electronic Construction Stormwater General Permit NOI form for construction activity and, as applicable, a link to the electronic Industrial Stormwater General Permit NOI form for industrial activity to representatives of proposed new development and redevelopment. Permittees shall continue to enforce local ordinances controlling runoff from sites that are also covered by stormwater permits issued by Ecology. **Citation:** Available on state websites. **Compliance Improvement:** Direction to forms is not available on the City's website**.** **Recommendation:** Recommend that COB to add active link to NOI form.
S5.C.6.e	Immediate	Record Keeping	**(Existing Requirement)** ☐ Each Permittee shall ensure that all staff whose primary job duties are implementing the program to control stormwater runoff from new development, redevelopment, and construction sites, including permitting, plan review, construction site inspections, and enforcement are trained to conduct these activities. Follow-up training must be provided as needed to address changes in procedures, techniques or staffing. Permittees shall document and maintain records of the training provided and the staff trained. **Citation**: None. **Gap**: While COB Public Works Department staff is trained on implementing BMPs, stormwater facility design, pollution prevention, stormwater code training, DOE manual training, and permit overview, there are no records, other than CESCL certifications, of training and city staff that has received it. **Recommendation**: Develop training database to track and report on completion of required training, follow-up training, certifications, etc.

<table>
<tr><th>Permit Section</th><th>Compliance Date</th><th>Requirement Type</th><th>Description of Permit Condition</th></tr>
<tr><td colspan="4">S5.C.7 OPERATIONS AND MAINTENANCE</td></tr>
<tr><td>S5.C.7.a</td><td>June 30, 2022</td><td>O&M</td><td>(Existing Requirement)
Each Permittee shall implement maintenance standards that are as protective, or more protective, of facility function than those specified in the Stormwater Management Manual for Western Washington or a Phase I program approved by Ecology. (New Requirement)
✓ (i) The purpose of the maintenance standard is to determine if maintenance is required. The maintenance standard is not a measure of the facility’s required condition at all times between inspections. Exceeding the maintenance standard between inspections and/or maintenance is not a permit violation. (Existing Requirement)
Citation: BMC 15.42 Stormwater Management.
Gap: None.
Recommendation: None.
☐ (ii) Unless there are circumstances beyond the Permittee’s control, when an inspection identifies an exceedance of the maintenance standard, maintenance shall be performed for the following standards (New Requirement):
• Within 1 year for typical maintenance of facilities, except catch basins
• Within 6 months for catch basins
• Within 2 years for maintenance that requires capital construction of less than $25,000
If the agency is unable to perform the inspections due to circumstances beyond their control, the agency shall document the circumstances.
Citation: None.
Gap: This is a new requirement of the 2019 permit.
Recommendation: Develop or update operation and maintenance standard to match the standards in the permit.</td></tr>
</table>

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S5.C.7.b	Immediate	O&M	Maintenance of stormwater facilities regulated by the Permittee: (i). The program shall include provisions to verify adequate long-term O&M: ✓ (a) Implementation of an ordinance or other enforceable mechanism. **(New Requirement)** • Clearly identifies the party responsible for maintenance in accordance with maintenance standards established under S5.C.7.a. • Requires inspection of facilities in accordance with the requirements in (b) below. • Establishes enforcement procedures. **Citation**: BMC 15.42 **Gap:** This is a new requirement of the 2019 permit**.** **Recommendation:** Develop ordinance for enforcement of maintenance requirements of facilities regulated by COB**.** ✓ (b) Annual inspections of all stormwater treatment and flow control BMPs/facilities. Permittees may reduce the inspection based on maintenance records double the length of time of the proposed inspection frequency. **(Existing Requirement)** **Citation:** COB's TrakIT workflow management system. **Compliance Improvement:** COB plans and tracks all treatment and flow control facility inspection and maintenance activities in the TrakIT workflow management; however, this reference can be strengthened by providing a specific location in TrakIT inspection records are kept. **Recommendation:** Recommend including screen shots of TrakIT records in the annual SWMP report to Ecology along with a program description and requirements in the SWMP.
			✓ (ii). Compliance with the inspection requirements in (b) above shall be determined by the presence of records of an established inspection program designed to inspect all sites. Compliance during this permit term shall be determined by achieving at least 80% of all sites. **(Existing Requirement)** **Citation**: COB's TrakIT workflow management system. **Compliance Improvement:** COB plans and tracks all inspection and maintenance activities in the TrakIT workflow management; however, there are insufficient details in the SWMP to determine compliance with 80% requirement. This reference can be strengthened by providing a specific location in TrakIT inspection records are kept. **Recommendation**: Recommend including screen shots of TrakIT records in the annual SWMP report to Ecology along with a program description and requirements in the SWMP and developing an automated report summarizing inspection activities.
			☐ (iii). The program shall include a procedure for keeping records of inspections and enforcement actions. **(Existing Requirement)** **Citation**: COB's TrakIT workflow management system. **Gap**: COB plans and tracks all inspection and maintenance activities in the TrakIT workflow management; however, compliance formal procedure for record-keeping is not in place. **Recommendation**: Recommend including screen shots of TrakIT records in the annual SWMP report to Ecology along with a program description and requirements in the SWMP; develop formal procedure for record-keeping.
S5.C.7.c	Immediate	O&M	Maintenance of stormwater facilities owned or operated by the Permittee: ✓ (i). Each Permittee shall implement a program to annually inspect all municipally owned or operated permanent stormwater treatment flow control BMPs/facilities. Permittees may reduce the number of inspections based on maintenance records to double the length of time between the proposed inspection frequencies. **(Existing Requirement)** **Citation:** COB's TrakIT workflow management system (we can strengthen the reference by providing a specific location in TrakIT inspection records are kept). **Compliance Improvement:** COB plans and tracks all treatment and flow control facility inspection and maintenance activities in the TrakIT workflow management; however, this reference can be strengthened by providing a specific location in TrakIT inspection records are kept**.** **Recommendation:** Recommend including screen shots of TrakIT records in the annual SWMP report to Ecology along with a program description and requirements in the SWMP.
			✓ (ii). Spot checks of potentially damaged permanent stormwater treatment and flow control BMPs/facilities after major storm events and repairs as appropriate. **(Existing Requirement)** **Citation:** COB's TrakIT workflow management system. **Compliance Improvement:** The reference may be strengthened by providing a specific location in TrakIT inspection records are kept**.** **Recommendation:** Recommend COB to provide the program description and requirements in the SWMP.

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
			✓ (iii). Inspection of all catch basins and inlets owned or operated by the Permittee every two years. **(Existing Requirement)** (a) Permittees may reduce the numbers of inspections based on maintenance records to double the length of time between proposed inspection frequencies. (b) Inspection every two years may be conducted on a "circuit basis." (c) Permittee may clean all pipes, ditches, and catch basins and inlets within a circuit once during the permit term. Circuits selected for this alternative must drain to a single point. **Citation:** COB's TrakIT workflow management system. **Compliance Improvement:** The reference may be strengthened by providing a specific location in TrakIT inspection records are kept **Recommendation:** Recommend COB to provide the program description and requirements in the SWMP.
			✓ (iv). Compliance is determined by achieving at least 95% of required inspections. **(Existing Requirement)** **Citation:** COB's TrakIT workflow management system. **Compliance Improvement:** COB plans and tracks all inspection and maintenance activities in the TrakIT workflow management; however, there are insufficient details in the SWMP to determine compliance with 80% requirement. The reference may be strengthened by providing a specific location in TrakIT inspection records are kept. **Recommendation:** Recommend COB to provide the program description and requirements in the SWMP, and developing automated reporting to verify 95% target.
S5.C.7.d	Immediate	O&M	**(Existing Requirement)** ☐ Each permittee shall implement and document all practices, policies, and procedures to reduce stormwater impacts associated with runoff from all lands owned or maintained by the Permittee, and road maintenance activities under the functional control of the Permittee, and must include the following activities: i. Pipe cleaning ii. Cleaning of culverts that convey stormwater in ditch systems iii. Ditch maintenance iv. Street cleaning v. Road repair and resurfacing, including pavement grinding vi. Snow and ice control vii. Utility installation viii. Pavement striping maintenance ix. Maintain roadside areas, including vegetation management x. Dust control xi. Fertilizers, pesticides, and herbicides xii. Sediment and erosion control xiii. Landscape maintenance and vegetation disposal xiv. Trash and pet waste management xv. Building exterior cleaning and maintenance **Citation**: Section 6 of the 2019 SWMP describes numerous efforts by COB to meet these requirements. **Compliance Improvement**: COB plans and tracks all catch basins and stormwater facility inspection and maintenance activities in the TrakIT workflow management; however, there are not enough details in the SWMP (pages 23 and 30) to determine requirement compliance. The reference may be strengthened by providing a specific location in TrakIT inspection records are kept. **Recommendation:** Recommend COB to provide the program description and requirements in the SWMP. Automated reporting may be useful to verify compliance.

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S5.C.7.e	Immediate	O&M	**(Existing Requirement)** ✓ Implement an ongoing training program for employees of the Permittee whose primary construction, operations, or maintenance job functions may impact stormwater quality. **Citation**: Section 6 (6-1) of the 2019 SWMP mentions continued training for City staff and external partners in the development community program located in the document. **Gap**: None. **Recommendation**: None.
S5.C.7.f	Immediate	O&M	**(Existing Requirement)** ✓ Implement a SWPPP for all heavy equipment maintenance or storage yards, and material storage facilities owned or operated by the Permittee in areas subject to this Permit that are not required to have coverage under the Industrial Stormwater General Permit or another NPDES permit that authorizes stormwater discharges associated with the activity. i. Description of operational/structural BMPs in use and implementation schedule for future facilities ii. Annual inspections and documentation iii. Inventory of materials and equipment on site iv. Site map of drainage, discharge, pollutant exposure v. Prevention and spill response plans **Citation:** Under permit section S5.C.5.h, COB meets all requirements, all of which were updated in the 2019 SWMP **Gap:** None. **Recommendation**: None.
S5.C.7.g	Immediate	O&M	**(Existing Requirement)** ✓ Maintain records of inspections and maintenance or repair activities conducted by the Permittee. **Citation:** None. **Gap**: None.. **Recommendation**: Recommend COB to provide location of records in the SWMP and internally develop automated reporting for these activities.
S5.C.8 SOURCE CONTROL PROGRAM FOR EXISTING DEVELOPMENT			
S5.C.8.a	[See S5.C.8.b]	Policy Development and Implementation	**(New Requirement)** ☐ Each Permittee shall implement a program to prevent and reduce pollutants in runoff from areas that discharge to MS4s. (Specific compliance requirements and deadlines are described further in **S5C.8.a.** i. Application of operational and structural source control BMPs, and, if necessary, treatment BMPs/facilities to pollution generating sources associated with existing land uses and activities. ii. Inspections of pollutant generating sources at publically and privately owned commercial and industrial properties to enforce implementation of required BMPs to control pollution discharging into the Permittee's MS4. iii. Application and enforcement of local ordinances at sites, identified pursuant to S5.C.8.b.ii, including sites with discharges authorized by a separate NPDES permit. iv. Practices to reduce polluted runoff from the application of pesticides, herbicides, and fertilizer discharging into MS4s owned or operated by the Permittee. **Citation:** None**.** **Gap:** This is a new requirement for the 2019 permit. The 2019 SWMP mentions developing a source control program to meet upcoming permit requirements. **Recommendation:** Prepare a Source Control Program report that describes how the city developed it's program and includes Standard Operating Procedures for staff who implement the program.

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S5.C.8.b.	i. August 1, 2022	Regulatory	**(New Requirement)** ☐ Permittees shall adopt an ordinance, or other enforceable documents, requiring the application of source control BMPs for pollutant generating sources associated with existing land uses and activities. **Citation:** None**.** **Gap:** This is a new requirement for the 2019 permit. The 2019 SWMP mentions developing a source control program to meet upcoming permit requirements. **Recommendation:** Update city ordinance by the effective date noted in the permit.
	ii. August 1, 2022	Record Keeping	**(New Requirement)** ☐ Permittees shall establish an inventory that identifies publically and privately owned institutional, commercial, and industrial properties which have the potential to generate pollutants to the Permittee's MS4. The inventory shall include: (a) Businesses and/or properties identified based on the presence of activities that are pollutant generating (refer to Appendix 8). (b) Complaint-based response to identify other pollutant generating sources, such as: mobile or home-based businesses and multi-family properties. **Citation:** None**.** **Gap:** This is a new requirement for the 2019 permit. The 2019 SWMP mentions developing a source control program to meet upcoming permit requirements. **Recommendation:** Agenda item with COB to discuss this new requirement.
	iii. January 1, 2023	Inspection	**(New Requirement)** ☐ Permittees shall implement an inspection program for sites identified pursuant to S5.C.8.b.ii. (a) Inventory of businesses. (b) Annual completion of inspections of 20% of businesses/sites. (c) Inspect 100% of sites identified through credible complaints. (d) Complaint inspections may go toward the 20%. **Citation:** None**.** **Gap:** This is a new requirement for the 2019 permit. The 2019 SWMP mentions developing a source control program to meet upcoming permit requirements. **Recommendation:** Develop Standard Operating Procedures describing how this program is implemented.
	iv. January 1, 2023	Enforcement	**(New Requirement)** ☐ Permittee shall implement a progressive enforcement policy that requires sites to comply with stormwater requirements within a reasonable time period. **Citation:** None**.** **Gap:** This is a new requirement for the 2019 permit. The 2019 SWMP mentions developing a source control program to meet upcoming permit requirements. **Recommendation:** Develop Standard Operating Procedures describing how this program is implemented.
	v. Ongoing following source control program schedule	Training	**(New Requirement)** ☐ Permittees shall train staff who are responsible for implementing the source control program to conduct these activities. The ongoing training program shall cover the legal authority for source control, source control BMPs and their proper application, inspection protocols, lessons learned, typical cases, and enforcement procedures. Follow-up training must be provided as needed to address changes in procedures, techniques, requirements, or staff. Permittees shall document and maintain records of the training provided and the staff trained. **Citation:** None**.** **Gap:** This is a new requirement for the 2019 permit. The 2019 SWMP mentions developing a source control program to meet upcoming permit requirements. **Recommendation:** Develop Standard Operating Procedures describing how this program is implemented.
S6 STORMWATER MANAGEMENT PROGRAM FOR SECONDARY PERMITTEES			

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
			NA to COB; these are for secondary permittees. This would occur if other public entities (such as ports, prisons, parks, etc.) own or operate a stormwater sewer in the City. This separate system is called an MS4, and one of these other public entities with an MS4 may be required to get a secondary municipal stormwater permit.
S7 COMPLIANCE WITH TOTAL MAXIMUM DAILY LOAD REQUIREMENTS			

S7.A	Immediate	Documentation	**(New Requirement for COB)** For applicable TMDLs listed in Appendix 2, affected Permittees shall comply with the specific requirements identified in Appendix 2. Each Permittee shall keep records of all actions required by this Permit that are relevant to applicable TMDLs within their jurisdiction. The status of the TMDL implementation shall be included as part of the annual report submitted to Ecology. Each annual report shall include a summary of relevant SWMP and Appendix 2 activities conducted in the TMDL area to address the applicable TMDL parameter(s). Lake Whatcom Watershed Total Phosphorus and Bacteria TDML (Appendix 2 Requirements): ☐ 1) Public Education, Outreach, and Engagement a. Develop repeatable survey to measure watershed residents' beliefs, behaviors and attitudes over time related to Lake Whatcom water quality problems and solutions to inform the development of Lake Whatcom Watershed outreach programs. b. With each annual report, report on progress developing repeatable survey. c. No later than March 31, 2022, attach results of survey with annual report. d. Provide to Ecology the informational packet distributed to all watershed residents, and track how many new watershed property owners received copies. e. No later than March 31, 2020, provide to Ecology the Lake Whatcom Cooperative Management Program Five-Year Work Plan, Program Area 9 updates. **Citation:** 2019 Lake Whatcom Implementation Plan. **Gap:** Future requirements to be met. **Recommendation:** None. ☐ 2) Stormwater Management a. With each annual report, update and prioritize a list of new treatment and flow control Capital Improvement Projects. Each Permittee shall track all relevant steps of the project(s) including but not limited to: i. Land acquisition ii. Design iii. Construction iv. Estimated Cost v. Drainage Area vi. Treated Acres v. Funding Status and Sources b. No later than March 31, 2024, provide a list of retrofit opportunities with applicable timelines to incorporate new technology and new strategies into existing stormwater facilities. c. With each annual report, the COB shall evaluate and track phosphorus reductions in the following categories: i. Phosphorus treatment and flow control capital projects; ii. Homeowner improvements through the Homeowner Incentive Program (HIP) iii. Land use regulations; and iv. Operations and maintenance activities Reductions shall be expressed as reduction in Effective Developed Acres, and may also be expressed as mass per unit time. With each annual report, COB shall provide an estimate of the mass of total phosphorus removed from roads with enhanced street sweeping and estimate the equivalent reduced effective developed acres. **Citations:** a. 2019 Lake Whatcom Implementation Plan. Includes updates every 5 years and covers this requirement. b. Consultant contract to perform water quality retrofit prioritization study; to be completed by 2022. c. The annual report does not include any reporting on the Lake Whatcom TMDL. **Gap:** None. Funding for TMDL is in existing budget. **Compliance improvement:** Include in the annual report how the city evaluates and tracks phosphorus reductions. ☐ 3) Operational Best Practices and Good Housekeeping No later than March 31, 2024, submit the watershed-specific appendix to COB's operational plan for managing public areas such as park, trails, rights-of-way and open spaces. **Citation:** None**.**

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
			Gap: Future requirements to be met. **Recommendation:** Develop watershed-specific appendix to COB's operational plan for managing public areas such as park, trails, rights-of-way and open spaces. ☐ 4) Water Quality Monitoring and Effectiveness Evaluation In August 2018, COB (in coordination with the County) submitted a list of studies designed to narrow uncertainty in the lake response and watershed loading models. Items a through c are based on these studies. a. By March 31, 2020, submit Quality Assurance Project Plan (QAPP), jointly with Lake Whatcom Cooperative Management Program, for approval by Ecology for updates to models used to assess pollutant loading and lake response. b. In annual reports starting in March 2020, COB shall track and report the status of the timelines in the QAPPs approved by Ecology. c. By March 31, 2021, annual report COB shall provide an evaluation of the effectiveness of built stormwater treatment and flow control facilities and an assessment of overall performance in reducing phosphorus and fecal coliform. **Citation:** None**.** **Gap:** Future requirements to be met. **Recommendation:** Develop procedures for tracking and reporting the status of the QAPP. ☐ 5) Administration a. By December 31, 2023, COB, in coordination with the County, shall submit Lake Whatcom Implementation tasks for 2024-2029. b. With the March 2024 annual report, COB shall submit new loading capacity based on new models **Citation:** None**.** **Gap:** Future requirements to be met. **Recommendation:** Update the Lake Whatcom plan to reflect revised loading capacities predicted by the models.
S8 MONITORING AND ASSESSMENT			
S8.A.1	December 1, 2019	Payment	Regional status and trends monitoring. **(Existing Requirement)** ✓ Permittees that chose S8.B Status and Trends Monitoring Option #1 in the Phase II Western Washington Municipal Stormwater Permit August 1, 2013–July 31, 2018 (extended to July 31, 2019) shall pay into the collective fund to implement regional small streams and marine near-shore areas status and trends monitoring in Puget Sound. The payments into the collective fund are due on or before December 1, 2019, and the S8.A amounts are listed in Appendix 11. **Citation**: budget code number is 430-5628-311-4920. 4920 is for Operating Permit Fees 2015 Urban Streams Monitoring Report https://www.cob.org/services/environment/water-quality/pages/urban-streams-monitoring.aspx. **Gap**: None.
S8.A.2	December 1, 2019	Documentation	Regional status and trends monitoring **(Existing Requirement)** ✓ No later than December 1, 2019, all City and County Permittees covered under the Phase II Western Washington Municipal Stormwater Permit August 1, 2013–July 31, 2018 (extended to July 31, 2019) shall notify Ecology in writing which of the following two options for regional status and trends monitoring the Permittee chooses to carry out during the duration of this permit. Either option will fully satisfy the Permittee's obligations under this section (S8.A.2). Each Permittee shall select a single option for the duration of this permit. a. Collective fund to implement regional receiving water status and trends monitoring ***OR*** b. Conduct stormwater discharge monitoring per requirements in S8.C. **Citation**: 22 November 20, 2019 letter from City to Ecology committing the regional monitoring program. **Gap**: None. **Recommendation.** Include a copy of the city's notification to Ecology in the annual SWMP report.

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S8.B.1	December 1, 2019	Payment	Stormwater management program effectiveness and source identification studies **(Existing Requirement)** ✓ Permittees that chose S8.C Effectiveness Studies Option #1 in in the Phase II Western Washington Municipal Stormwater Permit August 1, 2013–July 31, 2018 (extended to July 31, 2019) shall pay into the collective fund to implement effectiveness studies and source identification studies. The payments are due on or before December 1, 2019. The S8.B payment amounts are listed in Appendix 11. **Citation**: 22 November 20, 2019 letter from City to Ecology committing the regional monitoring program. **Gap**: None. **Recommendation.** Include a copy of the city's notification to Ecology in the annual SWMP report.
S8.B.2	December 1, 2019	Documentation	Stormwater management program effectiveness and source identification studies **(Existing Requirement)** ✓ This permit is not applicable (NA) to Bellingham since the city implements a water quality monitoring program. No later than December 1, 2019, all City and County Permittees covered under the Phase II Western Washington Municipal Stormwater Permit August 1, 2013–July 31, 2018 (extended to July 31, 2019) shall notify Ecology in writing which of the following two options for effectiveness and source identification studies the Permittee chooses to carry out during this permit cycle. Either option will fully satisfy the Permittee's obligations under this section (S8.B.2). Each Permittee shall select a single option for the duration of this permit term. a. Collective fund to implement Stormwater Action Monitoring (SAM) effectiveness and source identification studies ***OR*** b. Conduct stormwater discharge monitoring per requirements in S8.C. **Citation**: NA. **Gap**: NA. **Recommendation.** NA.
S8.C.1	December 1, 2019	Documentation	✓ This Applies only to Permittees who choose to conduct stormwater discharge monitoring per S8.A.2.b and/or S8.B.2.b in lieu of participation in the regional status and trends monitoring and/or effectiveness and source identification studies. These Permittees shall conduct monitoring in accordance with Appendix 9 and an Ecology-approved Quality Assurance Project Plan (QAPP) as follows:
S8.C.1.a		Documentation	✓ This Permittees who choose the option to conduct stormwater discharge monitoring for either S8.A.2 or S8.B.2 shall monitor three independent discharge locations. **Citation**: 2020 Water Quality Prioritization scope of work and contract. **Gap**: None. **Recommendation.** None
S8.C.1.b	February 1, 2020	Documentation	✓ This Each Permittee shall submit to Ecology a draft stormwater discharge monitoring QAPP for review and approval. The QAPP shall be prepared in accordance with the requirements in Appendix 9. The final QAPP shall be submitted to Ecology for approval as soon as possible following finalization, and before August 15, 2020 or within 60 days of receiving Ecology's comments on the draft QAPP (whichever is later). **Citation**: 2020 Water Quality Prioritization scope of work and contract. **Gap**: None. **Recommendation.** None
S8.C.1.c	October 1, 2020	Documentation	✓ This Flow monitoring shall begin no later than October 1, 2020 or within 30 days of receiving Ecology's approval of the final QAPP (whichever is later). Stormwater discharge monitoring shall be fully implemented no later than October 1, 2021. **Citation**: 2020 Water Quality Prioritization scope of work and contract. **Gap**: None. **Recommendation.** None

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S8.C.1.d	Annually	Documentation	✓ This Data and analyses shall be reported annually in accordance with the Ecology-approved QAPP. Each Permittee shall enter into the Department's Environmental Information Management (EIM) database all water and solids concentration data collected pursuant to Appendix 9. **Citation**: 2020 Water Quality Prioritization scope of work and contract. **Gap**: None. **Recommendation.** None
S8.D			This section provide the mailing address to where payments are sent to Ecology. No documentation required.
S9 REPORTING REQUIREMENTS			
S9.A	March 31 of each year beginning 2020	Documentation	**(Existing Requirement)** ✓ No later than March 31 of each year beginning in 2020, each Permittee shall submit an annual report. The reporting period for the annual report will be the previous calendar year unless otherwise specified. Each shall include: • A copy of the Permittee's current SWMP Plan as required by S5.A.2. • Submittal of the annual report form as provided by Ecology pursuant to S9.A, describing the status of implementation of the requirements of this permit during the reporting period. • Attachments to the annual report form including summaries, descriptions, reports, and other information as required, or, as applicable, to meet the requirements of this permit during the reporting period. Refer to Appendix 3 for annual report questions. • If applicable, notice that the MS4 is relying on another governmental entity to satisfy any of the obligations under this permit. • Certification and signature pursuant to G19.D, and notification of any changes to authorization pursuant to G19.C. • A notification of any annexations, incorporations or jurisdictional boundary changes resulting in an increase or decrease in the Permittee's geographic area of permit coverage during the reporting period **Citation**: City verified submittal dates. **Gap**: None. **Recommendation**: None.
S9.B		Documentation	**(Existing Requirement)** ☐ Each Permittee is required to keep all records related to this permit and the SWMP for at least five years. **Citation**: COB has 2015, 2016, 2017, and 2018 SWMP posted on their website. **Compliance Improvement**: Years, specifically 2014, are missing. **Recommendation**: Suggest posting all previous SWMP in centralized location on the current SWMP page. (https://www.cob.org/services/planning/environmental/Pages/stormwater-program.aspx).
S9.C		Documentation	**(Existing Requirement)** ✓ Each Permittee shall make all records related to this permit and the Permittee's SWMP available to the public at reasonable times during business hours. **Citation**: City provides all available records related to permit and the SWMP to the public online. **Gap**: None. **Recommendation**: Recommend COB to provide the SWMP and Annual Reports online for at least five years.

Permit Section	Compliance Date	Requirement Type	Description of Permit Condition
S9.D		Documentation	✓ Annual report for cities, towns, and counties. Each annual report shall include the following: 1. Copy of current SWMP Plan 2. Annual report form 3. Attachments to annual report 4. Notice of reliance on another governmental entity to satisfy obligations if applicable 5. Certification and signature 6. Notification of annexations, incorporations, or jurisdictional boundary changes **Citation**: https://www.cob.org/services/planning/environmental/Pages/stormwater-program.aspx. **Gap**: None. **Recommendation:** None.
S9.E		Documentation	Annual report for Secondary Permittees (not applicable).

Assumptions

No.	Assumption	Value	Unit
1	Average Hourly Rate	$ 175.00	dollars
2	Hours per Page	4	hours
3	Annual Days Off	25	days
4	Timespan	1	calendar year
5	Start date	8/1/2019	date
6	End date	7/31/2024	date
7	Budget start date	2020	year

Source:
-HDR profession judgment and experience with other agencies
-Discussion and review by City staff

Type of Compliance Measure	Description
Compliance tracking	Data collection and capture for reporting purposes
N/A	Additional resources not expected (level of effort to achieve compliance is negligible)
Policy development and implementation	Documentation of strategies, procedures, etc. and training and execution as needed
Program evaluation	Assessment of current practices for impact
SWMP documentation	Formal documentation to meet regulatory requirement

Bellingham MS4 Permit Gap Analysis

Table Notes:

[1]"NA" indicates that the compliance gap can be closed with a negligible impact on existing resources and assumes existing staff have the required skills to close the gap. The cumulative impact of these gaps may have an impact on resource needs; it is recommended that the City prepares for each regulatory requirement, the specific resources assigned are reviewed to ensure the impact is not greater than staff's availability. For definitions for each type, see "Assumptions" tab.

[2]If Maintenance Hours are shown, it is expected they will continue beyond 2024 (not shown in table). For the purposes of rate projections, all maintenance costs should carry forward beyond 2024. Development costs are one-time and should be included only in the year shown.

												FTE					
Permit Section	Gap	Assumptions	Compliance Date	Type [1]	# Pages	Development Hours	Maintenance Hours [2]	Development Cost	Maintenance Cost	Development FTE	Maintenance FTE	2020	2021	2022	2023	2024	Total FTE
S5A.1	The City of Bellingham's (COB) SWMP applies to the geographical City limits. (COB does not explicitly state Permit applies to geographical city limits.)		8/1/2019	N/A													0.00
S5A.3.a	COB shall track the estimated cost of development of each component of the SWMP. Recommend COB develop a system for tracking all related costs and estimated costs related to the SWMP.	Planning and implementation effort to ID components, cost sources, and where information resides. Will also need to be maintained, QC'd, etc.	8/1/2019	SWMP documentation		1,040	520	$182,000	$91,000	0.50	0.25	0.75	0.25	0.25	0.25	0.25	1.75
S5.A.3.b	The SWMP Annual Report aggregates and describes some inspections, enforcement actions, and public education activities; however it does not track each of these items individually as required by the permit. Effective August 1, 2019, COB must also track follow-up actions as well. Recommend COB disaggregate the respective records from the TrakIT software program, begin tracking follow-up actions as a result of inspections, and include in the SWMP Annual Report.	Developer configuring TrakIT to collect follow-up actions associated with original work order; training for crews and others to enter data as required. Will need to be QC'd, etc.	8/1/2019	SWMP documentation		213	173	$37,333	$30,333	0.10	0.08	0.19	0.08	0.08	0.08	0.08	0.52
S5.A.5.b	The SWMP shall include coordination mechanisms among departments within each jurisdiction to eliminate barriers to compliance with the terms of this Permit. COB shall include a written description of internal coordination mechanisms in the Annual Report due no later than March 31, 2021.	Will require some policy and organizational definition before documentation. Assume 6 ppl, two 2-hr meetings, plus documentation	3/31/2021	Policy development and implementation	2	32	-	$5,600	$0	0.02	0.00	0.02	0.02	0.00	0.00	0.00	0.03
S5.C.1.a	Convene an inter-disciplinary team to inform and assist in the development, progress, and influence of this program.	Assume 6 ppl, quarterly 4-hr meetings with 0.1 FTE to support; plus 1-day chartering session	8/1/2020	Policy development and implementation		56	304	$9,800	$53,200	0.03	0.15	0.17	0.15	0.15	0.15	0.15	0.76
S5.C.1.b.i.(a)	COB shall respond to the series of Stormwater Planning Annual Report questions to describe how anticipated stormwater impacts on water quality were addressed, if at all, during the 2013-2019 permit term in updates to the Comprehensive Plan (or equivalent) and in other locally initiated or state-mandated, long-range land use plans that are used to accommodate growth or transportation.	Assumes information is generally available	3/31/2020	SWMP documentation	10	40	-	$7,000	$0	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.02
S5.C.1.b.i.(b)	COB shall submit a report responding to the same questions included in (a), above, to describe how water quality is being addressed, if at all, during this permit term in updates to the Comprehensive Plan (or equivalent) and in other locally initiated or state-mandated, long-range land use plans that are used to accommodate growth or transportation.	Assumes information is generally available	3/31/2022	SWMP documentation	10	40	-	$7,000	$0	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.02
S5.C.1.c.i.(a)	Annually, COB shall assess and document any newly identified administrative or regulatory barriers to implementation of LID Principles or LID BMPs since local codes were updated in accordance with the 2013 Permit, and the measures developed to address the barriers. If applicable, the report shall describe mechanisms adopted to encourage or require implementation of LID principles or LID BMPs.		8/1/2019	N/A			-			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Bellingham MS4 Permit Gap Analysis

Table Notes:

[1]"NA" indicates that the compliance gap can be closed with a negligible impact on existing resources and assumes existing staff have the required skills to close the gap. The cumulative impact of these gaps may have an impact on resource needs; it is recommended that the City prepares for each regulatory requirement, the specific resources assigned are reviewed to ensure the impact is not greater than staff's availability. For definitions for each type, see "Assumptions" tab.

[2]If Maintenance Hours are shown, it is expected they will continue beyond 2024 (not shown in table). For the purposes of rate projections, all maintenance costs should carry forward beyond 2024. Development costs are one-time and should be included only in the year shown.

												FTE					
Permit Section	Gap	Assumptions	Compliance Date	Type [1]	# Pages	Development Hours	Maintenance Hours [2]	Development Cost	Maintenance Cost	Development FTE	Maintenance FTE	2020	2021	2022	2023	2024	Total FTE
S5.C.1.c.ii	COB shall review, revise, and make effective codes, rules, standards, or other enforceable documents to incorporate and require LID principles and LID BMPs. A summary of results must be submitted with the annual report no later than March 31, 2024 and list participants, codes, rules, standards, and other enforceable documents revisions and existing requirements that incorporate and require LID principles and BMPs, organized as follows: (a) Measures to minimize impervious surfaces. (b) Measures to minimize loss of native vegetation. (c) Other measures to minimize stormwater runoff.	LID policy already in place; new requirement will only require documentation	12/31/2023	N/A						0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S5C.1.d.i	Document and assess existing information of local receiving waters and contributing area conditions to identify what water bodies would benefit from stormwater management planning. Submit a watershed inventory and include a brief description of the relative conditions of the receiving waters and the contributing areas. The watershed inventory shall be submitted as a table with each receiving water name, its total watershed area, the percent of the total watershed area that is in COB's jurisdiction, and the findings of the stormwater management influence assessment for each basin. Indicate which receiving waters will be included in the S5.C.1.d.ii prioritization process. Include a map of the delineated basins with references to the watershed inventory table.	Assume fairly robust GIS exists	3/31/2022	SWMP documentation	20	120	48	$21,000	$8,400	0.06	0.02	0.00	0.00	0.08	0.02	0.02	0.13
S5C.1.d.ii	Prioritize and rank identified water basins that would benefit from implementation of stormwater facility retrofits and management actions to reduce pollutant loading and address hydrologic impacts from existing development. Additional requirements include: (a) Document priority ranking process to identify high priority areas. (b) The ranking process shall include the identification of high priority catchment area(s) for focus of the SMAP.	150 hrs development	6/30/2022	SWMP documentation	10	190	-	$33,250	$0	0.09	0.00	0.00	0.00	0.09	0.00	0.00	0.09
S5C.1.d.iii	Develop a Stormwater Management Action Plan (SMAP) for at least one high priority area	150 hrs development	3/31/2023	SWMP documentation	25	300	-	$52,500	$0	0.14	0.00	0.00	0.00	0.00	0.14	0.00	0.14
S5.C.2.a.ii(b)	COB shall conduct an evaluation of effectiveness of ongoing behavior change program and document lessons learned and recommendations.	Develop criteria for evaluation, perform evaluation, documentation	7/1/2020	Program evaluation		80	-	$14,000	$0	0.04	0.00	0.04	0.00	0.00	0.00	0.00	0.04
S5.C.2.a.ii(c)	COB shall develop a social marketing campaign and strategy tailored to the community as well as a program evaluation plan.	Assume retaining existing campaign and improving or expanding. Need to: -develop strategy and schedule -develop program evaluation plan	2/1/2021	Policy development and implementation		100	-	$17,500	$0	0.05	0.00	0.00	0.05	0.00	0.00	0.00	0.05
S5.C.2.a.ii(d)	Implement social marketing strategy.	Assume 1 FTE devoted to outreach, new campaign = .25	4/1/2021	Policy development and implementation		-	520	$0	$91,000	0.00	0.25	0.00	0.25	0.25	0.25	0.25	1.00

Bellingham MS4 Permit Gap Analysis

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[2]If Maintenance Hours are shown, it is expected they will continue beyond 2024 (not shown in table). For the purposes of rate projections, all maintenance costs should carry forward beyond 2024. Development costs are one-time and should be included only in the year shown.

												FTE					
Permit Section	Gap	Assumptions	Compliance Date	Type [1]	# Pages	Development Hours	Maintenance Hours [2]	Development Cost	Maintenance Cost	Development FTE	Maintenance FTE	2020	2021	2022	2023	2024	Total FTE
S5.C.2.a.ii(e)	Evaluate and report on changes in understanding and adoption of targeted behaviors resulting from implementation and any planned or recommended changes for the program to be more effective; describe strategies and process to achieve results. Use results of evaluation to continue to direct effective methods of implementation of ongoing behavior change	Continuous improvement =.05 FTE	3/31/2024	Program evaluation		40	104	$7,000	$18,200	0.02	0.05	0.00	0.00	0.00	0.00	0.07	0.07
S5.C.4.b(i)	Include size and material for all known MS4 outfalls.		1/1/2020	N/A						0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S5.C.4.b(ii)	Complete mapping of all known connections from the MS4 to a privately owned stormwater system	Assume connections have not been mapped; 40 hrs for initial, 40 hrs for additional research, plus on-going maintenance (4 hrs per mo.)	8/1/2021	SWMP documentation		80	48	$14,000	$8,400	0.04	0.02	0.00	0.06	0.02	0.02	0.02	0.13
S5.C.4.d	To the extent consistent with national security laws and directives, COB shall make available to Ecology, upon request, available maps depicting information required in S5.C.4.a through c, above.		8/1/2019	N/A						0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S5.C.4.e	Upon request, and to the extent appropriate, COB shall provide mapping information to federally recognized Indian tribes, municipalities, and other Permittees.		8/1/2019	N/A						0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S5.C.5.d	COB shall implement an ongoing program designed to detect and identify non-stormwater discharges and illicit connections in COB's MS4. Program will include: (i). Procedures for conducting investigations of the COB's MS4, including field screening and methods for identifying potential sources. Procedures may also include source control inspections. (a) Complete field screening for an average of 12% of the MS4 per year. Track total percentage annually beginning August 1, 2019. (ii). A publicly listed and publicized hotline or other telephone number for public reporting of spills and other illicit discharges. (iii). An ongoing training program for all municipal field staff, who, as part of their normal job responsibilities, might come into contact with or otherwise observe an illicit discharge and/or illicit connection to the MS4, on the identification of an illicit discharge and/or connection, and on the proper procedures for reporting and responding to the illicit discharge and/or connection. Follow-up training shall be provided as needed to address changes in procedures, techniques, requirements, or staffing. COB shall document and maintain records of the trainings provided and the staff trained.	It is assumed this requirement will be met with existing resources performing system maintenance	8/1/2019	Compliance tracking		-	-	$0	$0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Bellingham MS4 Permit Gap Analysis

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[2]If Maintenance Hours are shown, it is expected they will continue beyond 2024 (not shown in table). For the purposes of rate projections, all maintenance costs should carry forward beyond 2024. Development costs are one-time and should be included only in the year shown.

Permit Section	Gap	Assumptions	Compliance Date	Type [1]	# Pages	Development Hours	Maintenance Hours [2]	Development Cost	Maintenance Cost	Development FTE	Maintenance FTE	FTE 2020	FTE 2021	FTE 2022	FTE 2023	FTE 2024	Total FTE
S5.C.5.e	COB shall implement an ongoing program designed to address illicit discharges, including spills and illicit connections, into the COB's MS4. Program will include: (i). Procedures for characterizing the nature of, and potential public or environmental threat posed by, any illicit discharges found by or reported to COB. Procedures shall address the evaluation of whether the discharge must be immediately contained and steps to be taken for containment of the discharge. (ii). Procedures for tracing the source of an illicit discharge, including visual inspections, and, when necessary, opening manholes, using mobile cameras, collecting and analyzing water samples, and/or other detailed inspection procedures. (iii). Procedures for eliminating the discharge, including notification of appropriate authorities (as well as owners or operators of interconnected MS4s); notification of the property owner; technical assistance; follow-up inspections; and use of the compliance strategy developed pursuant to S5.C.3.b.v5.c.iv, including escalating enforcement and legal actions if the discharge is not eliminated. (iv). In the case of illicit discharge, compliance with the provisions in (i), (ii), and (iii), above, shall be achieved by meeting established timelines	Assume this will require developing formal documentation of what is currently occurring. (3 written SOPs)	8/1/2019	Policy development and implementation	15	60	-	$10,500	$0	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.03
S5.C.5.g	In each annual report, COB shall submit data for all illicit discharges, including spills and illicit connections found by, reported to, or investigated by COB during the previous calendar year.	SOP for illicit discharge data capture, maintenance, and reporting; 2 hr training to ensure appropriate data capture	8/1/2019	Compliance tracking	4	32	8	$5,600	$1,400	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.03
S5.C.6.e	COB shall ensure that all staff whose primary job duties are implementing the program to control stormwater runoff from new development, redevelopment, and construction sites, including permitting, plan review, construction site inspections, and enforcement are trained to conduct these activities. Follow-up training must be provided as needed to address changes in procedures, techniques or staffing. COB shall document and maintain records of the training provided and the staff trained.	Once tracking method is developed, maintenance should be minimal (~2hrs/mo), plus annual training (2 staff, 1 day)	8/1/2019	SWMP documentation		40	40	$7,000	$7,000	0.02	0.02	0.04	0.02	0.02	0.02	0.02	0.12
S5.C.7.a(ii)	Unless there are circumstances beyond COB's control, when an inspection identifies an exceedance of the maintenance standard, Maintenance shall be performed for the following standards unless there are circumstances beyond COB's control: -Within 1 year for typical maintenance of facilities, except catch basins -Within 6 months for catch basins -Within 2 years for maintenance that requires capital construction of less than $25,000 If the agency is unable to perform the inspections due to circumstances beyond their control, the agency shall document the circumstances.	Difficult to predict the extent to which this will occur. Suggest documentation of procedures should this occur.	6/30/2022	Compliance tracking	5	20	-	$3,500	$0	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01

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[2]If Maintenance Hours are shown, it is expected they will continue beyond 2024 (not shown in table). For the purposes of rate projections, all maintenance costs should carry forward beyond 2024. Development costs are one-time and should be included only in the year shown.

												FTE					
Permit Section	Gap	Assumptions	Compliance Date	Type[1]	# Pages	Development Hours	Maintenance Hours[2]	Development Cost	Maintenance Cost	Development FTE	Maintenance FTE	2020	2021	2022	2023	2024	Total FTE
S5.C.b(i)(a)	The program shall include provisions to verify adequate long-term O&M: Implementation of an ordinance or other enforceable mechanism. -Clearly identifies the party responsible for maintenance in accordance with maintenance standards established under S5.C.7.a. -Requires inspection of facilities in accordance with the requirements in (b). -Establishes enforcement procedures.	Development of ordinance to enforce maintenance conditions for facilities regulated	8/1/2019	Policy development and implementation		80	-	$14,000	$0	0.04	0.00	0.04	0.00	0.00	0.00	0.00	0.04
S5.C.7.b(iii)	iii. The program shall include a procedure for keeping records of inspections and enforcement actions. Records of maintenance inspections/activities shall be maintained.	Assume inspection program is documented; development of reporting capabilities is required Assume 5% admin time to manage data and 24 hrs to establish tracking parameters	8/1/2019	Compliance tracking		24	104	$4,200	$18,200	0.01	0.05	0.06	0.05	0.05	0.05	0.05	0.26
S5.C.7.g	Maintain records of inspections and maintenance or repair activities conducted by COB.	Addresses reporting needs for compliance verification for other elements of this section. Reporting can also serve internal purposes as well. Assume development for auto-reports plus minimal monthly maintenance for QC, modifications, etc.	8/1/2019	Compliance tracking		80	208	$14,000	$36,400	0.04	0.10	0.14	0.10	0.10	0.10	0.10	0.54
S5.C.8.b.i	COB shall adopt an ordinance or other enforceable documents, requiring the application of source control BMPs for pollutant generating sources associated with existing land uses and activities.	Need to perform stakeholder engagement (0.25 FTE)	8/1/2022	Policy development and implementation	10	560	-	$98,000	$0	0.27	0.00	0.00	0.00	0.27	0.00	0.00	0.27
S5.C.8.b.ii	COB shall establish an inventory that identifies publically and privately owned commercial, and industrial properties that have the potential to generate pollutants to the MS4. The inventory shall include: businesses with pollution generating activities and complaint based responses to identify other pollution generating sources.	Assume desktop inventory	8/1/2022	SWMP documentation		40	-	$7,000	$0	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.02
S5.C.8.b.iii.	COB shall implement an inspection program for sites within the inventory. (a) All identified sites must be provided information about activities that may generate pollutants and the source control requirements. (b) COB shall complete the number of inspections equal to 20% of the inventory list annually to assure BMP effectiveness and source control requirement compliance. (c) COB shall inspect 100% of sites identified through legitimate complaints.	Assume 2,000 sites, 400 per year, 2 inspectors for initial, complaint follow-up	1/1/2023	Policy development and implementation		150	4,160	$26,250	$728,000	0.07	2.00	0.00	0.00	0.00	2.07	2.00	4.07

Bellingham MS4 Permit Gap Analysis

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												FTE					
Permit Section	*Gap*	*Assumptions*	*Compliance Date*	*Type [1]*	*# Pages*	*Development Hours*	*Maintenance Hours [2]*	*Development Cost*	*Maintenance Cost*	*Development FTE*	*Maintenance FTE*	2020	2021	2022	2023	2024	Total FTE
S5.C.8.b.iv.	COB shall implement a progressive enforcement policy that requires sites to comply with stormwater requirements within a specified time period. (a) If COB determines a site has failed to implement BMPs COB must take measures to follow-up (b) After a follow-up inspection, COB shall take enforcement action as established through municipal code and ordinances, or the judicial system (c) COB shall maintain records with documentation relating to inspections. (d) COB may refer non-emergency violations to Ecology and include documentation of inspections and notice of violation warning letters.	Assume .5 FTE to manage enforcement plus development	1/1/2023	Policy development and implementation		150	1,040	$26,250	$182,000	0.07	0.50	0.00	0.00	0.00	0.57	0.50	1.07
S5.C.8.b.v.	COB shall train staff who are responsible for implementing the source control program to conduct these activities. The ongoing training program shall cover the legal authority for source control, source control BMPs and their proper application, inspection protocols, lessons learned, typical cases, and enforcement procedures. Follow-up training must be provided as needed to address changes in procedures, techniques, requirements, or staff. COB shall document and maintain records of the training provided and the staff trained.	Initial training plus follow-on training, assume 3 people trained, plus trainer	1/1/2023	Policy development and implementation		64	32	$11,200	$5,600	0.03	0.02	0.00	0.00	0.00	0.05	0.02	0.06
S8.A	Regional status and trends monitoring - participation in collective fund requires payment[3] and notification (Aug. 2013-July 2018) by 12/1/19 and annual payments by 8/15 beginning in 2020. *[3] This cost is not captured in development or maintenance costs in this table as is it is not tied to an FTE.*		12/1/2019	N/A						0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S8.B	SWMP effectiveness and source identification studies - participation in collective fund requires payment[3] and notification (Aug. 2013-July 2018) by 12/1/19 and annual payments by 8/15 beginning in 2020. *[3] This cost is not captured in development or maintenance costs in this table as is it is not tied to an FTE.*		12/1/2019	N/A						0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S9.B	COB is required to keep all records related to this permit and the SWMP for at least five years.		8/1/2019	N/A						0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S9.D	Annual report for cities, towns, and counties. Each annual report shall include the following: 1. Copy of current SWMP Plan 2. Annual report form 3. Attachments to annual report 4. Notice of reliance on another governmental entity to satisfy obligations if applicable 5. Certification and signature 6. Notification of annexations, incorporations, or jurisdictional boundary changes	Most information will be developed via other requirements of the permit; the time is for compilation, review, finalization, submittal	3/21/2020	SWMP documentation		-	80	$0	$14,000	0.00	0.04	0.04	0.04	0.04	0.04	0.04	0.19

Sizing			
Row Labels	Gap	Development Hours	Total FTE (development + maintenance)
S5.A.3.b	The SWMP Annual Report aggregates and describes some inspections, enforcement actions, and public education activities; however it does not track each of these items individually as required by the permit. Effective August 1, 2019, COB must also track follow-up actions as well. Recommend COB disaggregate the respective records from the TrakIT software program, begin tracking follow-up actions as a result of inspections, and include in the SWMP Annual Report.	213	0.52
S5.A.5.b	The SWMP shall include coordination mechanisms among departments within each jurisdiction to eliminate barriers to compliance with the terms of this Permit. COB shall include a written description of internal coordination mechanisms in the Annual Report due no later than March 31, 2021.	32	0.03
S5.C.1.a	Convene an inter-disciplinary team to inform and assist in the development, progress, and influence of this program.	56	0.76
S5.C.1.b.i.(a)	COB shall respond to the series of Stormwater Planning Annual Report questions to describe how anticipated stormwater impacts on water quality were addressed, if at all, during the 2013-2019 permit term in updates to the Comprehensive Plan (or equivalent) and in other locally initiated or state-mandated, long-range land use plans that are used to accommodate growth or transportation.	40	0.02
S5.C.1.b.i.(b)	COB shall submit a report responding to the same questions included in (a), above, to describe how water quality is being addressed, if at all, during this permit term in updates to the Comprehensive Plan (or equivalent) and in other locally initiated or state-mandated, long-range land use plans that are used to accommodate growth or transportation.	40	0.02
S5.C.2.a.ii(b)	COB shall conduct an evaluation of effectiveness of ongoing behavior change program and document lessons learned and recommendations.	80	0.04
S5.C.2.a.ii(c)	COB shall develop a social marketing campaign and strategy tailored to the community as well as a program evaluation plan.	100	0.05
S5.C.2.a.ii(d)	Implement social marketing strategy.	0	1.00
S5.C.2.a.ii(e)	Evaluate and report on changes in understanding and adoption of targeted behaviors resulting from implementation and any planned or recommended changes for the program to be more effective; describe strategies and process to achieve results. Use results of evaluation to continue to direct effective methods of implementation of ongoing behavior change	40	0.07
S5.C.5.g	In each annual report, COB shall submit data for all illicit discharges, including spills and illicit connections found by, reported to, or investigated by COB during the previous calendar year.	32	0.03
S5.C.6.e	COB shall ensure that all staff whose primary job duties are implementing the program to control stormwater runoff from new development, redevelopment, and construction sites, including permitting, plan review, construction site inspections, and enforcement are trained to conduct these activities. Follow-up training must be provided as needed to address changes in procedures, techniques or staffing. COB shall document and maintain records of the training provided and the staff trained.	40	0.12
S5.C.8.b.i	COB shall adopt an ordinance or other enforceable documents, requiring the application of source control BMPs for pollutant generating sources associated with existing land uses and activities.	560	0.27
S5.C.8.b.ii	COB shall establish an inventory that identifies publically and privately owned commercial, and industrial properties that have the potential to generate pollutants to the MS4. The inventory shall include: businesses with pollution generating activities and complaint based responses to identify other pollution generating sources.	40	0.02
S5.C.8.b.iii.	COB shall implement an inspection program for sites within the inventory. (a) All identified sites must be provided information about activities that may generate pollutants and the source control requirements. (b) COB shall complete the number of inspections equal to 20% of the inventory list annually to assure BMP effectiveness and source control requirement compliance. (c) COB shall inspect 100% of sites identified through legitimate complaints.	150	4.07
S5.C.8.b.iv.	COB shall implement a progressive enforcement policy that requires sites to comply with stormwater requirements within a specified time period. (a) If COB determines a site has failed to implement BMPs COB must take measures to follow-up (b) After a follow-up inspection, COB shall take enforcement action as established through municipal code and ordinances, or the judicial system (c) COB shall maintain records with documentation relating to inspections. (d) COB may refer non-emergency violations to Ecology and include documentation of inspections and notice of violation warning letters.	150	1.07
S5.C.8.b.v.	COB shall train staff who are responsible for implementing the source control program to conduct these activities. The ongoing training program shall cover the legal authority for source control, source control BMPs and their proper application, inspection protocols, lessons learned, typical cases, and enforcement procedures. Follow-up training must be provided as needed to address changes in procedures, techniques, requirements, or staff. COB shall document and maintain records of the training provided and the staff trained.	64	0.06
S5A.3.a	COB shall track the estimated cost of development of each component of the SWMP. Recommend COB develop a system for tracking all related costs and estimated costs related to the SWMP.	1040	1.75
S5C.1.d.i	Document and assess existing information of local receiving waters and contributing area conditions to identify what water bodies would benefit from stormwater management planning. Submit a watershed inventory and include a brief description of the relative conditions of the receiving waters and the contributing areas. The watershed inventory shall be submitted as a table with each receiving water name, its total watershed area, the percent of the total watershed area that is in COB's jurisdiction, and the findings of the stormwater management influence assessment for each basin. Indicate which receiving waters will be included in the S5.C.1.d.ii prioritization process. Include a map of the delineated basins with references to the watershed inventory table.	120	0.13
S5C.1.d.ii	Prioritize and rank identified water basins that would benefit from implementation of stormwater facility retrofits and management actions to reduce pollutant loading and address hydrologic impacts from existing development. Additional requirements include: (a) Document priority ranking process to identify high priority areas. (b) The ranking process shall include the identification of high priority catchment area(s) for focus of the SMAP.	190	0.09
S5C.1.d.iii	Develop a Stormwater Management Action Plan (SMAP) for at least one high priority area	300	0.14
S9.D	Annual report for cities, towns, and counties. Each annual report shall include the following: 1. Copy of current SWMP Plan 2. Annual report form 3. Attachments to annual report 4. Notice of reliance on another governmental entity to satisfy obligations if applicable 5. Certification and signature 6. Notification of annexations, incorporations, or jurisdictional boundary changes	0	0.19

Sizing			
Row Labels	Gap	Development Hours	Total FTE (development + maintenance)
S5.C.4.b(ii)	Complete mapping of all known connections from the MS4 to a privately owned stormwater system	80	0.13
S5.C.5.d	COB shall implement an ongoing program designed to detect and identify non-stormwater discharges and illicit connections in COB's MS4. Program will include: (i). Procedures for conducting investigations of the COB's MS4, including field screening and methods for identifying potential sources. Procedures may also include source control inspections. (a) Complete field screening for an average of 12% of the MS4 per year. Track total percentage annually beginning August 1, 2019. (ii). A publicly listed and publicized hotline or other telephone number for public reporting of spills and other illicit discharges. (iii). An ongoing training program for all municipal field staff, who, as part of their normal job responsibilities, might come into contact with or otherwise observe an illicit discharge and/or illicit connection to the MS4, on the identification of an illicit discharge and/or connection, and on the proper procedures for reporting and responding to the illicit discharge and/or connection. Follow-up training shall be provided as needed to address changes in procedures, techniques, requirements, or staffing. COB shall document and maintain records of the trainings provided and the staff trained.	0	0.00
S5.C.5.e	COB shall implement an ongoing program designed to address illicit discharges, including spills and illicit connections, into the COB's MS4. Program will include: (i). Procedures for characterizing the nature of, and potential public or environmental threat posed by, any illicit discharges found by or reported to COB. Procedures shall address the evaluation of whether the discharge must be immediately contained and steps to be taken for containment of the discharge. (ii). Procedures for tracing the source of an illicit discharge, including visual inspections, and, when necessary, opening manholes, using mobile cameras, collecting and analyzing water samples, and/or other detailed inspection procedures. (iii). Procedures for eliminating the discharge, including notification of appropriate authorities (as well as owners or operators of interconnected MS4s); notification of the property owner; technical assistance; follow-up inspections; and use of the compliance strategy developed pursuant to S5.C.3.b.v5.c.iv, including escalating enforcement and legal actions if the discharge is not eliminated. (iv). In the case of illicit discharge, compliance with the provisions in (i), (ii), and (iii), above, shall be achieved by meeting established timelines	60	0.03
S5.C.7.a(ii)	Unless there are circumstances beyond COB's control, when an inspection identifies an exceedance of the maintenance standard, Maintenance shall be performed for the following standards unless there are circumstances beyond COB's control: -Within 1 year	20	0.01
S5.C.b(i)(a)	The program shall include provisions to verify adequate long-term O&M: Implementation of an ordinance or other enforceable mechanism. -Clearly identifies the party responsible for maintenance in accordance with maintenance standards established under S5.C.7.a. -Requires inspection of facilities in accordance with the requirements in (b). -Establishes enforcement procedures.	80	0.04
S5.C.7.b(iii)	iii. The program shall include a procedure for keeping records of inspections and enforcement actions. Records of maintenance inspections/activities shall be maintained.	24	0.26
S5.C.7.g	Maintain records of inspections and maintenance or repair activities conducted by COB.	80	0.54
Grand Total			

Budget Year	FTE
2020	1.6
2021	1.1
2022	1.4
2023	3.8
2024	3.6

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Appendix C. System Analyses Technical Information

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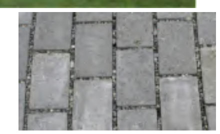
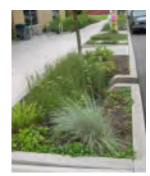
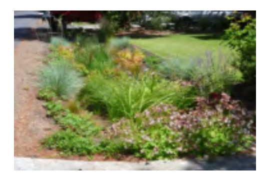
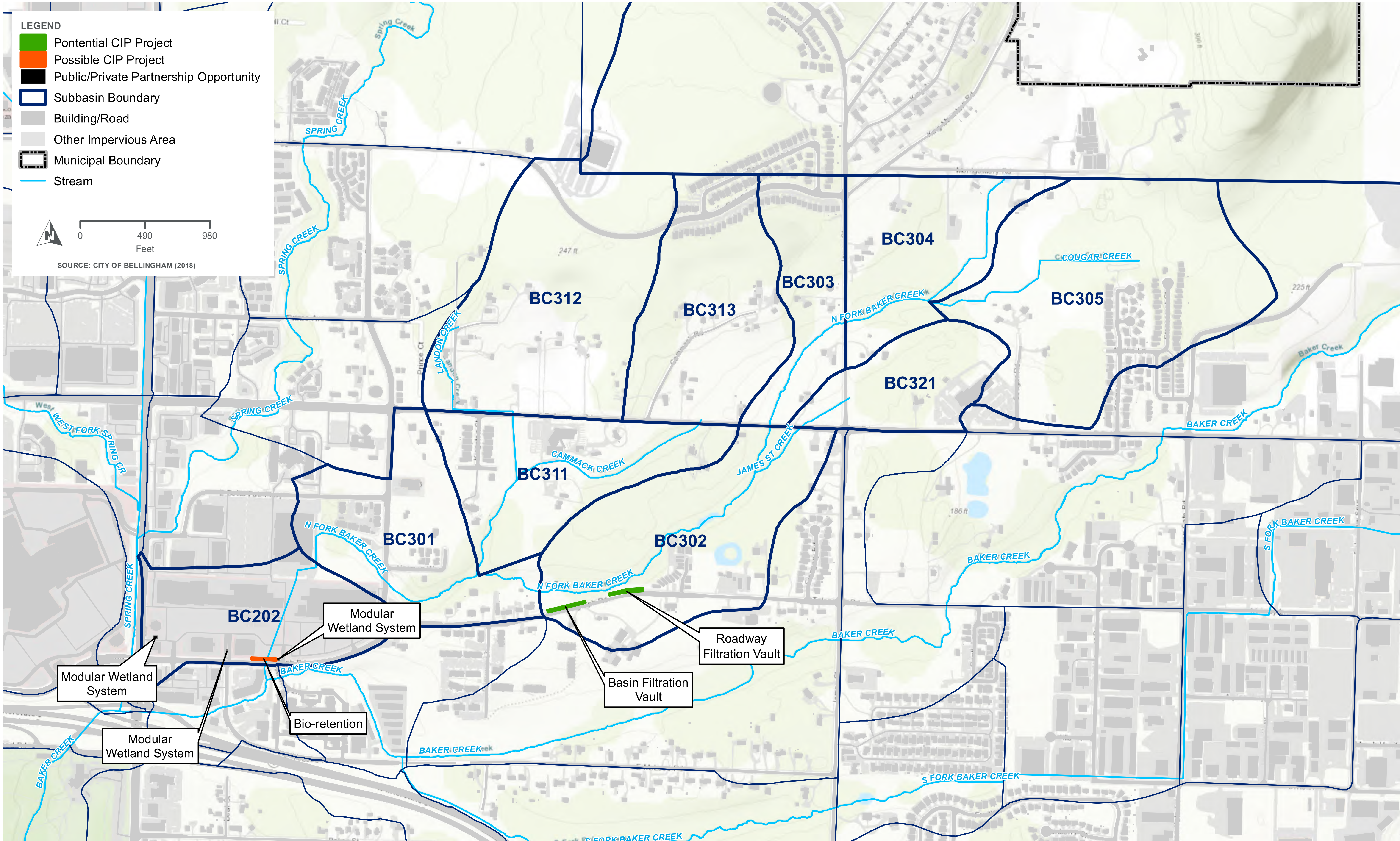
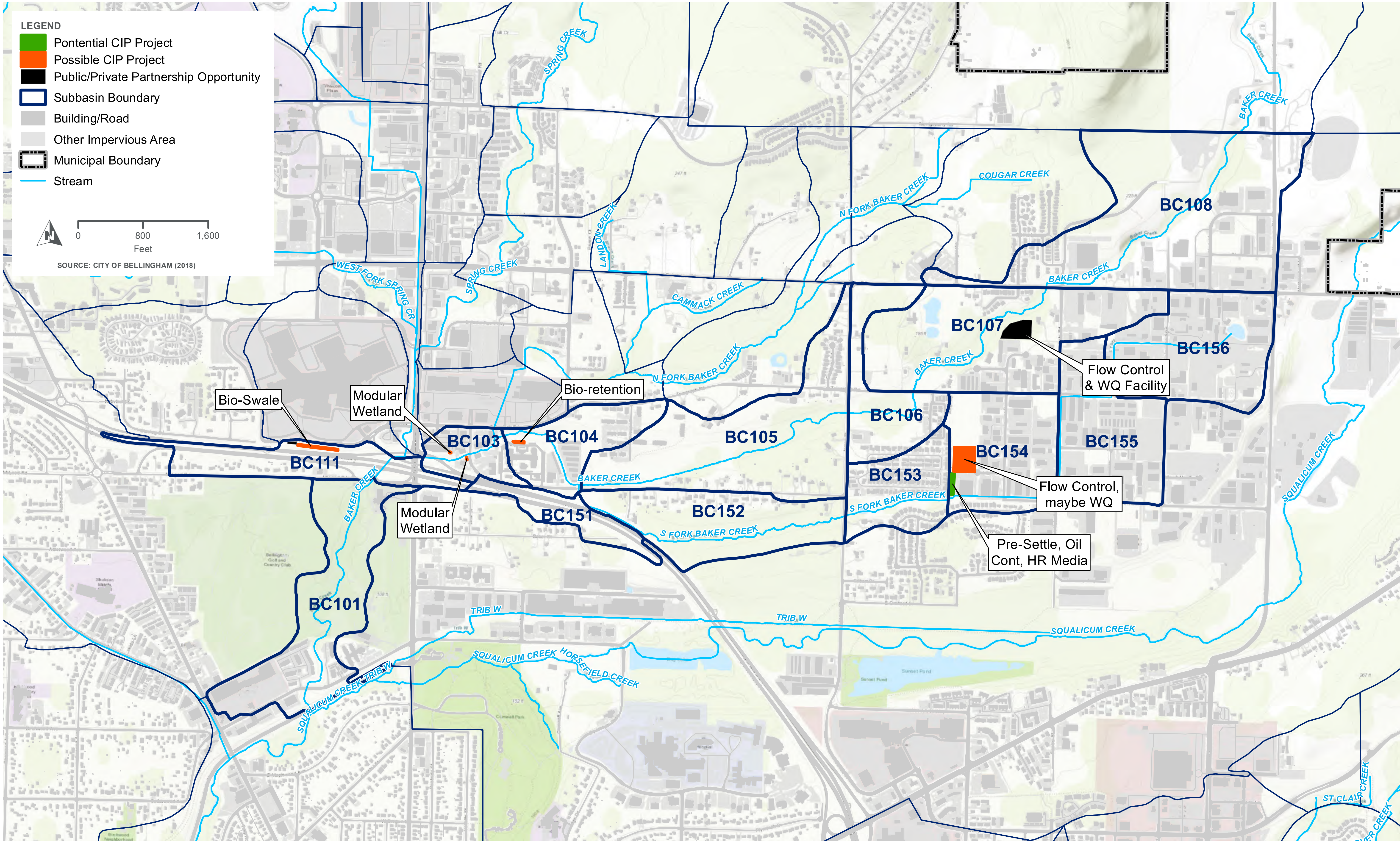
Bellingham LID Retrofit Plan
DRAFT Retrofit LID Types

Type	Description	BMP List	Example
Right-of-Way Flat Streets	This type includes BMPs to be installed in the public-right-of-way when the longitudinal slopes are less than or equal to 5%	Bioretention, Curb Bulb-out Bioretention, Enhanced Tree Pits, Sidewalk Planters, Permeable Pavement, Vegetated Filter Strips, Pocket Treatment Wetland, Permeable Road Subbase, Complete Green Street Design, Deep Infiltration, Compost Amended Soils	 
Right-of-Way Cascade Streets	This type includes BMPs to be installed in the public-right-of-way when the longitudinal slopes are greater than 5%	Cascading Bioretention Swales, Sidewalk Planters, Compost Amended Soils, Dispersion, Street Tree List	 
Park	This type includes retrofitting existing park facilities to provide flood storage capacity and water quality treatment	Detention Pond Pocket Park, Depressed Detention Storage, Bioretention, Constructed Stormwater Wetlands, Modular Wetlands, Permeable Pavement, Deep Infiltration, Compost Amended Soils	 
Commercial	This type includes BMPs to be installed on existing commercial properties, including parking lots and large impervious surfaces.	Permeable Pavement, Bioretention Facilities Enhanced Tree Pits, Modular Wetlands, Impervious Surface Reduction and Disconnection, Roof Downspout Dispersion, Roof Downspout Disconnection, Planter Boxes, Compost Amended Soils	 
Residential	This type includes BMPs that residents can install on their private properties.	Bioretention, Roof Downspout Disconnection, Roof Downspout Dispersion, Roof Downspout Bioretention, Rainwater Harvest Cisterns, Permeable Pavement, Compost Amended Soils, Residential Rain Garden Cost Share Program	 
Institutional	This includes BMPs to be installed in institutional settings, including tribal property and school property	Bioretention, Roof Downspout Bioretention Planter Boxes, Constructed Stormwater Wetlands, Modular Wetlands, Rainwater Harvest Cisterns, Impervious Surface Reduction and Disconnection, Permeable Pavement, Permeable Paver Systems, Compost Amended Soil	 
State Highway	This type includes BMPs to be installed in the public-right-of-way along state highways when the longitudinal slopes are less than or equal to 5%	Bioretention, Enhanced Tree Pits, Permeable Pavement, Vegetated Filter Strips, Impervious Surface Reduction, Compost Amended Soils, Dispersion	 



BAKER CREEK TRIBUTARY

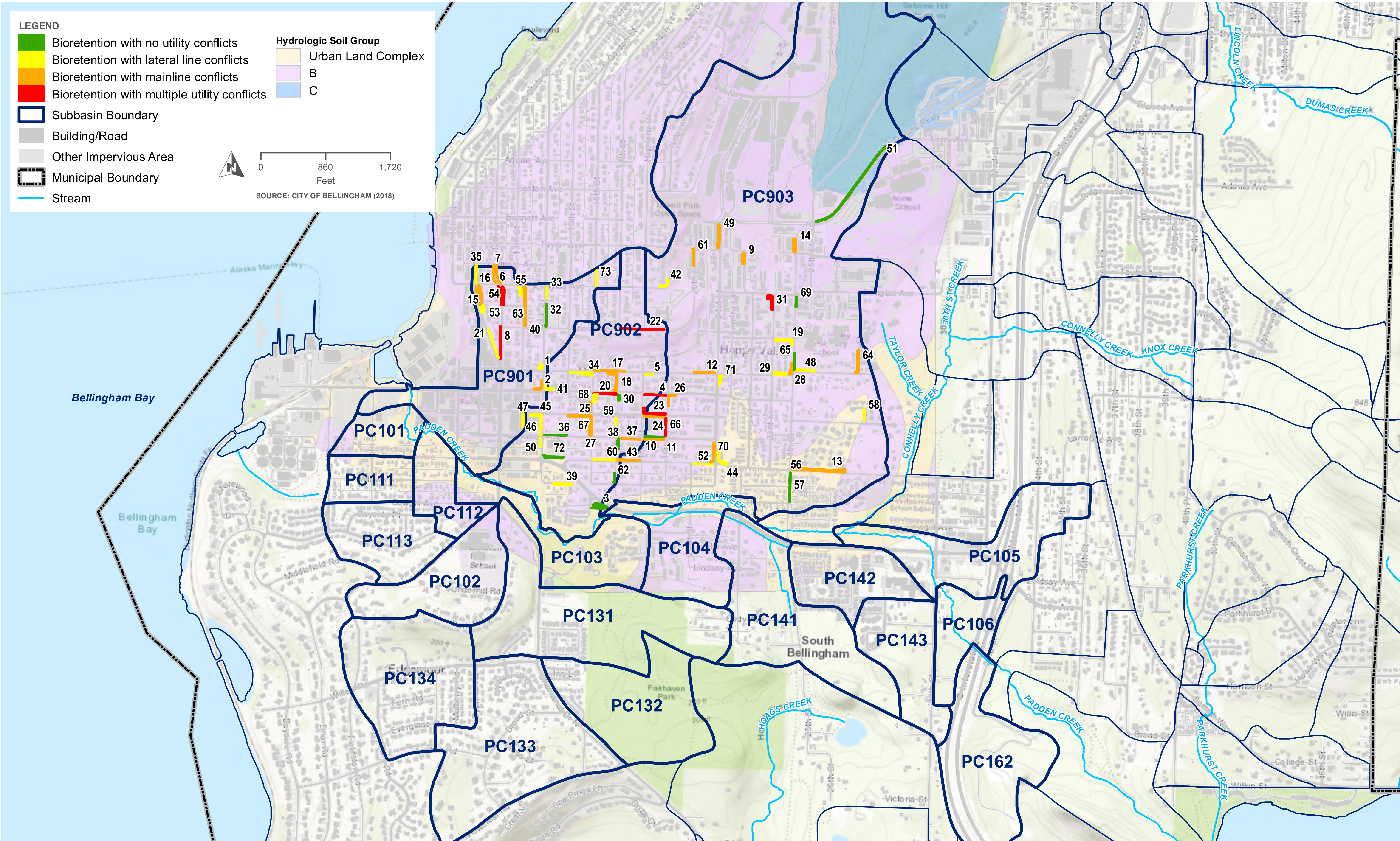
STORMWATER COMPREHENSIVE PLAN UPDATE



HDR

LOWER BAKER CREEK

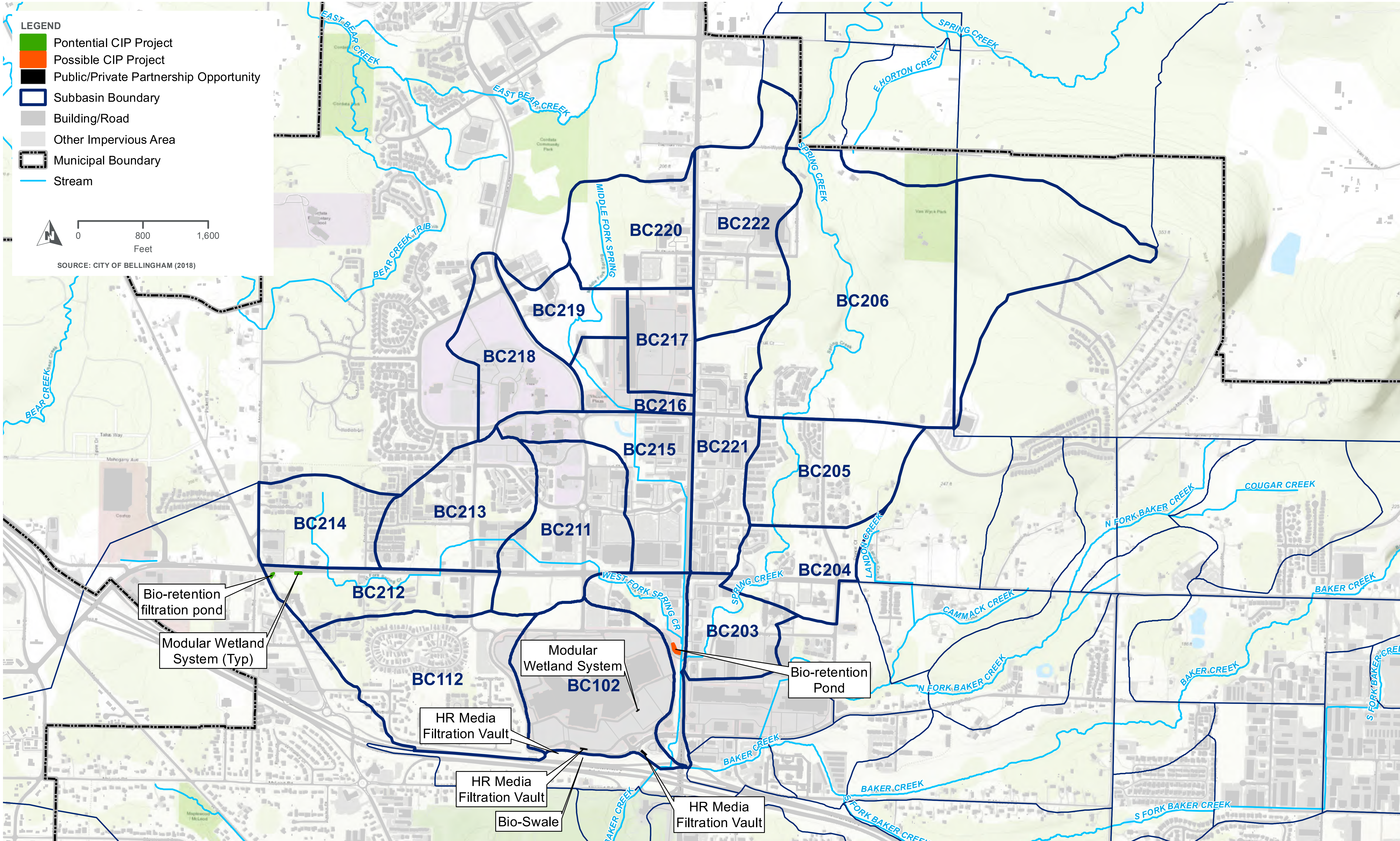
STORMWATER COMPREHENSIVE PLAN UPDATE



LOWER PADDEN CREEK

STORMWATER COMPREHENSIVE PLAN UPDATE

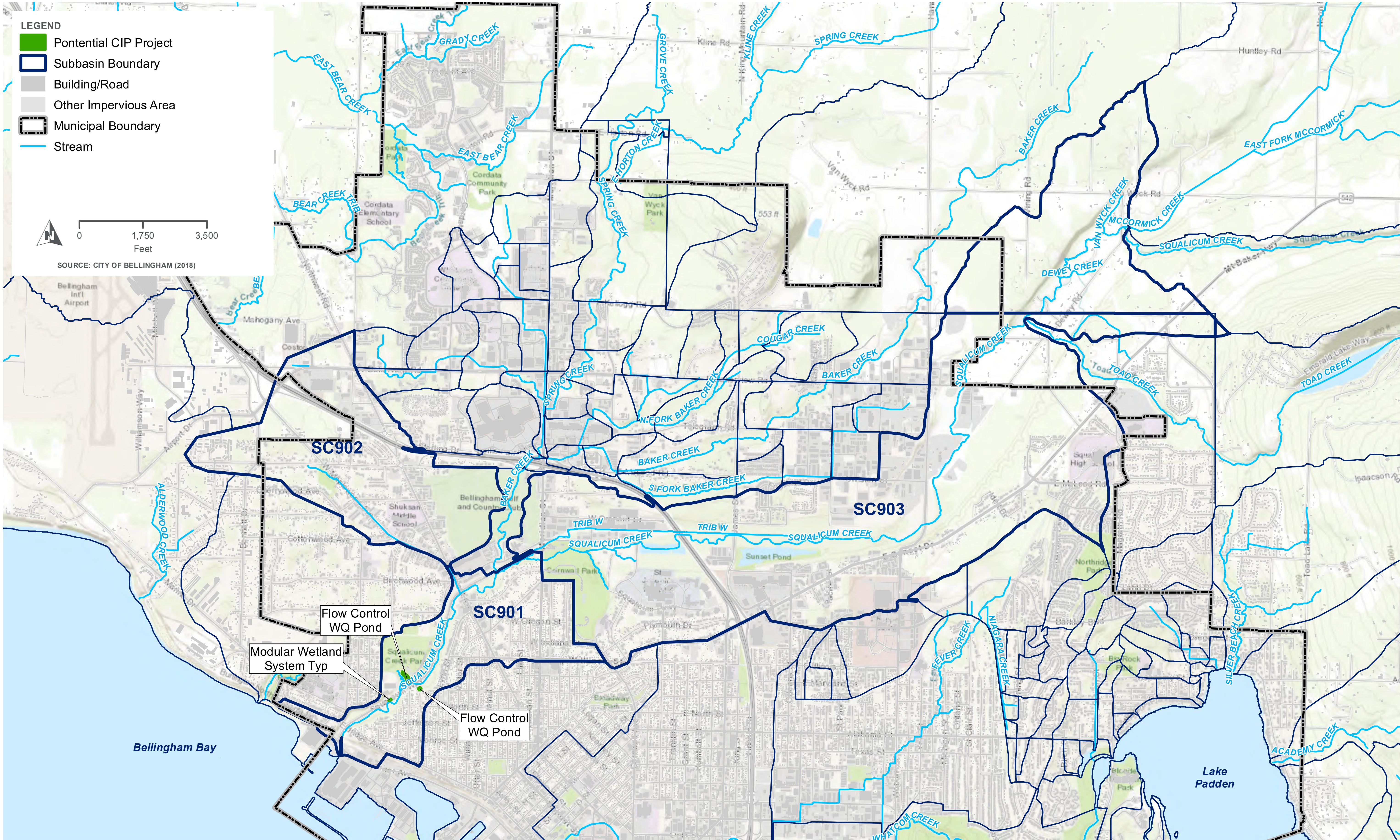
PATH: G:\PROJECTS\WASHINGTON\CITY_OF_BELLINGHAM_000055\SW_COMPPLAN_10131071\7.2_WP\MAP_DOCS\PRESENTATION\LOWERPADDEN_SOIL.MXD - USER: MDALZELL - DATE: 5/29/2019



LOWER SPRING CREEK

STORMWATER COMPREHENSIVE PLAN UPDATE

PATH: G:\PROJECTS\WASHINGTON\CITY_OF_BELLINGHAM_000055\SW_COMPPLAN_10131071\7.2_WP\MAP_DOCS\PRESENTATION\BASINMAP.MXD - USER: MDALZELL - DATE: 5/29/2019



LOWER SQUALICUM

STORMWATER COMPREHENSIVE PLAN UPDATE

PATH: G:\PROJECTS\WASHINGTON\CITY_OF_BELLINGHAM_000055\SW_COMPPLAN_10131071\7.2_WP\MAP_DOCS\PRESENTATION\BASINMAP.MXD - USER: MDALZELL - DATE: 5/29/2019

City of Bellingham – BC154 WQ Treatment

Hydrology Methodology

MGSFlood Version – 4.46 was used to simulate the runoff and water quality for this project. MGS flood utilizes the Hydrological Simulation Program-FORTRAN (HSPF) mathematical model. HSPF requires several inputs in order to accurately simulate the runoff, infiltration, and water quality characteristics of a watershed. Below is a summary of the inputs and assumptions used for the project.

Watershed Delineation

The initial watershed was delineated from the 2013 Bellingham Digital Terrain Model (DTM) dataset using ArcHydro Tools within ArcGIS. The watershed was then refined using a combination of the City of Bellingham's stormwater atlas and visual inspection of the terrain features. This resulted in a contributing drainage area of approximately 128.18 acres.

Precipitation Data

The extended timeseries option was utilized for this analysis as it is reported to produce the most accurate results.

The climate region was chosen from the MGSFlood table as 15. Puget East 40 in MAP based on the climate region map.

The mean annual precipitation for the project location was calculated using the approximate coordinates of the centroid of the watershed in Decimal Degree format. These were identified as:

- Project Latitude – 48.7857
- Project Longitude – 122.4508

This location resulted in an MAP of 40.0 inches.

The final precipitation data was obtained from the following stations:

- Precipitation Station – Puget East 40 in_5min (Period of Record: 10/01/1939-10/01/2097)
- Evaporation Station – Puget East 40 in MAP (Period of Record: 10/01/1939-10/01/2097)

Scenarios

Existing Conditions –

PERLND Data - The existing conditions scenario utilized the previously defined watershed area and considered a "pre-development" scheme. The PERLND data was entered as 128.18 acres of "Outwash Forest" based on soil Hydrologic Soil Group B soil data.

Proposed Conditions –

The proposed conditions scenario considers routing the watershed runoff through a pre-treatment pond. A flow splitter is utilized to send 20 cfs into the proposed pond and bypass the remainder of into the existing stormwater infrastructure. The proposed pond uses a riser outlet structure to control the outlet discharge of the pond back into the existing drainage infrastructure.

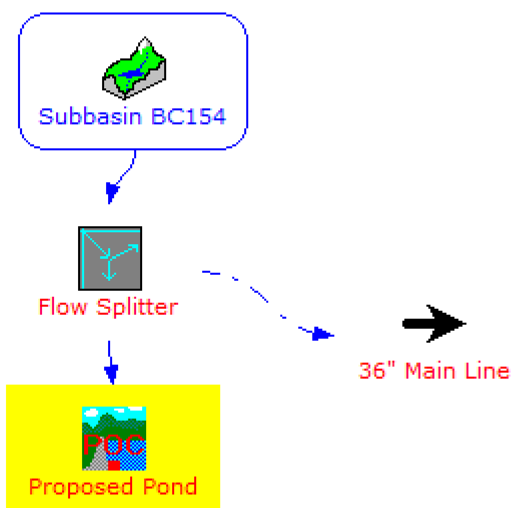
PERLND/IMPLND Data - The proposed conditions scenario utilized the previously defined watershed area and considered the current PERLND and IMPLND characteristics. These are defined below:

- Till Forest – 0.95 acres
- Till Pasture – 6.87 acres
- Till Grass – 1.23 acres
- Outwash Forest – 2.65 acres
- Outwash Pasture – 4.64 acres
- Outwash Grass – 3.81 acres
- Wetland – 1.06 acres
- Impervious – 106.97 acres

Flow Splitter – The flow splitter was designed to route a maximum of 20 cfs into the pre-treatment pond and bypass the remainder of flow into the existing stormwater infrastructure.

Pre-Treatment Pond –

- Pond/Vault Geometry – The pond geometry was designed based on the DTM and by visual observation of the aerial imagery. The base of the pond was designed to begin at elevation 158.50 ft (NAVD88) with a footprint of 230 ft by 230 ft and extend to elevation 164.00 ft (NAVD88) using a 3H:1V side slope. This provided a maximum pond storage of 7.828 ac-ft.
- Outlet Structure – A 36 in diameter open top circular overflow riser was utilized for this design. The riser crest was set at 162.00 ft (NAVD88). In addition to the open top riser, an 8 in circular orifice in vertical configuration was emplaced at elevation 158.50 ft (NAVD88).



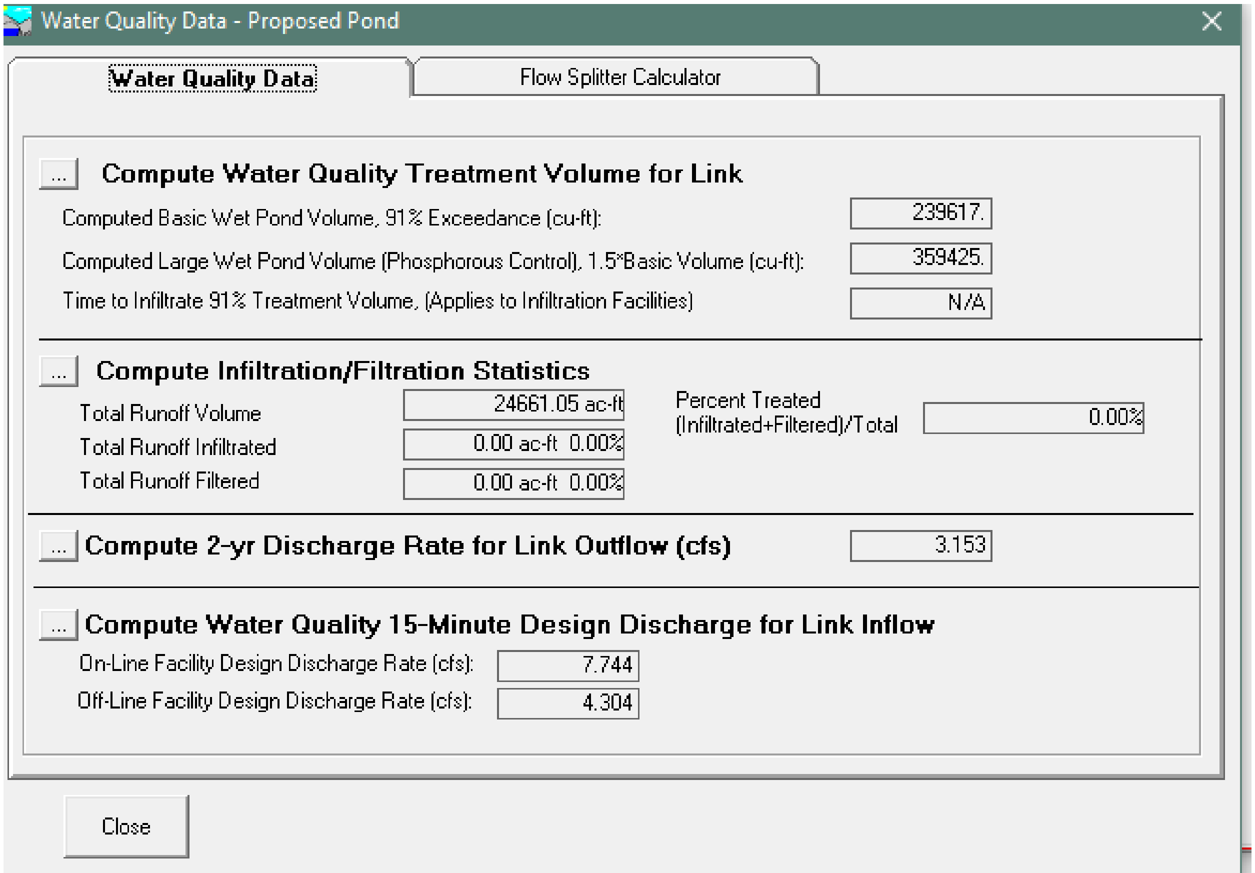
Simulation

The entire 158 year span of record (10/01/1939 – 10/01/2097) was utilized for the analysis at a 15 min computational timestep.

Results

Results:

Tr (yrs)	WSEL Peak (ft)
1.05-Year	160.654
1.11-Year	161.002
1.25-Year	161.296
2.00-Year	162.020
3.33-Year	162.222
5-Year	162.366
10-Year	162.470
25-Year	162.593
50-Year	162.628
100-Year	162.650


Water Quality Data - Proposed Pond

Water Quality Data | Flow Splitter Calculator

Compute Water Quality Treatment Volume for Link

Computed Basic Wet Pond Volume, 91% Exceedance (cu-ft):	239617.
Computed Large Wet Pond Volume (Phosphorous Control), 1.5*Basic Volume (cu-ft):	359425.
Time to Infiltrate 91% Treatment Volume, (Applies to Infiltration Facilities)	N/A

Compute Infiltration/Filtration Statistics

Total Runoff Volume	24661.05 ac-ft
Total Runoff Infiltrated	0.00 ac-ft 0.00%
Total Runoff Filtered	0.00 ac-ft 0.00%

Percent Treated (Infiltrated+Filtered)/Total: 0.00%

Compute 2-yr Discharge Rate for Link Outflow (cfs) 3.153

Compute Water Quality 15-Minute Design Discharge for Link Inflow

On-Line Facility Design Discharge Rate (cfs):	7.744
Off-Line Facility Design Discharge Rate (cfs):	4.304

Close

Appendix C.4

LITTLE SQUALICUM WATER QUALITY RETROFIT PROJECT

8/26/2019

Preliminary Project Description

General overview of conditions, opportunities, and preliminary considerations related to improving water quality in Little Squalicum Creek by retrofits of city-owned stormwater infrastructure.

Little Squalicum Water Quality Retrofit Project

PRELIMINARY PROJECT DESCRIPTION

INTRODUCTION

Little Squalicum Creek, while wholly outside of City of Bellingham city limits, is the receiving water body for stormwater runoff from approximately 300 acres of developed area within the City. The City's conveyance into and through this short, nearshore stream consists of traditional "gray" infrastructure that provides little to no water quality treatment for flows from the medium-density residential basin that is estimated to be approximately 28% impervious. Where this stream meets Bellingham Bay, a significant nearshore restoration project is under development, intended to provide pocket estuary habitat at the mouth. That project is the culmination of a long-term reclamation project at Little Squalicum Park, creating public open space adjacent to this stream and future estuary. Best available science indicates that water quality decline can be correlated to basins in which impervious coverage exceeds 10%, while impacts to benthic invertebrates occur at even lower percentages. The long-term success of the past reclamation work and the current restoration effort, and the future of healthy nearshore processes, rely on improving and protecting water quality within this drainage basin.

This project aims to characterize, segregate, infiltrate, disperse, and/or treat stormwater flows draining to Little Squalicum Creek from the City of Bellingham to offset the impact of developed surfaces on the health of both fresh and surface waters. Best Management Practices (BMPs) employed to meet this goal could include traditional infrastructure, such as flow splitters and sand filters, along with low impact development (LID) improvements such as bioretention and permeable pavement, supplemented with proprietary treatment systems as needed.

PROJECT NARRATIVE

Phase 1; Design and Permitting

This project will require significant pre-design, conceptual design, and final design work in order to meet the requirements of the City, environmental regulations, and Department of Ecology stormwater facility design guidelines. The following design and permitting steps are expected for this project:

- State Environmental Policy Act (SEPA) review and approval
- Department of Archeology and Historic Preservation (DAHP) review and approval
- Geotechnical explorations
- Site survey
- 30% Plans, Specifications, Estimate, and Schedule
- 90% Plans, Specifications, Estimate, and Schedule
- Bid-ready Documents
- City of Bellingham Shoreline Permit
- City of Bellingham Minor Critical Areas Permit
- City of Bellingham Stormwater Land Disturbance Permit

Phase 2; Construction

Phase 2A; Eldridge and Lindberg Ave. Drainage

The drainage system that leads to the westernmost discharge points into Little Squalicum Creek emanates from the Eldridge Avenue alignment and nearby streets west of Bellingham Technical College. Approximately 20 acres of development, including a portion of BTC's campus, that is currently untreated would pass through a treatment BMP near the intersection of Eldridge Ave. and Lindberg Street. The current network has three known outfalls, which would ideally be combined to allow treatment in a single location. Alternatively, smaller BMPs could be installed at each outfall, with a combined dispersion system connecting all three outlets. The current configuration, as it appears on City IQ, with some preliminary mark-up, is shown below.

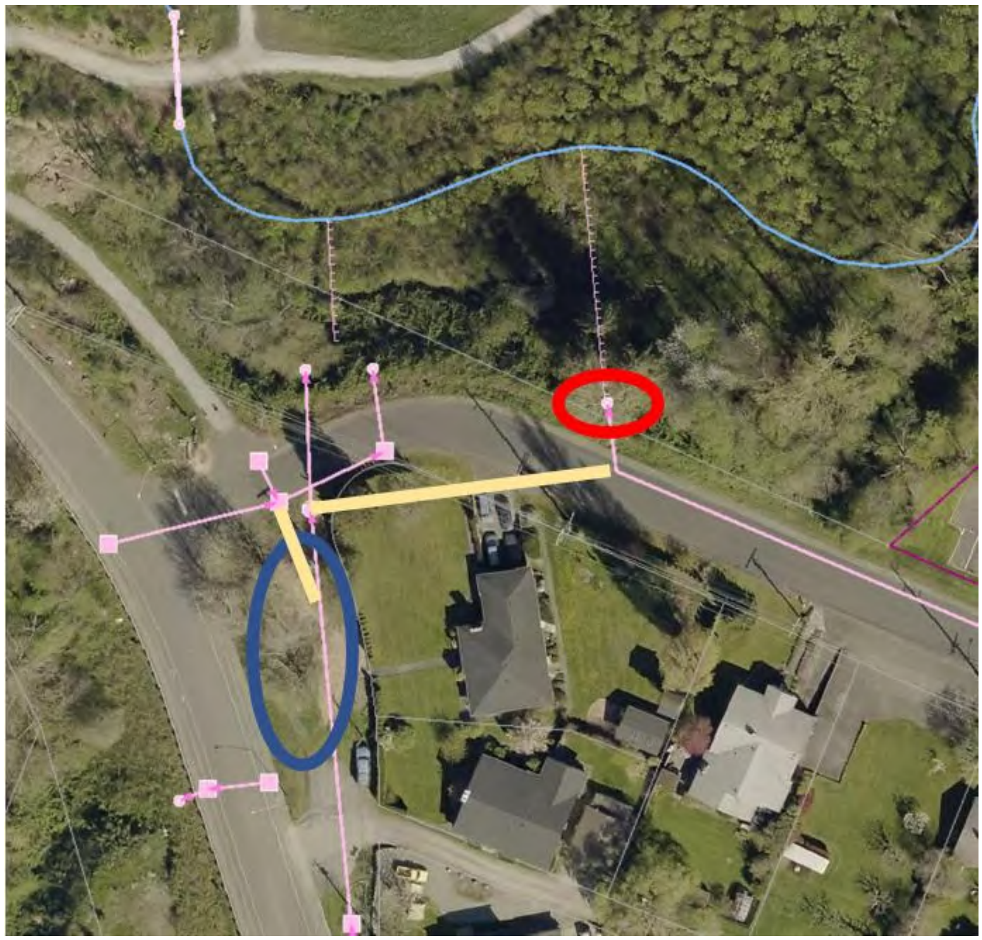
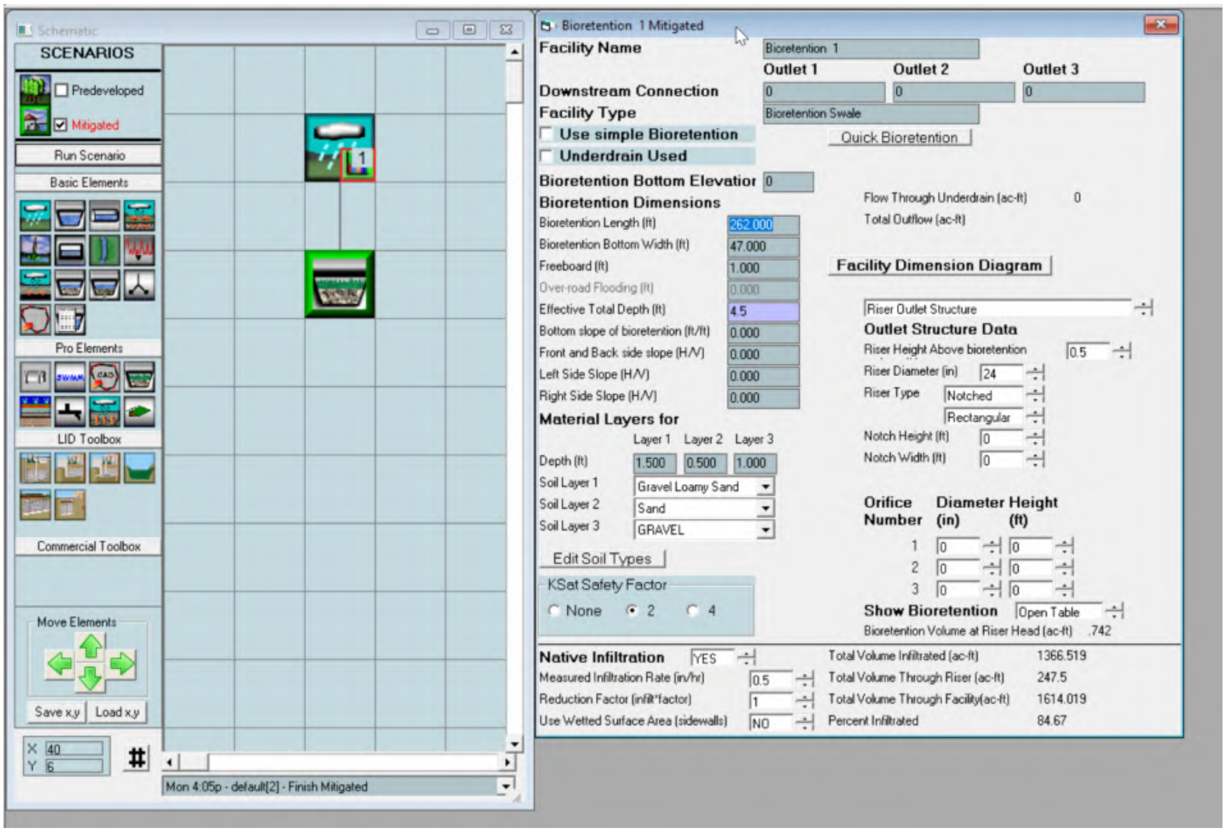
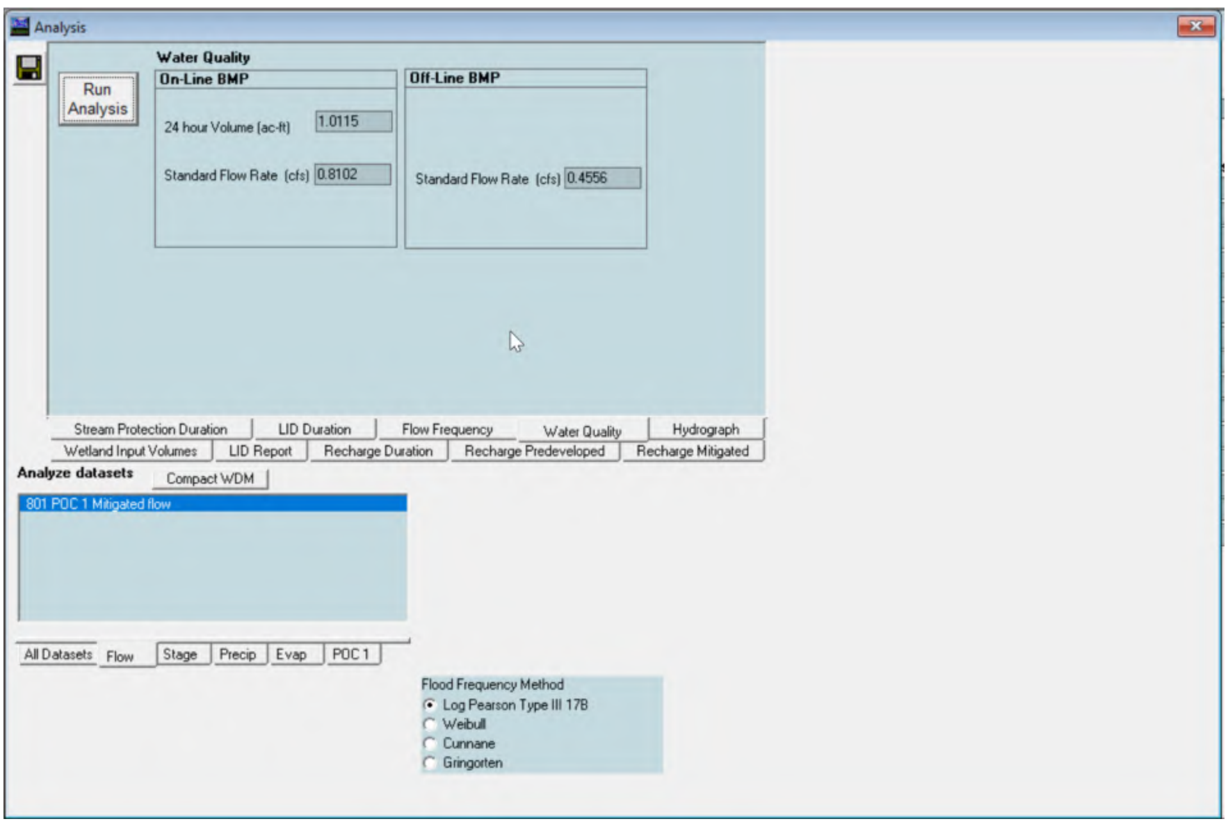


Figure 1: Potential Retrofit Location at Eldridge and Lindberg. Blue circle indicates primary BMP location. Red circle indicates secondary BMP location. Yellow lines indicate potential new piping to or from facility

Figure 2: Google Maps image of publicly-owned area adjacent to Eldridge Ave. CB in foreground is shown on map above and area containing second sidewalk is within the blue circle on the image above.

Figure 3: Looking south on Lindbergh Ave. Valley gutter to left of image carries much of the surface flow, but a buried pipe in this location carries a significant amount of flow from upstream in the basin.


Schematic
SCENARIOS
Predeveloped
Mitigated
Run Scenario
Basic Elements
Pro Elements
LID Toolbox
Commercial Toolbox
Move Elements
Save x,y
Load x,y
Mon 4:05p - default[2] - Finish Mitigated
Bioretention 1 Mitigated
Facility Name
Bioretention 1
Outlet 1
Outlet 2
Outlet 3
Downstream Connection
Facility Type
Bioretention Swale
Use simple Bioretention
Quick Bioretention
Underdrain Used
Bioretention Bottom Elevation
Bioretention Dimensions
Bioretention Length (ft) 262.000
Bioretention Bottom Width (ft) 47.000
Freeboard (ft) 1.000
Over-road Flooding (ft) 0.000
Effective Total Depth (ft) 4.5
Bottom slope of bioretention (ft/ft) 0.000
Front and Back side slope (H/V) 0.000
Left Side Slope (H/V) 0.000
Right Side Slope (H/V) 0.000
Material Layers for
Layer 1 Layer 2 Layer 3
Depth (ft) 1.500 0.500 1.000
Soil Layer 1 Gravel Loamy Sand
Soil Layer 2 Sand
Soil Layer 3 GRAVEL
Edit Soil Types
KSat Safety Factor
None 2 4
Flow Through Underdrain (ac-ft) 0
Total Outflow (ac-ft)
Facility Dimension Diagram
Riser Outlet Structure
Outlet Structure Data
Riser Height Above bioretention 0.5
Riser Diameter (in) 24
Riser Type Notched
Rectangular
Notch Height (ft) 0
Notch Width (ft) 0
Orifice Number
Diameter (in)
Height (ft)
Show Bioretention
Open Table
Bioretention Volume at Riser Head (ac-ft) .742
Native Infiltration YES
Measured Infiltration Rate (in/hr) 0.5
Reduction Factor (infilt*factor) 1
Use Wetted Surface Area (sidewalls) NO
Total Volume Infiltrated (ac-ft) 1366.519
Total Volume Through Riser (ac-ft) 247.5
Total Volume Through Facility(ac-ft) 1614.019
Percent Infiltrated 84.67


Analysis
Run Analysis
Water Quality
On-Line BMP
24 hour Volume (ac-ft) 1.0115
Standard Flow Rate (cfs) 0.8102
Off-Line BMP
Standard Flow Rate (cfs) 0.4556
Stream Protection Duration
LID Duration
Flow Frequency
Water Quality
Hydrograph
Wetland Input Volumes
LID Report
Recharge Duration
Recharge Predeveloped
Recharge Mitigated
Analyze datasets
Compact WDM
801 POC 1 Mitigated flow
All Datasets
Flow
Stage
Precip
Evap
POC 1
Flood Frequency Method
Log Pearson Type III 17B
Weibull
Cunnane
Gringorten

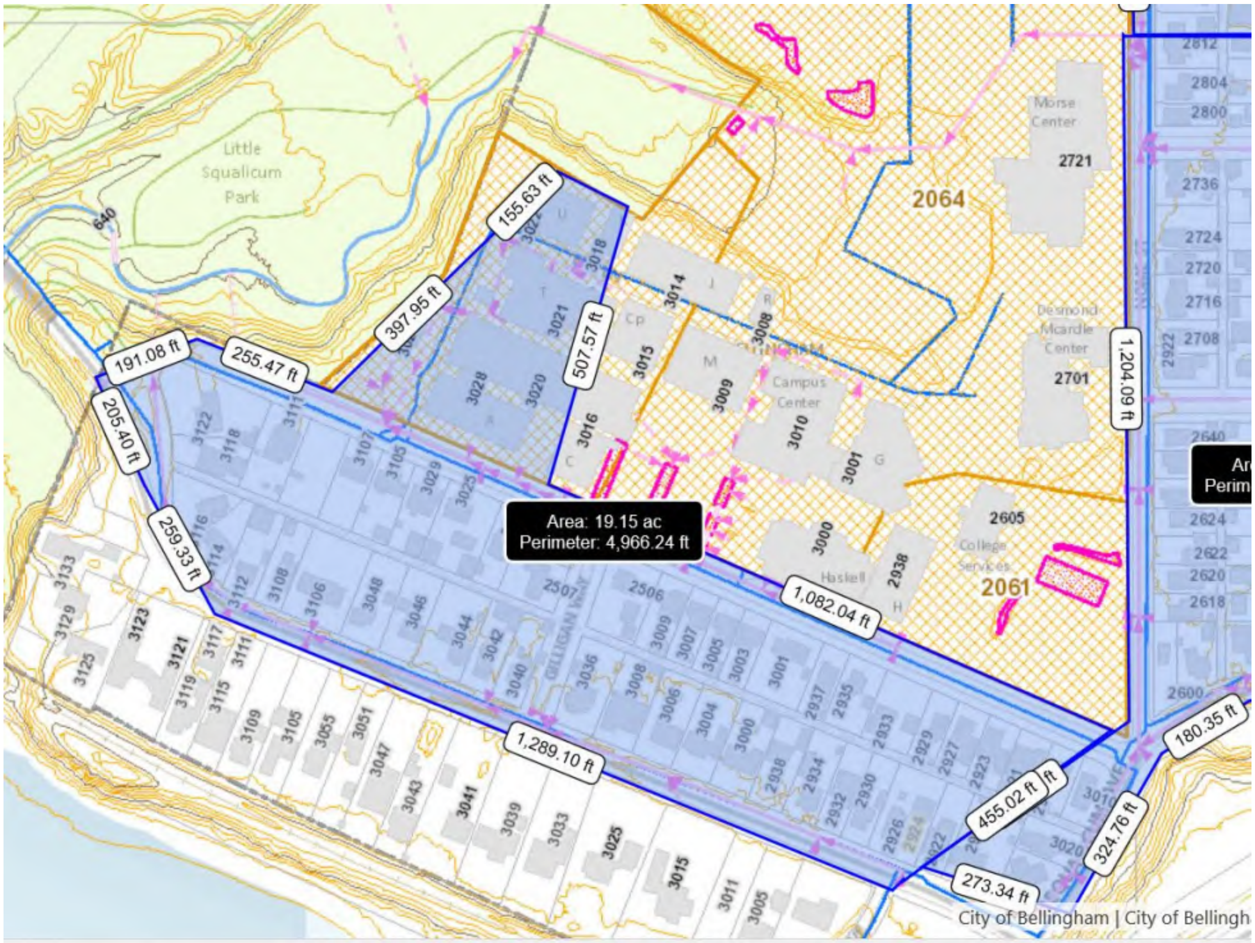
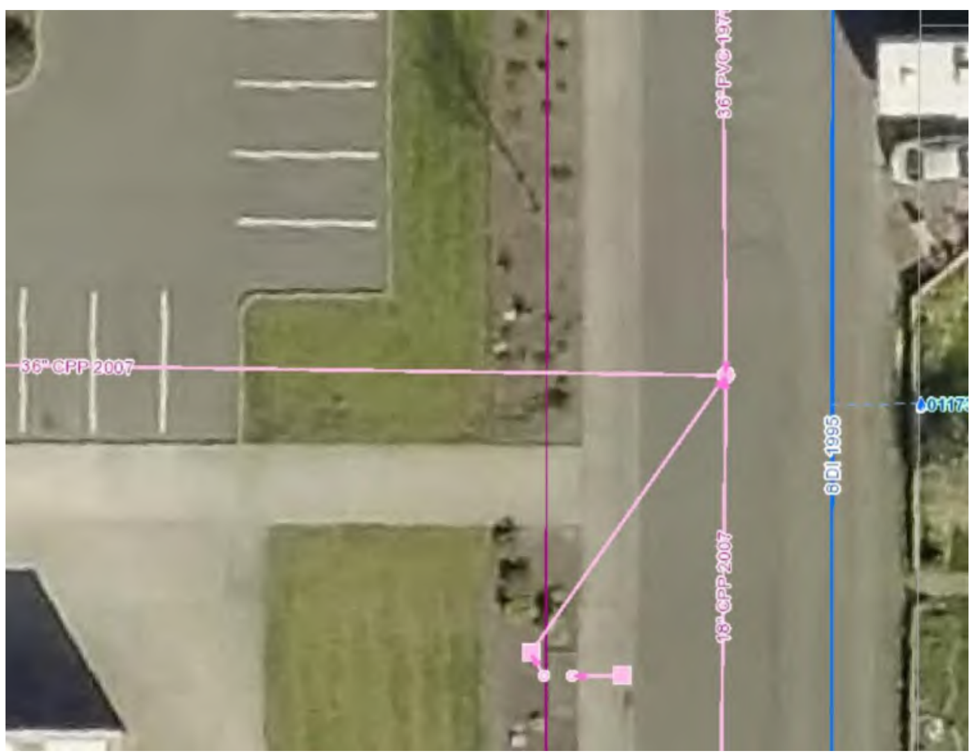


Figure 4: Overview map of tributary basin draining to Eldridge/Lindbergh Improvement Site

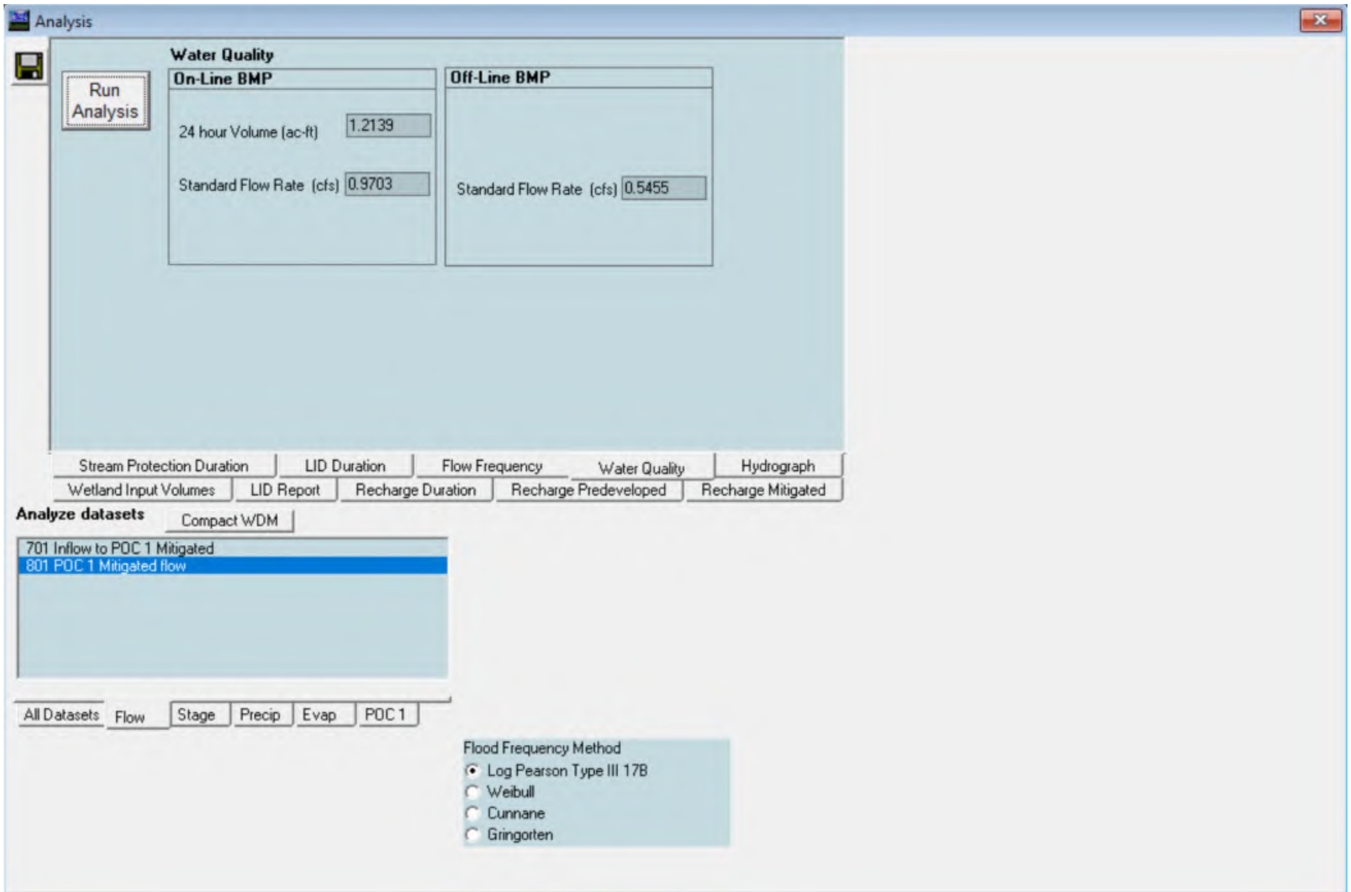
Phase 2B; Nome Street Treatment Vault

Runoff that drains to the stream from the east is generated from a vast infrastructure network that traverses more than one mile of distance, in pipes of varying composition at variable depths. This piped network outlets into Little Squalicum Creek a single location, in a single pipe passing through the Bellingham Technical College campus.

The last location where this network is accessible, before it passes onto private property, is along Nome Street, running along the eastern boundary of BTC.



Approximately 24 acres of developed area contributes to the pipe flowing from the south to this location on Nome Street. Right-of-way in this area is wide enough to support the installation of a treatment vault beneath the landscaping and sidewalk, extending to beneath the street if needed. Constructing the vault in the street would allow for re-adjustment of pipe elevations to accommodate for hydraulic drop, if needed. Chasing the 36" outlet pipe would also allow for significant depth at vault outlet, if needed.



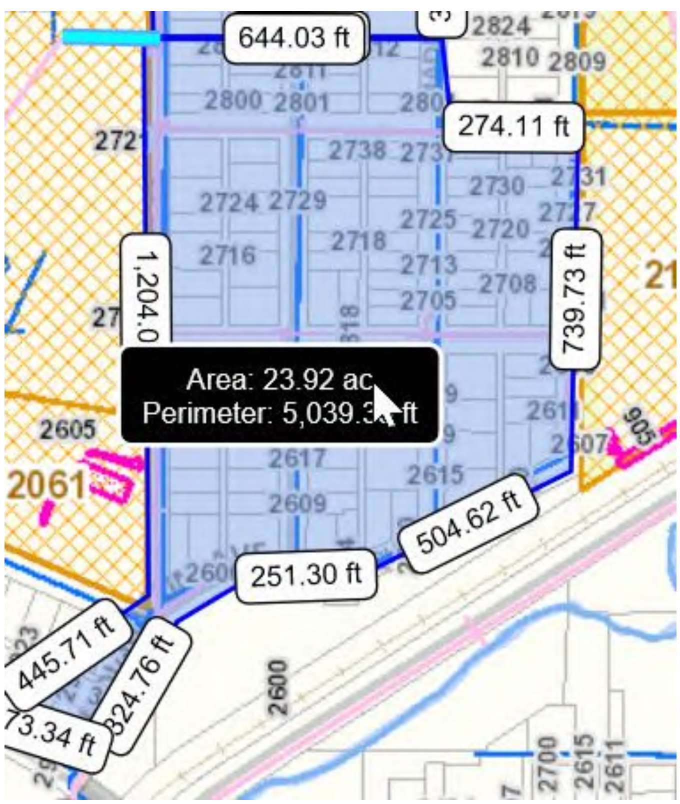


Figure 5: Basin Tributary area to Nome Street Retrofit Site

Phase 2C; Birchwood Neighborhood Stormwater Retrofit

The stormwater main running south down Nome Street from the Birchwood neighborhood is the trunk line for a system of stormwater piping that drains approximately 260 acres of residential development. Developing plans to treat this vast area relies on the ability to install distributed treatment facilities throughout the residential basin, where opportunities present themselves. The City of Bellingham recently completed a similar project in the Columbia neighborhood, installing three vaults in residential settings to treat 80 acres of similar-intensity development. Assuming equivalent conditions, that would suggest that this basin would require 10 vaults located at important nodes in the stormwater system. The following locations were identified using simply desktop surveying and would need to be identified, assessed, and prioritized based on a number of additional feasibility metrics not explored in this evaluation.

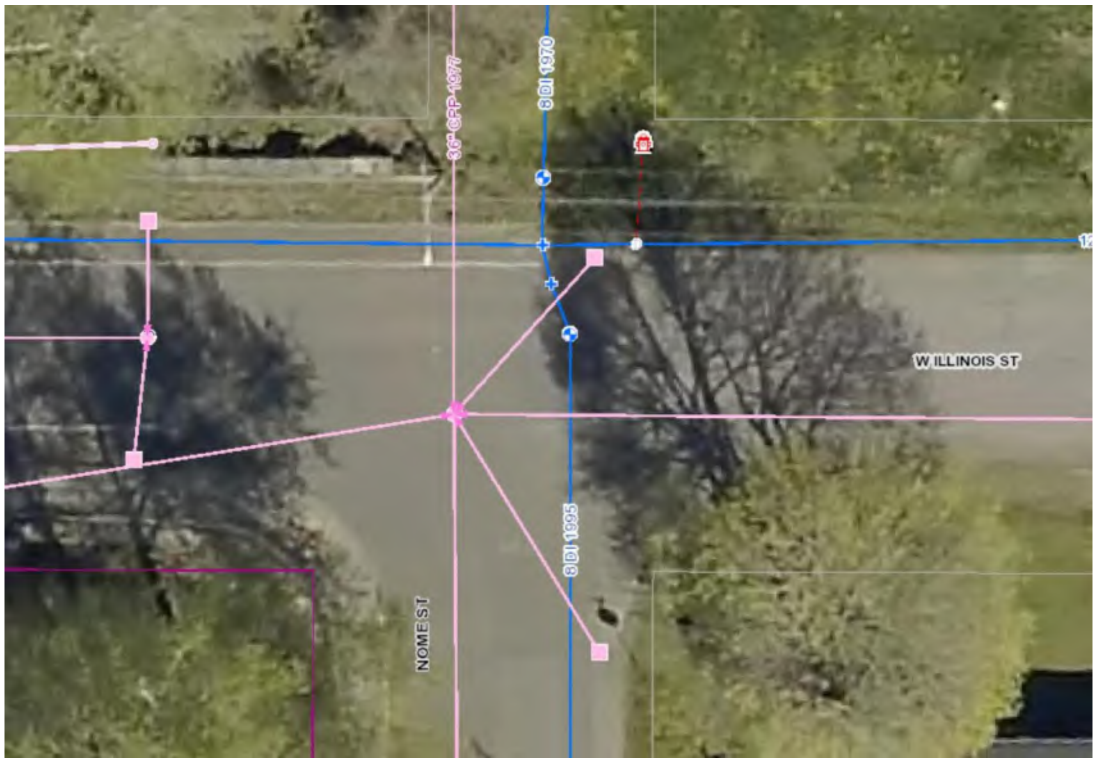


Figure 6: Location 1, West Illinois and Nome St. Drainage from east and west on Illinois and north and south from intersection with Nome St.

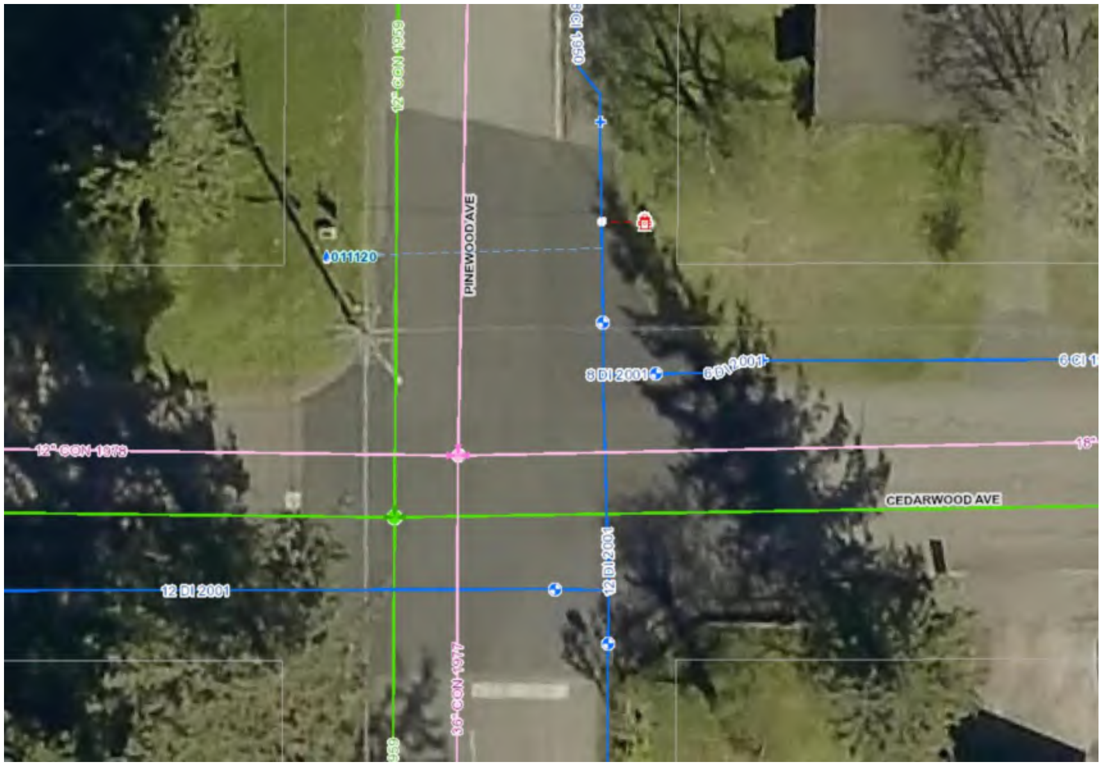


Figure 7: Location 2, Cedarwood and Pinewood. Drainage from East and West on Cedarwood

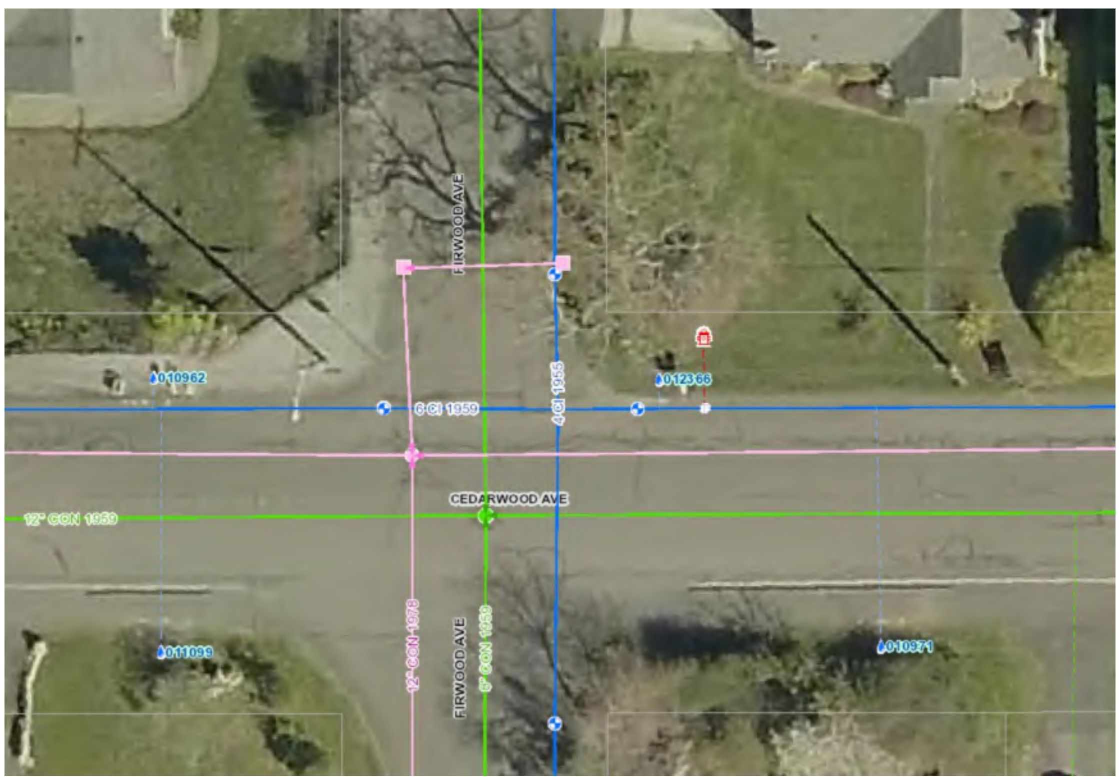


Figure 8: Location 3: Cedarwood and Firwood. Drainage from east on Cedarwood and from North/South on Firwood.

Figure 9: Location 4: Pinewood and Birchwood. Drainage from east and west on Birchwood.

Figure 10: Location 5: Firwood at Birchwood. Drainage from east on Birchwood and from North/South on Firwood.

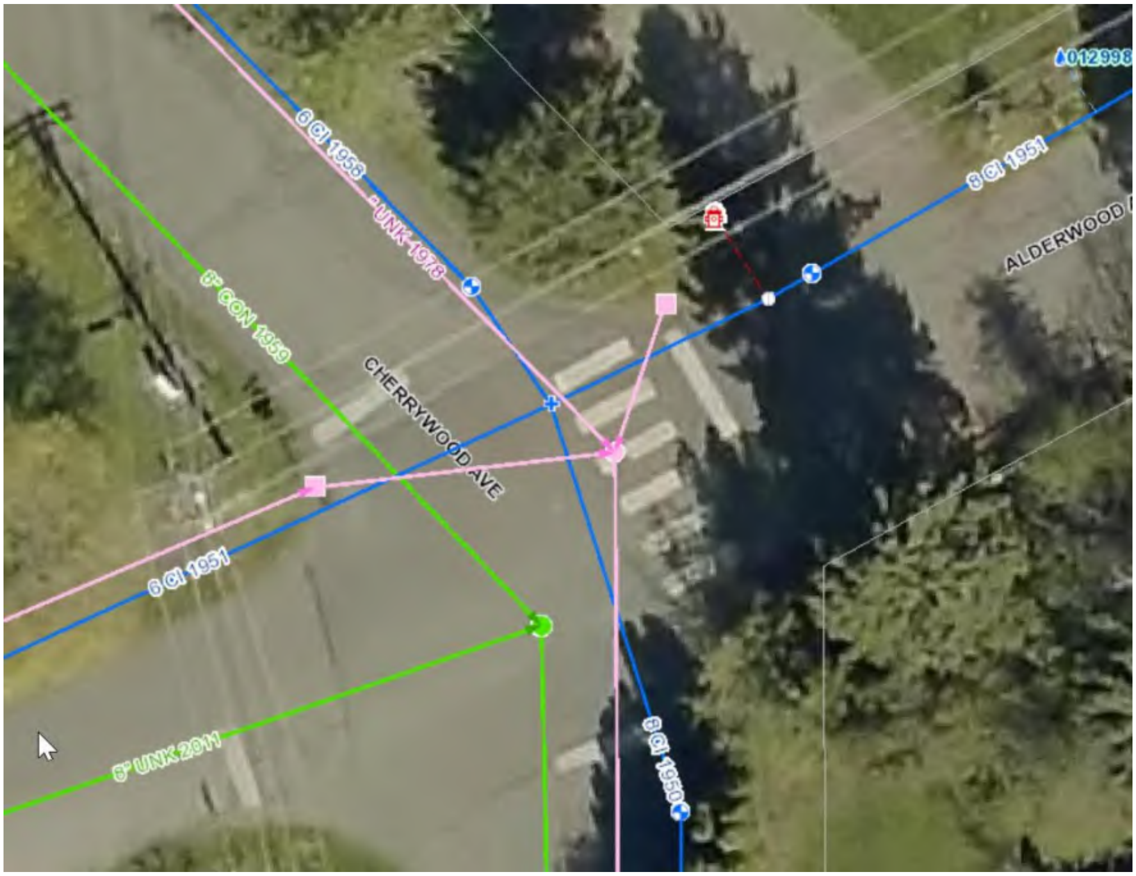


Figure 11: Location 6. Alderwood at Cherrywood. Drainage from northwest and southwest

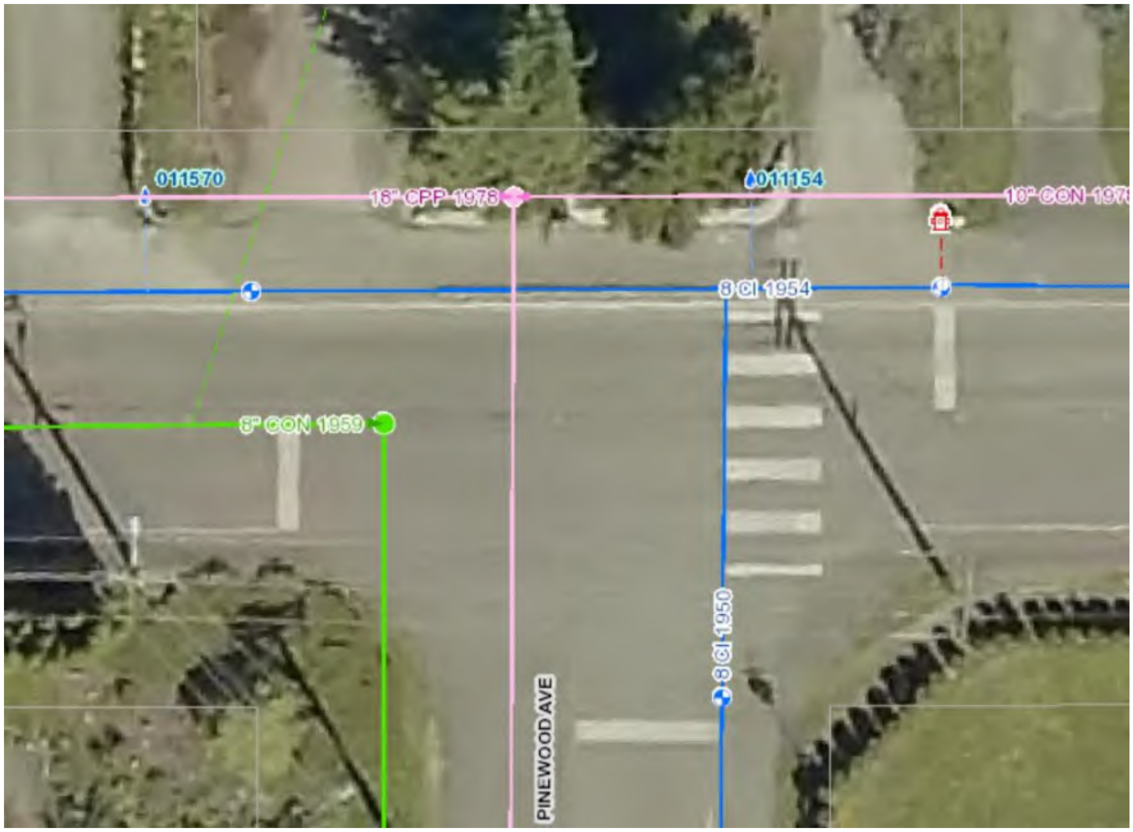


Figure 12: Location 7: Cottonwood and Pinewood, drainage from east and west

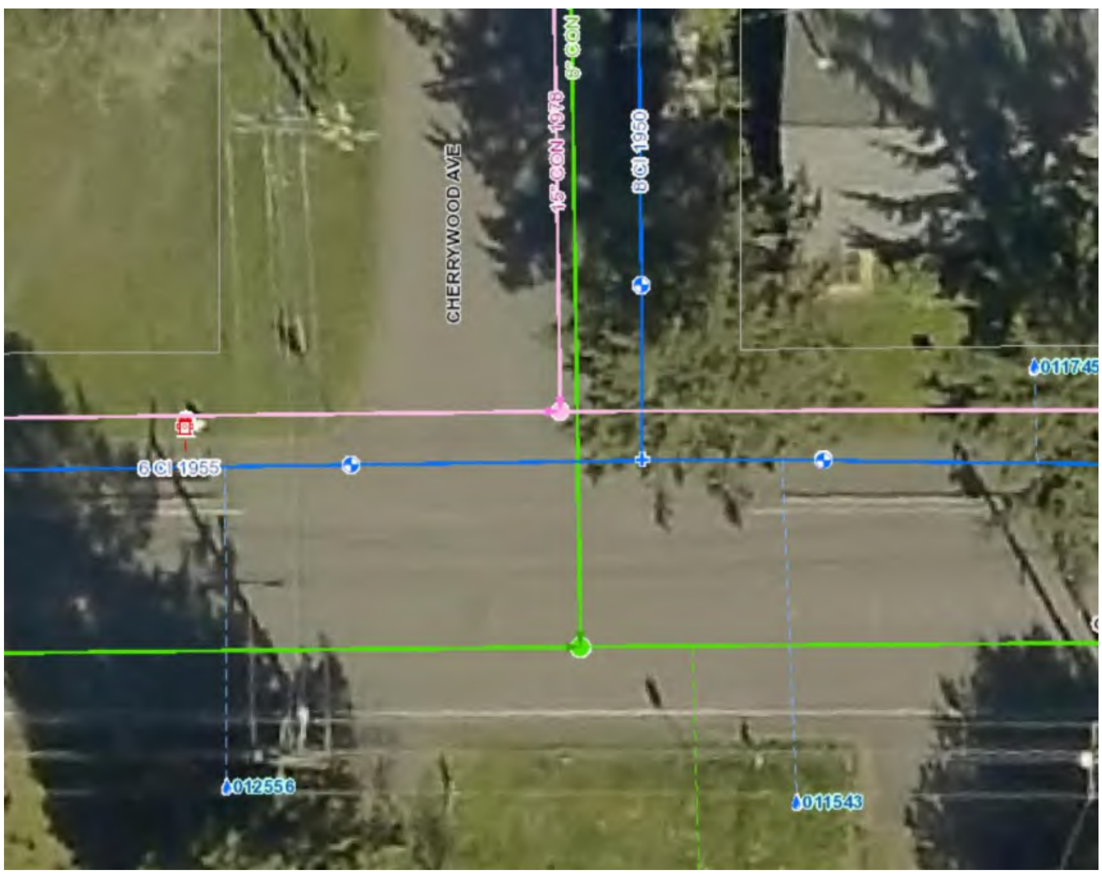


Figure 13: Location 8: Cherrywood at Cottonwood. Drainage from north and west

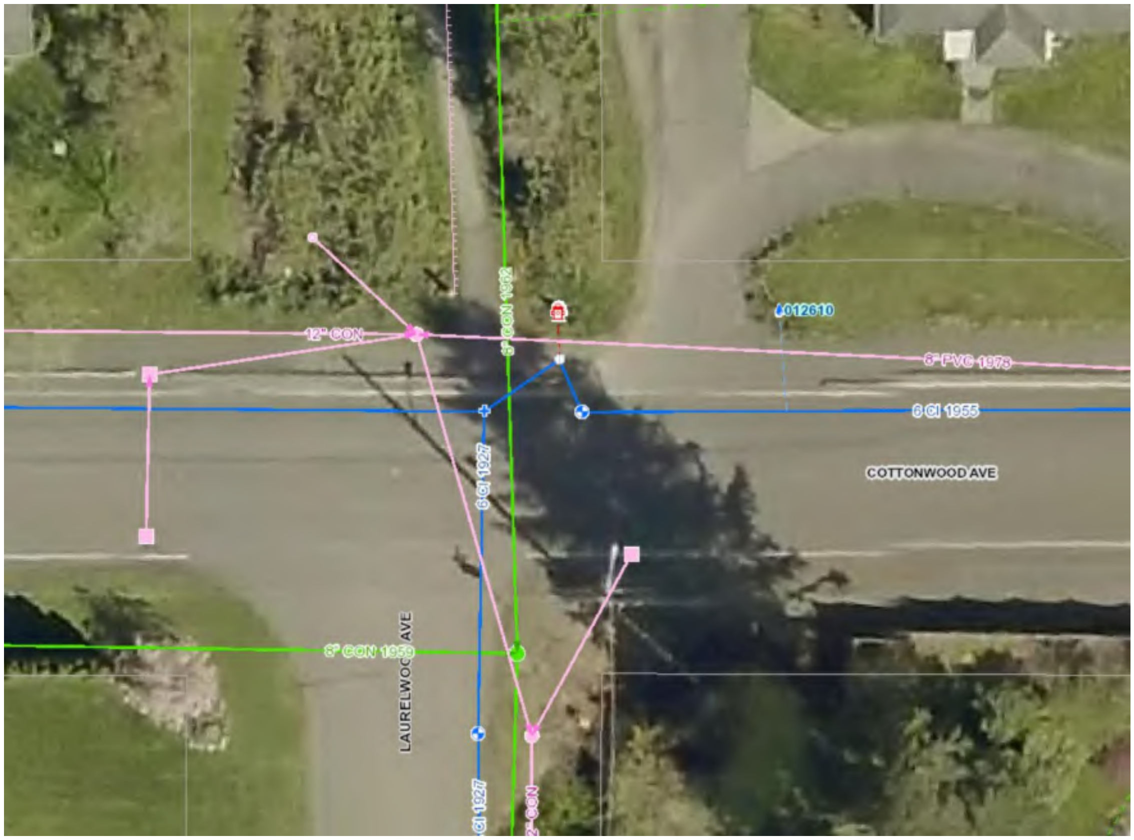


Figure 14: Location 9, Cottonwood at Laurelwood. Drainage from north, south, east, and west. Drains to private pipe

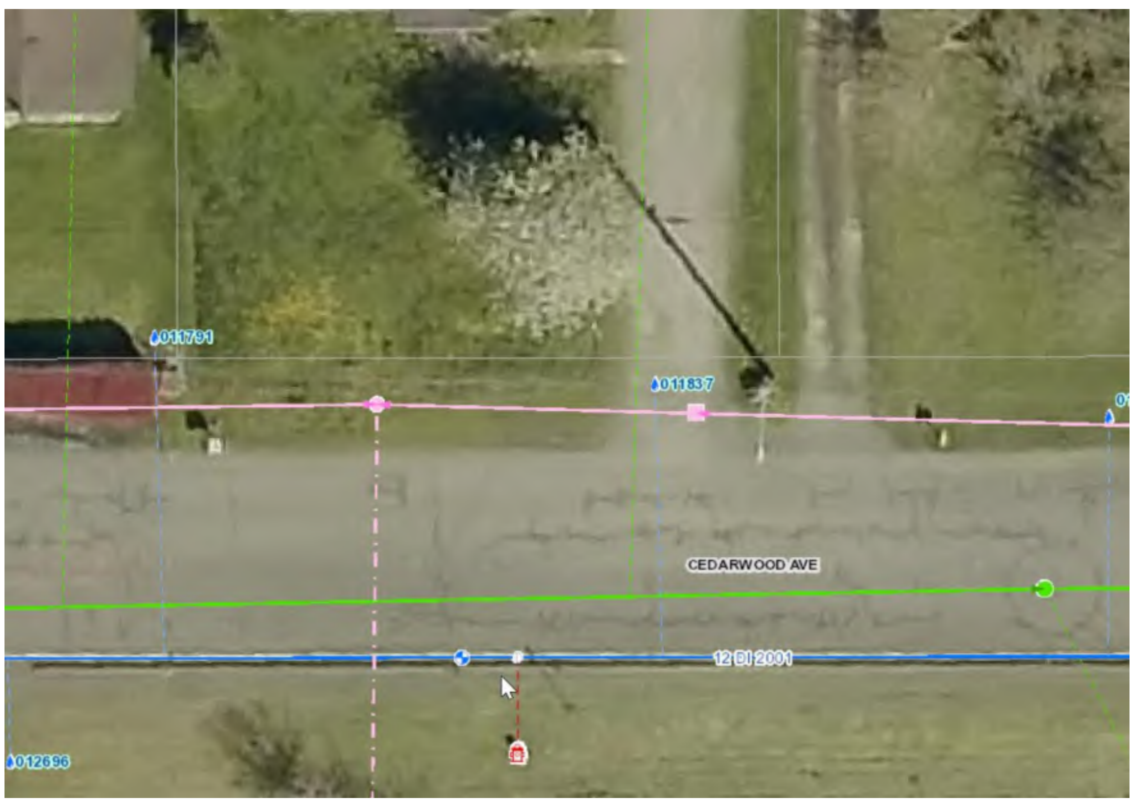
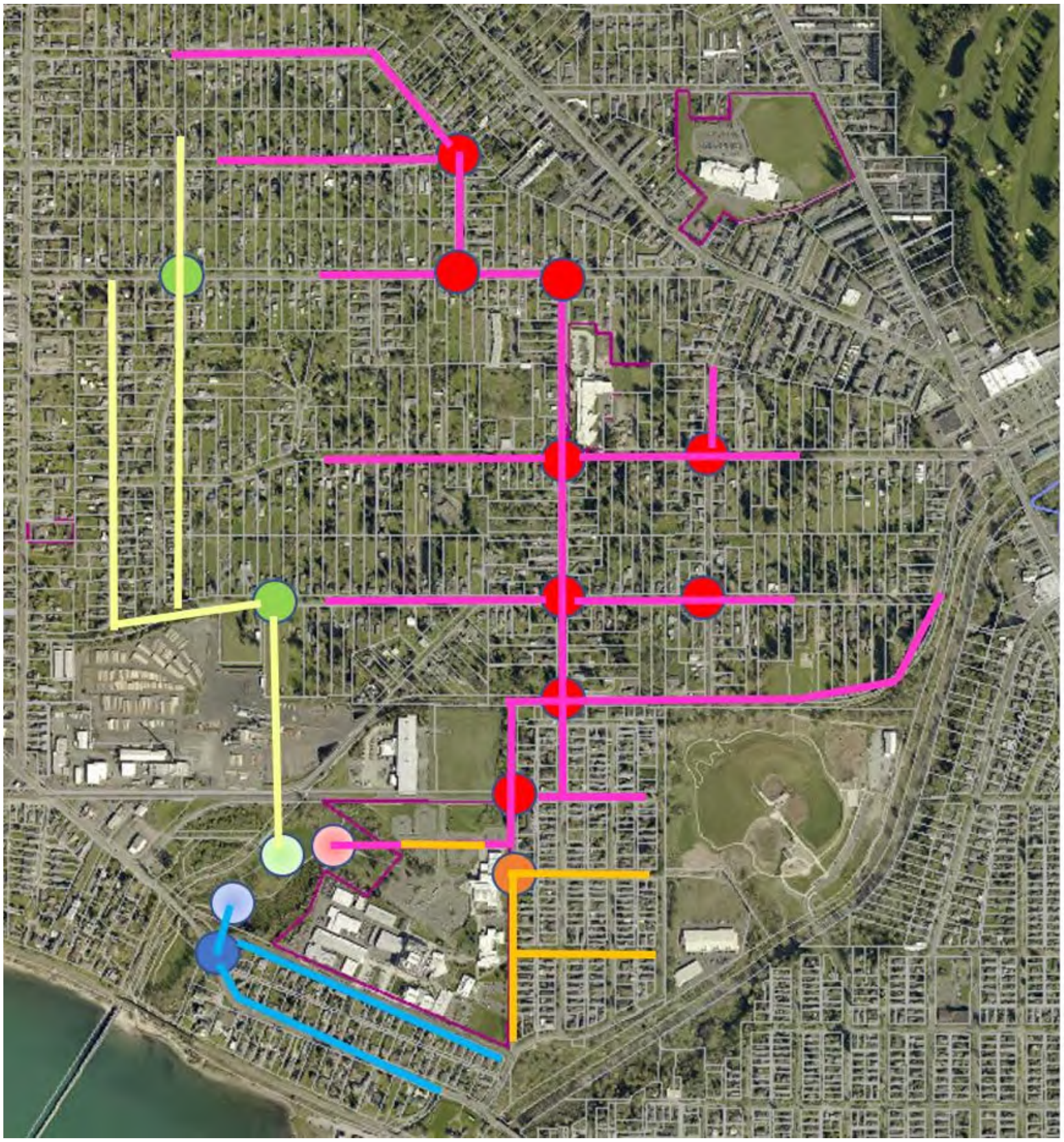


Figure 15: Location 10: Cedarwood at private pipe junction.

OVERVIEW MAP



KEY TO MAP			
(blue circle)	ELDRIDGE AND LINDBERGH IMPROVEMENTS	(blue line)	STORM MAINS TREATED BY ELDRIDGE/LINDBERGH PROJECT
(orange circle)	NOME STREET VAULT LOCATION	(orange line)	STORM MAINS TREATED BY NOME STREET VAULT
(red circle)	DISTRIBUTED BIRCHWOOD IMPROVEMENTS – MAIN BASIN	(pink line)	STORM MAINS TREATED BY MAIN BASIN WATER QUALITY PROJECT
(green circle)	DISTRIBUTED BIRCHWOOD IMPROVEMENTS – WEST BASIN	(yellow line)	STORM MAINS TREATED BY WEST BASIN WATER QUALITY PROJECT

10% DESIGN BUDGET ESTIMATE

The following table outlines the very rough estimate of project costs, based wholly on the work completed in the Columbia and Roosevelt neighborhoods in 2016, as part of a similar project. Soft costs that are partially-derived from the Columbia project and partially developed based on the average percentage of construction costs applied to each additional work item. The estimate below is not considered a professional opinion, as the estimator is not a professional engineer.

	Eldridge/Lindbergh	Nome Street Vault	Birchwood Distributed
Design	$ 95,341	$ 172,491	$ 732,208
Construction	$ 158,901	$ 287,486	$ 3,050,868
Constuction Management	$ 28,602	$ 51,747	$ 366,104
Contingency	$ 31,780	$ 57,497	$ 610,174
Total	$ 314,625	$ 569,222	$ 4,759,354
Grant Ask	$ 235,969	$ 426,916	$ 3,569,515
Match	$ 78,656	$ 142,305	$ 1,189,838

Grand Total	
Design	$ 1,000,040
Construction	$ 3,497,255
Construction Management	$ 446,454
Contingeny	$ 699,451
Total	$ 5,643,200
Grant Ask	$ 4,232,400
Match	$ 1,410,800

Eldridge/Lindbergh Improvements				
Item	**QTY**	**Units**	**Unit Cost**	**Ext**
Removal of structures (asphalt)	60.7	CY	$24.34	$1,476.63
Removal of structures (concrete)	119.2	CY	$25.13	$2,994.66
Pothole existing utility	2.4	EA	$359.81	$857.55
Shoring	379.2	LF	$1.51	$572.54
Controlled Density Fill	8.7	CY	$117.39	$1,017.38
Gravel Base	1083.3	TON	$11.92	$12,913.33
Aggregate for Bioretention Cell	70.4	TON	$33.97	$2,392.05
4" perforated pvc storm pipe	58.3	LF	$19.08	$1,112.05
8" pvc storm pipe	64.4	LF	$30.19	$1,942.73
8" ductile iron storm pipe	43.3	LF	$49.62	$2,150.20
18" PE storm pipe	148.6	LF	$45.62	$6,780.65
24" corregated PE storm pipe	99.0	LF	$61.85	$6,124.18
Catch Basin type 1	5.2	EA	$923.56	$4,802.51
Catch Basin type 2	2.4	EA	$2,106.45	$5,020.37
Flow Control structure	0.7	EA	$6,001.26	$3,900.82
Cement concrete curbs	203.7	LF	$27.38	$5,576.39
Cement concrete sidewalk w ramps	125.7	SY	$65.71	$8,257.56
Topsoil	13.0	CY	$102.09	$1,327.17
Seed	58.5	SY	$7.61	$445.19
Mulch	16.3	CY	$65.03	$1,056.74
Bioretention plantings	0.2	LS	$60,000.00	$13,000.00
Excavation and Haul	335.8	CY	$15.07	$5,061.01
Connection to structure	0.2	EA	$650.00	$140.83
			Construction Subtotal	**$88,922.54**
Mobilization	1.0	LS	10%	$8,892.25
Construction Survey	1.0	LS	10%	$8,892.25
Traffic Control	411.7	HR	$50.35	$20,727.42
Clearing and Grubbing	0.2	LS	$3,000.00	$650.00
Erosion Control	0.4	LS	$10,000.00	$4,333.33
			Construction Associated Subtotal	**$43,495.26**
Other Costs	1.0	LS	20%	$26,483.56
Contingency	1.0	LS	20%	$31,780.27
			Contingency Subtotal	**$58,263.83**
			Construction Total	**$190,681.62**
Engineering Services	1	PCT	20%	$38,136.32
Permitting	1	PCT	10%	$19,068.16
Survey	1	PCT	10%	$19,068.16
Geotechnical Explorations	1	PCT	10%	$19,068.16
Construction Management	1	PCT	15%	$28,602.24
			Soft Cost Subtotal	**$123,943.05**
			Project Total	**$314,624.67**
			w/o contingency	$282,844.40

Nome Street Vault				
Item	**QTY**	**Units**	**Unit Cost**	**Ext**
Water Quality Vaults (0.5 cfs ea.)	0.8	EA	$100,000.00	$81,666.67
Removal of structures (asphalt)	76.2	CY	$24.34	$1,855.25
Removal of structures (concrete)	149.7	CY	$25.13	$3,762.52
Pothole existing utility	3.0	EA	$359.81	$1,077.43
Shoring	476.4	LF	$1.51	$719.35
Controlled Density Fill	10.9	CY	$117.39	$1,278.25
Gravel Base	1361.1	TON	$11.92	$16,224.44
4" perforated pvc storm pipe	73.2	LF	$19.08	$1,397.19
8" pvc storm pipe	80.9	LF	$30.19	$2,440.86
8" ductile iron storm pipe	54.4	LF	$49.62	$2,701.53
18" PE storm pipe	186.7	LF	$45.62	$8,519.28
24" corregated PE storm pipe	124.4	LF	$61.85	$7,694.48
Catch Basin type 1	6.5	EA	$923.56	$6,033.93
Catch Basin type 2	3.0	EA	$2,106.45	$6,307.65
Flow Control structure	0.8	EA	$6,001.26	$4,901.03
Cement concrete curbs	255.9	LF	$27.38	$7,006.24
Cement concrete sidewalk w ramps	157.9	SY	$65.71	$10,374.88
Topsoil	16.3	CY	$102.09	$1,667.47
Seed	73.5	SY	$7.61	$559.34
Excavation and Haul	421.9	CY	$15.07	$6,358.70
Connection to structure	0.3	EA	$650.00	$176.94
			Construction Subtotal	**$172,723.42**
Mobilization	1.0	LS	10%	$17,272.34
Construction Survey	1.0	LS	10%	$17,272.34
Traffic Control	517.2	HR	$50.35	$26,042.14
Clearing and Grubbing	0.3	LS	$3,000.00	$816.67
Erosion Control	0.5	LS	$10,000.00	$5,444.44
			Construction Associated Subtotal	**$66,847.93**
Other Costs	1.0	LS	20%	$47,914.27
Contingency	1.0	LS	20%	$57,497.13
			Contingency Subtotal	**$105,411.40**
			Construction Total	**$344,982.75**
Engineering Services	1	PCT	20%	$68,996.55
Permitting	1	PCT	10%	$34,498.28
Survey	1	PCT	10%	$34,498.28
Geotechnical Explorations	1	PCT	10%	$34,498.28
Construction Management	1	PCT	15%	$51,747.41
			Soft Cost Subtotal	**$224,238.79**
			Project Total	**$569,221.54**
			w/o Contingency	$511,724.41

Birchwood Neighborhood Distributed Vaults				
Item	**QTY**	**Units**	**Unit Cost**	**Ext**
Water Quality Vaults (0.5 cfs ea.)	8.7	EA	$100,000.00	$866,666.67
Removal of structures (asphalt)	808.9	CY	$24.34	$19,688.36
Removal of structures (concrete)	1588.9	CY	$25.13	$39,928.78
Pothole existing utility	31.8	EA	$359.81	$11,433.96
Shoring	5055.6	LF	$1.51	$7,633.89
Controlled Density Fill	115.6	CY	$117.39	$13,565.07
Gravel Base	14444.4	TON	$11.92	$172,177.78
4" perforated pvc storm pipe	777.1	LF	$19.08	$14,827.28
8" pvc storm pipe	858.0	LF	$30.19	$25,903.02
8" ductile iron storm pipe	577.8	LF	$49.62	$28,669.33
18" PE storm pipe	1981.8	LF	$45.62	$90,408.70
24" corregated PE storm pipe	1320.2	LF	$61.85	$81,655.74
Catch Basin type 1	69.3	EA	$923.56	$64,033.49
Catch Basin type 2	31.8	EA	$2,106.45	$66,938.30
Flow Control structure	8.7	EA	$6,001.26	$52,010.92
Cement concrete curbs	2715.6	LF	$27.38	$74,351.91
Cement concrete sidewalk w ramps	1675.6	SY	$65.71	$110,100.76
Topsoil	173.3	CY	$102.09	$17,695.60
Seed	780.0	SY	$7.61	$5,935.80
Excavation and Haul	4477.8	CY	$15.07	$67,480.11
Connection to structure	2.9	EA	$650.00	$1,877.78
			Construction Subtotal	**$1,832,983.24**
Mobilization	1.0	LS	10%	$183,298.32
Construction Survey	1.0	LS	10%	$183,298.32
Traffic Control	5488.9	HR	$50.35	$276,365.56
Clearing and Grubbing	2.9	LS	$3,000.00	$8,666.67
Erosion Control	5.8	LS	$10,000.00	$57,777.78
			Construction Associated Subtotal	**$709,406.65**
Other Costs	1.0	LS	20%	$508,477.98
Contingency	1.0	LS	20%	$610,173.57
			Contingency Subtotal	**$1,118,651.55**
			Construction Total	**$3,661,041.45**
Engineering Services	1	PCT	10%	$366,104.14
Permitting	1	PCT	5%	$183,052.07
Survey	1	PCT	3%	$91,526.04
Geotechnical Explorations	1	PCT	3%	$91,526.04
Construction Management	1	PCT	10%	$366,104.14
			Soft Cost Subtotal	**$1,098,312.43**
			Project Total	**$4,759,353.88**
			W/o Contingency	$4,149,180.31

CITY OF BELLINGHAM FISH BARRIOR PRIORITZATION, 9/9/2019

RANK	Stream	Road Crossing	Total PI (Form)	Barrier Reason	Passability (%)	Coordination-Barriers	Coordination-Transportation	Benefits	Cost Estimate	Notes	SCORE
1	Squalicum Cr	Baker Cr confluence	unknown	WS drop	33	downstream of private McLeod 2007, COB Squal Ph 1/2 2015, COB McLeod2015, WSDOT prioritized 2025, COB Squal Ph 3/4 2020; upstream of COB Willow Spring 2010/2018, COB lower Squal restoration sites	None		$ 200,000	flood "dam" (riser). Retrofit completed in 2005 EV-18?? Riser may not have been included in retrofit. Minor adjustment to riser?	**14.7**
2	SF Baker Cr	James St	0.00	unknown	unknown	1 mi upstream of COB barrier improvement on Baker Cr at McLeod 2015, location of the James St Multimodal Study	James St Multimodal project, 2025 at earliest (unfunded), result of 2019 study will be a recommended design for James Street from Orchard to Kellogg that we will use to seek funding for construction. Major infrastructure revisions (wider roadway, curb, gutter, culvert replacement)	wider floodplain	$ 1,000,000	Transpo Group estimated $1 million for full width bridge (2019 James St Mulitmodal Study)	**14.7**

Ranked Fish Passage Culverts

RANK	Stream	Road Crossing	Total PI (Form)	Barrier Reason	Passability (%)	Coordination-Barriers	Coordination-Transportation	Benefits	Cost Estimate	Notes	SCORE
3	Baker Cr	James St	15.61	other	67	upstream of private McLeod 2007, COB McLeod2015, WSDOT prioritized 2025, COB Willow Spring 2010/2018, COB lower Squal restoration sites	James St Multimodal project, 2025 at earliest (unfunded), result of 2019 study will be a recommended design for James Street from Orchard to Kellogg that we will use to seek funding for construction. Major infrastructure revisions (wider roadway, curb, gutter, sidewalk) that would likely precipitate this culvert being replaced (but not	upstream of COB Baker Cr, COB Willow Spring 2010/2018, COB lower Squal restoration sites; upstream of COB planned restoration at Filippini; in Tier 1 subwatershed, in priority restoration polygon	$ 1,000,000		**14.2**
4	Padden Cr	16th St	53.96	WS drop	67	downstream of WSDOT 2014 bridge, WSDOT prioritized project 2025	None	downstream of COB 2015 Padden Daylighting, COB 16th St repair 2016, WSDOT 2014 SR 11 Tier 1 subwatershed, in priority restoration polygon	$ 1,000,000	Completed repair of pool in 2016. Full fish passage requires replacing fish ladder and culvert.	**14.0**
5	Squalicum Cr	Roeder Ave	unknown	tides	unknown	downstream of private McLeod 2007, COB Willow Spring 2010/2018, COB Squal Ph 1/2 2015, COB McLeod2015, WSDOT prioritized 2025, COB Squal Ph 3/4 2020, COBlower Squal restoration sites,	None	downstream of COB Willow Spring 2010/2018, COB Squal Ph 1/2 2015, COB Squal Ph 3/4 2020, COBlower Squal restoration sites; in Tier 1 subwatershed (not within prioritized restoration polygon); project is prioritized BBAT restoration site	$ 4,000,000	Partial design COB/Port, $millions	**14.0**
6	Padden Cr	14th St	48.14	depth	67	downstream of COB 16thSt repair 2016, WSDOT 2014 bridge, WSDOT prioritized project 2025	None	downstream of COB 2015 Padden Daylighting, Tier 1 subwatershed, in priority restoration polygon	$ 200,000		**13.5**

RANK	Stream	Road Crossing	Total PI (Form)	Barrier Reason	Passability (%)	Coordination-Barriers	Coordination-Transportation	Benefits	Cost Estimate	Notes	SCORE
7	Padden Cr	Lake Padden	30.88	WS drop	0	upstream of COB 16thSt repair 2016, WSDOT 2014 bridge (9,500'), 2 WSDOT prioritized projects 2025 (4,250')	none		$ 500,000	at outlet of Lake Padden- dam, not sure if there are juveniles that can access site but assumed yes to be consistent w/WDFW assessment that gorge not a natural barrier	**13.5**
8	NF Baker Cr	Telegraph Rd Telegraph Flood Dam	unknown	other	33	upstream of WSDOT prioritized 2025, COB McLeod 2015, COB lower Squal restoration sites	ES-0537 Telegraph Rd project, 2021, this is a road construction project – curb, gutter, sidewalk, lights, etc. This particular fish blockage is the dam/control structure in the flood control facility on the north side of Telegraph. This project will not be touching the facility or fish blockage. However, one of the stormwater options may be to utilize this facility in its current condition if possible. I would not anticipate that affecting the fish blockage, but I want to bring the project to your attention in the event you wanted to try and coordinate construction.	upstream of lower Squal restoration sites, COB Willow Spring 2010/2018, in Tier 1 subwatershed and in priority restoration polygon	$ 1,000,000	Telegraph flood dam, fish passability from ESA 2019, cost estimated by Analiese	**13.3**
9	Squalicum Cr	Meridian St	unknown	WS drop	67	downstream COB Squal Ph 1/2 2015, COB Squal Ph 3/4 2020; upstream of COB lower Squal fish barrier improvements near Squal Cr Park	None	upstream of COB Willow Spring 2010/2018 and COB/NSEA lower Squalicum restoration; downstream of Squalicum Re-route Phases 1 and 2 2015; in Tier 1 subwatershed	$ 1,000,000	cost estimated by Analiese	**13.2**

RANK	Stream	Road Crossing	Total PI (Form)	Barrier Reason	Passability (%)	Coordination-Barriers	Coordination-Transportation	Benefits	Cost Estimate	Notes	SCORE
10	Baker Cr	Telegraph Rd	unknown	slope	0	upstream of WSDOT prioritized 2025, COB McLeod 2015, COB Baker Cr restoration site, lower Squal restoration sites	None	upstream of lower Squal restoration sites, COB Willow Spring 2010/2018	$ 500,000	immediately upstream to Filippini donation	**12.5**
11	Spring Cr	Kellogg Rd	21.03	unknown	unknown	upstream of WSDOT prioritized 2025, COB McLeod 2015, COB lower Squal restoration sites	None	upstream of COB Spring Cr restoration site, lower Squal restoration sites, COB Willow Spring 2010/2018; in Tier 1 subwatershed	$ 1,000,000	upstream of Irongate flood dam	**11.8**
12	b W, Squalicum	Meridian St	unknown	WS drop	67	upstream of COB lower Squal fish barrier improvements near Squal Cr Park	Meridian/Birchwood/Squalicum roundabout study, 2025 at earliest (unfunded), this is just a study of this intersection right now. The result will be a recommend design for improvements to this intersection(s) that we will use to seek funding for construction. Major infrastructure revisions that would likely precipitate this culvert being replaced (but not guaranteed).	upstream of COB Willow Spring 2010/2018 and COB/NSEA lower Squalicum restoration (not downstream of Squalicum Re-route Phases 1 and 2 2015 because isolated fish habitat as part of that project); in priority restoration polygon in Tier 1 subwatershed	$ 500,000	lineal gain based on WDFW decision that Trib W not suitable fish habitat in Squal Re-route Ph 1-2, cost estimated by Analiese	**11.8**
13	Spring Cr	E Bakerview Rd	25.43	velocity	67	upstream of WSDOT prioritized 2025, COB McLeod 2015, COB lower Squal restoration sites; downstream of 2001 culvert repair at Van Wyck Rd	None	upstream of Spring Creek restoration site 2004, lower Squal restoration sites, COB Willow Spring 2010/2018, in Tier 1 subwatershed	$ 1,000,000		**11.7**

RANK	Stream	Road Crossing	Total PI (Form)	Barrier Reason	Passability (%)	Coordination-Barriers	Coordination-Transportation	Benefits	Cost Estimate	Notes	SCORE
14	Padden Cr	39th St ROW	27.65	slope	0	upstream of WSDOT prioritized 2025, WSDOT Padden Daylighting	none	upstream of COB 2015 Padden Daylighting 2015, COB 16th St repair 2016, WSDOT 2014 SR 11; in Tier 1 subwatershed, in priority restoration polygon	$ 1,500,000	in Padden Gorge, not sure if there are juveniles that can access site but assumed yes to be consistent w/WDFW assessment that gorge not a natural barrier	**11.0**
15	Baker Cr	Deemer Rd	unknown	slope	33	upstream of WSDOT prioritized 2025, COB McLeod 2015, COB lower Squal restoration sites	None	upstream of lower Squal restoration sites, COB Willow Spring 2010/2018	$ 3,000,000	Upstream of long private culvert under Home Depot	**11.0**
16	SF Baker Cr	E McLeod Rd	15.48		unknown	upstream of private McLeod 2007, COB McLeod2015, WSDOT prioritized 2025, COB Willow Spring 2010/2018, COB lower Squal restoration sites	none	upstream of COB Baker Cr, COB Willow Spring 2010/2018, COB lower Squal restoration sites; upstream of COB planned restoration at Filippini; in Tier 1 subwatershed, in priority restoration polygon	$ 500,000		**10.7**
17	Padden Cr	30th St	18.01	slope	33	upstream and downstream of WSDOT prioritized 2025, upstream of WSDOT 2014 Padden Daylighting	none	upstream of COB 2015 Padden Daylighting 2015, COB 16th St repair 2016, WSDOT 2014 SR 11; in Tier 1 subwatershed, in priority restoration polygon	$ 3,000,000		**10.3**
18	SF Baker Cr	Strider Lp Hannegan Flood Dam	24.77	other	67	upstream of WSDOT prioritized 2025, COB McLeod 2015, COB Willow Spring 2010/2018, COB lower Squal restoration sites	None	CB Baker Cr restoration site, lower Squal restoration sites,	$ 1,000,000	Hannegan flood dam, fish passability from ESA 2019, cost estimated by Analiese	**9.8**

RANK	Stream	Road Crossing	Total PI (Form)	Barrier Reason	Passability (%)	Coordination-Barriers	Coordination-Transportation	Benefits	Cost Estimate	Notes	SCORE
19	Baker Cr	E Bakerview Rd @ Irongate	25.04	depth	33	upstream of WSDOT prioritized 2025, COB McLeod 2015, lower Squal restoration sites, COB Willow Spring 2010/2018, upstream of Filippini donation to COB 2018 for restoration	None	downstream of COB Spring Cr restoration site 2004; upstream of lower Squal restoration sites, COB Willow Spring 2010/2018, COB lower Squal restoration sites; in Tier 1 subwatershed and within prioritized restoration polygon	$ 1,000,000	no juveniles present because upstream of total barrier	**9.5**
20	Lincoln Cr	Lincoln St	unknown	slope	33		none	upstream of COB 2006 Red Tail Reach, COB Whatcom Creek Estuary	$ 1,000,000	downstream of fred meyer tunnel.	**9.0**
21	Baker Cr	Hannegan Rd	18.26	velocity	67	upstream of WSDOT prioritized 2025, COB McLeod 2015, COB Baker Cr restoration site, lower Squal restoration sites	proposed secondary arterial	upstream of COB Willow Spring 2010/2018, COB lower Squal restoration sites, COB planned restoration at Filippini, COB restoration at Baker Cr; in Tier 1 subwatershed	$ 1,000,000	upstream of Irongate flood dam, no juveniles present because upstream of total barrier	**8.5**
22	Baker Cr	Hannegan Rd	22.6	slope	33	upstream of WSDOT prioritized 2025, COB McLeod 2015, COB Baker Cr restoration site, lower Squal restoration sites	none	upstream of COB Willow Spring 2010/2018, COB lower Squal restoration sites, COB planned restoration at Filippini, COB restoration at Baker Cr	$ 1,000,000	upstream of Irongate flood dam and other culverts, no juveniles present because upstream of total barrier	**8.3**
23	Whatcom Cr	Woburn St	unknown	slope	0		None	downstream of Boulder Bend and Whatcom Falls Park 1999 restoration; upstream of COB Red Tail Reach, COB Salmon Park, COB Cemetery Cr, COB Whatcom Cr Estuary	$ 7,000,000	Ask WDFW, confirm 0% passability	**8.2**

RANK	Stream	Road Crossing	Total PI (Form)	Barrier Reason	Passability (%)	Coordination-Barriers	Coordination-Transportation	Benefits	Cost Estimate	Notes	SCORE
24	W Cemetery Cr	Old Lakeway Dr	unknown	WS drop	0		ES-0547 2019 TBD project, creating a 10-foot wide two-way bicycle connection at Lakeway/Old Lakeway, at this culvert crossing this is just striping/SLMs on the roadway – no excavation or roadway work, so COB not planning on doing anything with this culvert	upstream of COB 2006 Red Tail Reach, COB Whatcom Creek Estuary, planned W Cemetery Cr WQ improvements	$ 500,000	no juveniles present because upstream of total barrier	**8.0**
25	Cemetery Cr	Lopez St	unknown	slope	0		none	upstream of COB 2006 Red Tail Reach, COB Whatcom Creek Estuary	$ 500,000		**8.0**
26	W Cemetery Cr	Lakeway Dr	unknown	slope	0		none	upstream of COB 2006 Red Tail Reach, COB Whatcom Creek Estuary	$ 5,000,000	PW Ops concerned about integrity of road due to culvert failure	**8.0**
27	COB	Horton Flood Dam	unknown	velocity	67	1.5 mi upstream of City Mitigation Bank site (Bear Cr), 1.5 mi upstream of Whatcom County planned improvement for barrier 1280204	None	1.5 mi upstream of City Mitigation Bank site (Bear Cr), 1.5 mi upstream of Whatcom County planned improvement for barrier 1280204	$ 1,000,000	Horton flood dam, cost estimated by Analiese	**7.8**
28	Hoags Cr	25th St	17.78	slope	33		None	in Tier 1 subwatershed, in priority restoration polygon	$ 500,000	no juveniles present because upstream of total barrier	**7.0**
29	Hoags Cr		16.9	slope	0		None	in Tier 1 subwatershed, in priority restoration polygon	$ 75,000	no juveniles present because upstream of total barrier	**7.0**
30	Hoags Cr	Interurban Trail	17.81	slope	33		None	in Tier 1 subwatershed, in priority restoration polygon	$ 250,000	assume WSDOT prioritized list for Chuckanut Cr barrier impr. Is mainstem, not Hoags Creek), no juveniles present because upstream of total barrier. Parks funds?	**7.0**

Ranked Fish Passage Culverts

RANK	Stream	Road Crossing	Total PI (Form)	Barrier Reason	Passability (%)	Coordination-Barriers	Coordination-Transportation	Benefits	Cost Estimate	Notes	SCORE
31	Cemetery Cr	San Juan Blvd	unknown	slope	0		none	upstream of COB 2006 Red Tail Reach, COB Whatcom Creek Estuary, planned W Cemetery Cr WQ improvements	$ 500,000	no juveniles present because upstream of total barrier	**6.0**
32	E Cemetery Cr	Woburn St	unknown	WS drop	0		none	upstream of COB 2006 Red Tail Reach, COB Whatcom Creek Estuary	$ 5,000,000		**5.0**
								TOTAL	$ 46,225,000		

Memorandum

To: City of Bellingham, HDR

From: Larry Karpack, Tim Tschetter, Chris Meder

Date: July 29, 2020

Re: City of Bellingham Stormwater Comprehensive Plan Update- Marine Outfall Analysis

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INTRODUCTION

This memorandum summarizes an evaluation of the conveyance capacity of nine direct discharge marine outfall systems in the City of Bellingham, WA. Watershed Science and Engineering (WSE) completed this work for the City of Bellingham (City) as sub-consultant to HDR for the Stormwater Comprehensive Plan and Rate Study Update. This memo documents the development of hydrologic and hydraulic models and the evaluation of the stormwater conveyance systems in order to conceptually size improvements needed to adequately convey design discharges. The systems were evaluated for both the existing (2019 land-use) and future (full build-out) conditions of all parcels within the drainage basins. The models were used to simulate the 2-, 10-, 25-, and 100-year storm events and to identify areas of the storm drainage system that would flood during the 25-year storm event under full build-out land-use conditions. The 25-year storm is the City's standard for design of conveyance capacity improvements. A list of required improvements to the drainage network to eliminate flooding are provided based on this analysis.

HYDROLOGIC MODELING

WSE used the Western Washington Hydrology Model (WWHM) to generate flow hydrographs for input to the hydraulic model for each of the nine marine outfall drainage systems included in this study (Figure 1). WWHM is a continuous simulation hydrologic model developed by the Washington State Department of Ecology. WWHM uses the Hydrologic Simulation Program – Fortran (HSPF) computational engine and long-term precipitation and pan evaporation time series to simulate runoff based on user defined sub-basin, land-use, and soils information. No calibration data were available for the hydrologic modeling so the WWHM models were run using the default runoff parameters.

WWHM MODEL DEVELOPMENT

The basin for each marine outfall was delineated to encompass all areas contributing runoff to the outfall. The nine outfall basins were then subdivided into 23 drainage sub-basins based on topography, land-use, and key drainage features as shown in Figures 2 through 4. GIS topography and stormwater drainage network data sets used for the sub-basin delineation were provided to WSE by the City.

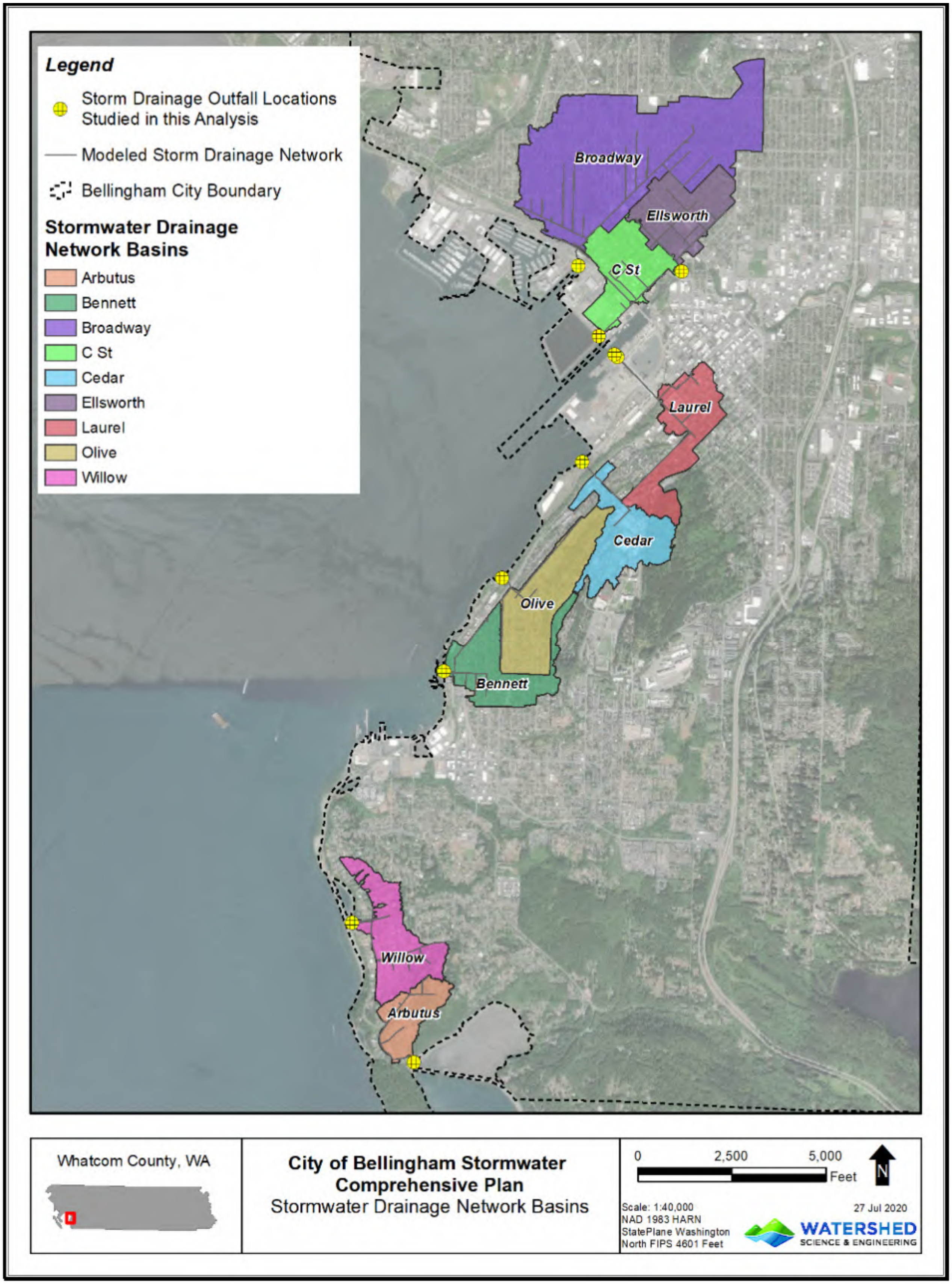

Figure 1. Location map of the nine marine outfall basins.

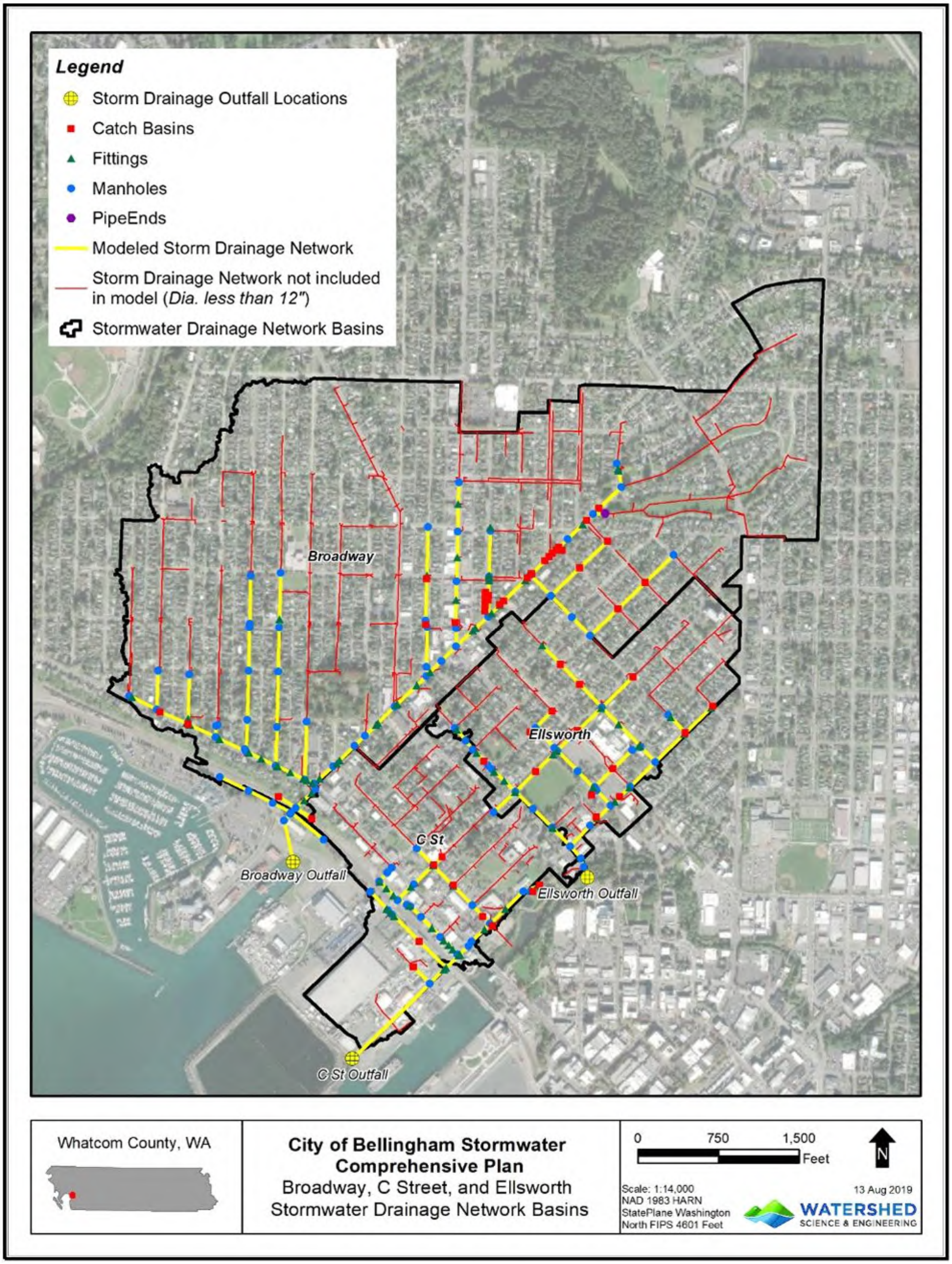

Figure 2. Broadway, C Street, and Ellsworth storm drainage network and sub-basins.

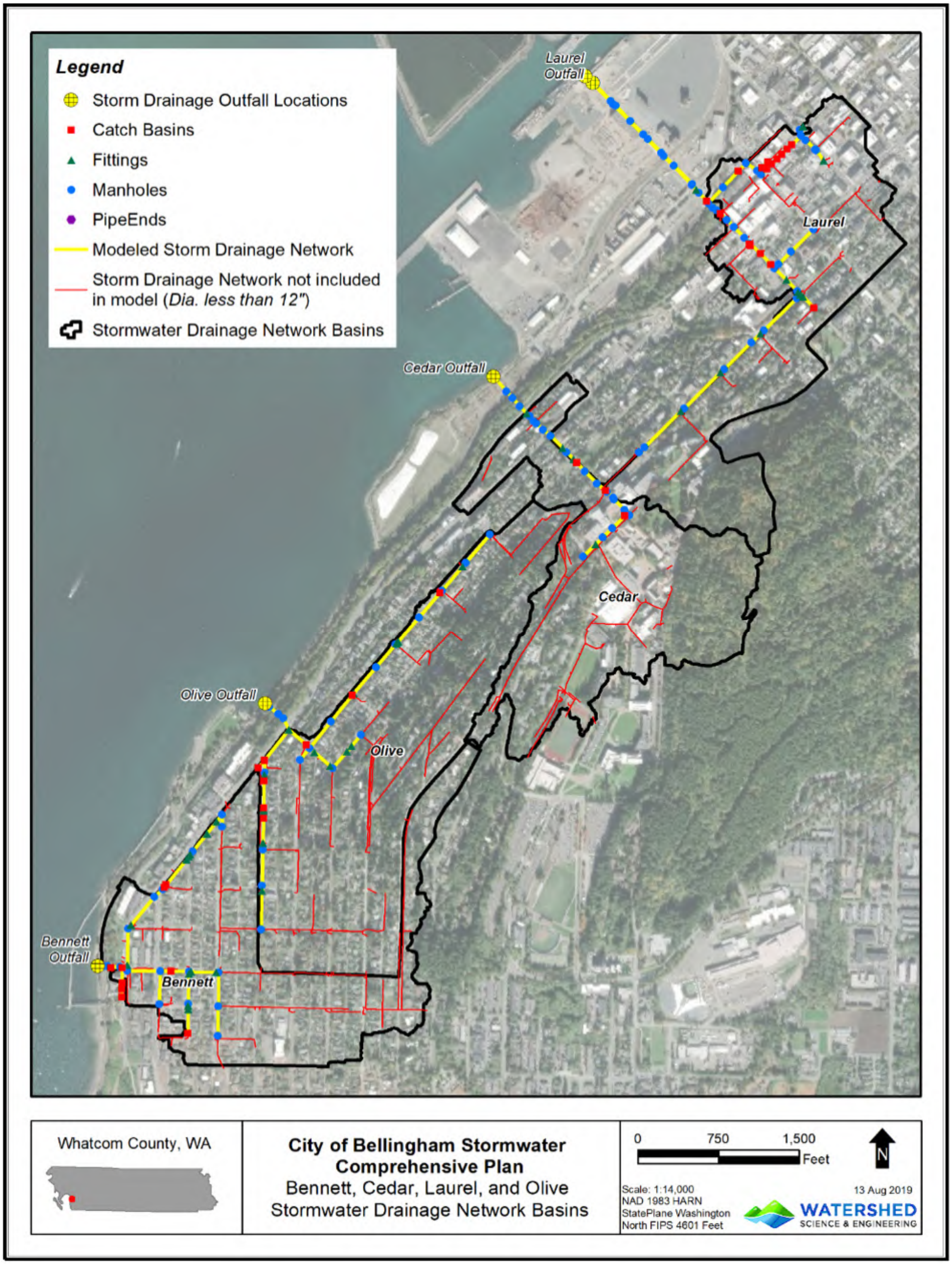

Figure 3. Bennett, Cedar, Laurel, and Olive storm drainage network and sub-basins.

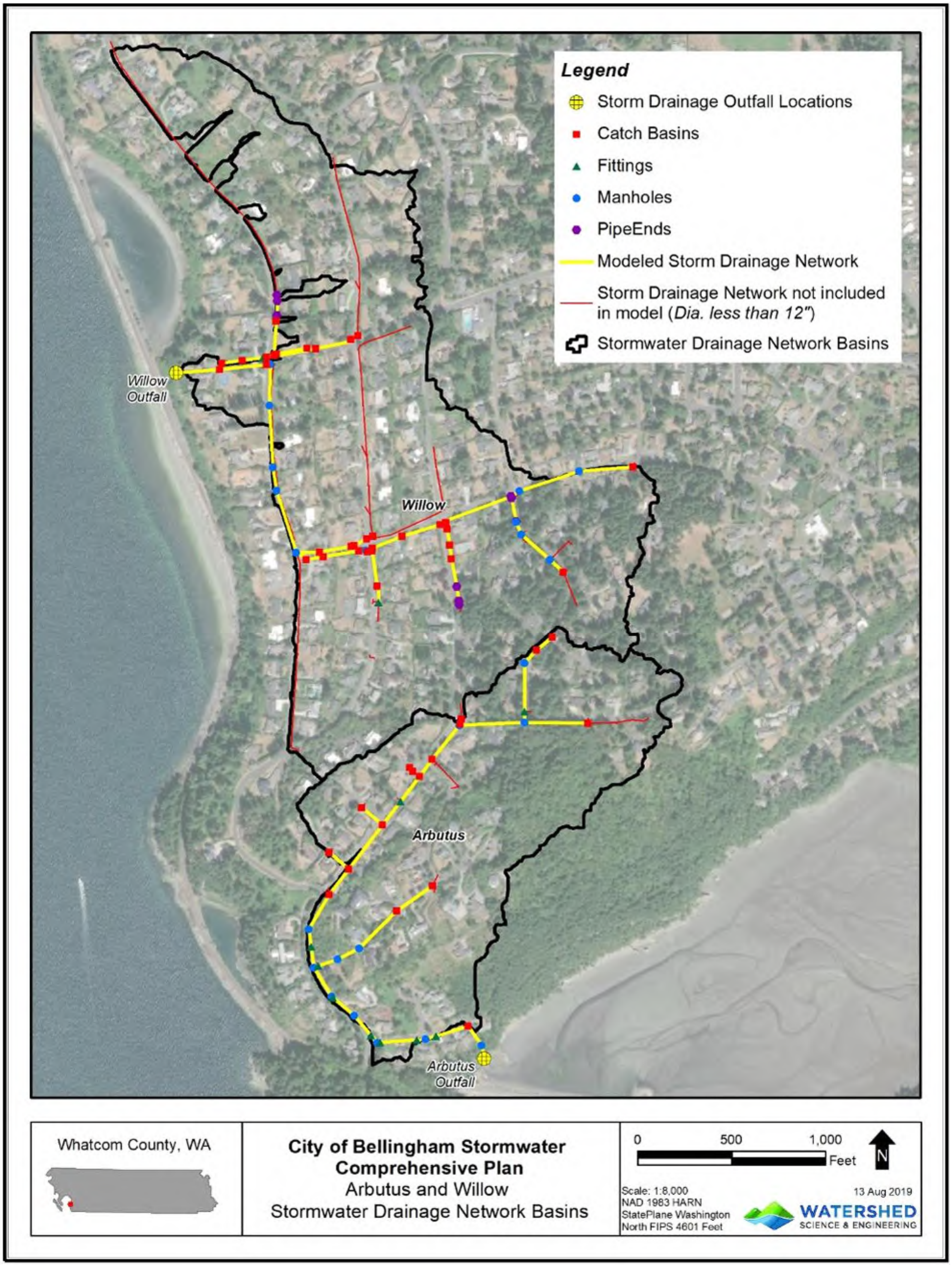

Figure 4. Arbutus and Willow storm drainage network and sub-basins

Land-use analyses were conducted for two development scenarios -- existing conditions and full build-out to the current zoned density. For the existing conditions scenario, the land-use analysis used the City's zoning map as a starting point for land-use types in each basin. These were then modified to reflect differences between the zoning and the actual current land-use (e.g. areas zoned as multi-family residential but currently containing single-family homes were reclassified as single family residential and areas not presently developed were reclassified as forest) based on 2018 aerial imagery and 2018 Google Street View imagery (where available). For the full build-out scenario the land-use was assumed to match current City zoning. The City's zoning classifications were grouped into seven general categories by combining classifications with similar ratios of pervious and impervious land cover as shown in Table 1. Figure 5 summarizes the results of the land-use analysis.

The relative percentages of land cover type (effective impervious area, lawn, or forest) for each land-use category were determined based on WSE's engineering judgement and in accordance with previous detailed hydrologic model studies in this region (Snohomish Co., 2002). The percentage effective impervious area (EIA) used in this study ranges from 18% for existing conditions single-family residential to 90% for full build-out commercial/industrial. For residential, commercial, and industrial land-use areas, the percentage EIA increases from existing conditions to full build-out conditions to reflect future infill of undeveloped parcels and potentially higher density redevelopment. Institutional and public parcels are assumed to have similar EIA percentages in both the existing and full build-out scenarios. Table 2 shows the land-use by category for each basin for existing and full build-out conditions and Table 3 shows estimated total effective impervious area by basin and the projected percent increase from existing conditions.

Table 1. Assumed impervious and pervious land cover percentages based on land-use/zoning

	Existing Conditions Land Cover			Full Build-Out Land Cover		
Land-Use Category (Zoning Classifications)	**Effective Impervious (%)**	**Lawn (%)**	**Forest (%)**	**Effective Impervious (%)**	**Lawn (%)**	**Forest (%)**
Single Family Residential (Low & Medium Density)	18	82	0	28	72	0
Multi-Family Residential (Medium & High Density), Urban Village Residential Transition 1 & 2	66.5	33.5	0	75	25	0
Commercial, Industrial, Urban Village Commercial Core, Urban Village Commercial Transition	85.5	14.5	0	90	10	0
Institutional	34	33	33	34	33	33
Public - Park	0	50	50	0	50	50
Public - School/Church	50	50	0	50	50	0
Undeveloped Forest	0	0	100	NA	NA	NA

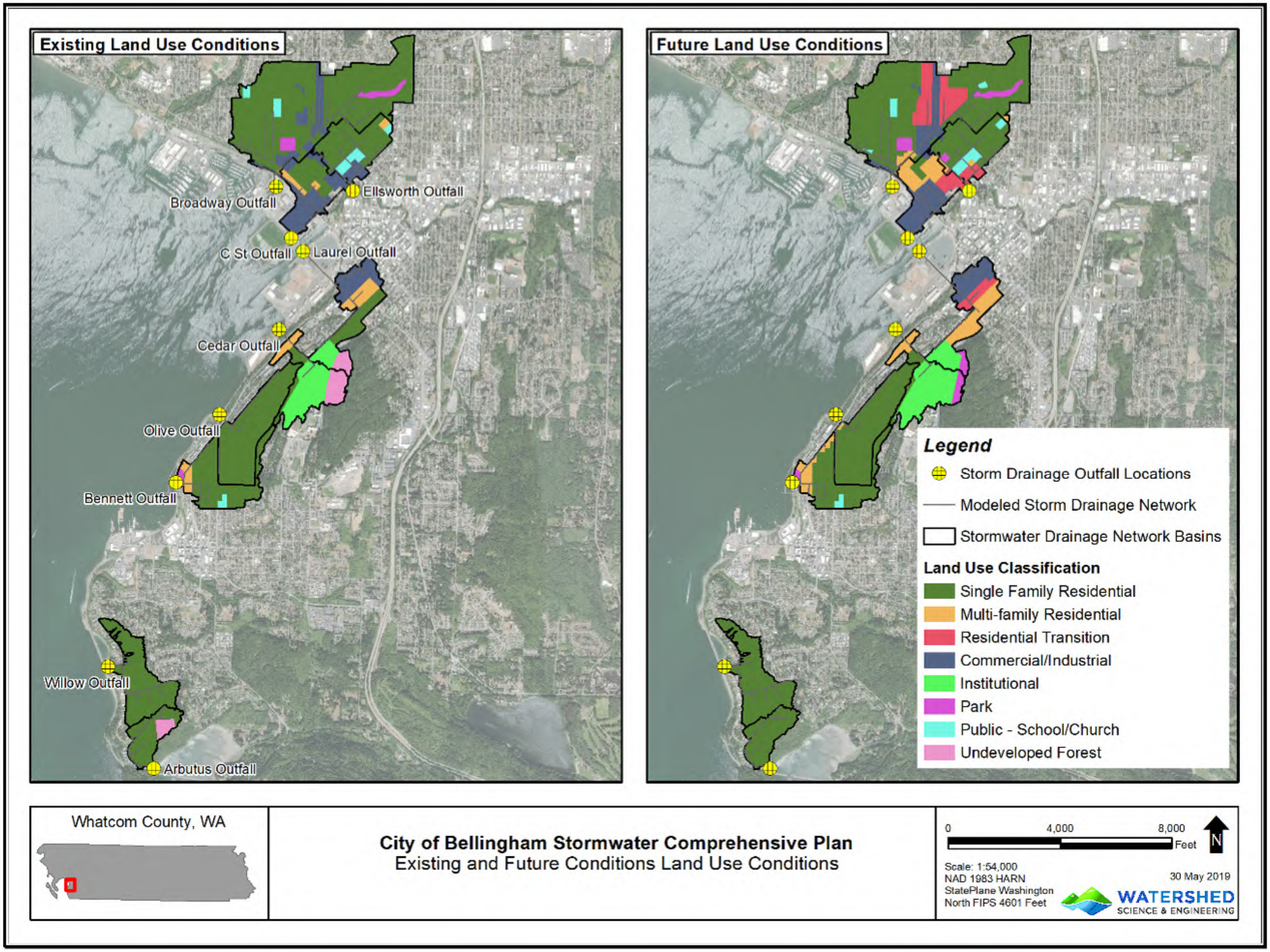

Figure 5. Existing and future full build-out conditions land-use.

Table 2. Summary of Existing and Future land-use

	Basin	SFR (ac)	MFR, Urban Village Residential Transition (ac)	Commercial, Industrial (ac)	Institutional (ac)	Public, Park (ac)	School, Church (ac)	Forest (ac)
Existing	Arbutus	43.7	0.0	0.0	0.0	0.0	0.0	8.6
	Bennett	77.9	8.8	0.0	0.0	2.6	3.1	0.0
	Broadway	338.2	0.6	34.3	0.0	13.9	6.7	0.0
	Cedar	12.5	9.5	0.0	52.1	0.0	0.0	19.3
	C St	28.7	6.4	52.5	0.0	0.0	0.0	0.0
	Ellsworth	66.0	2.1	12.8	0.0	0.0	12.6	0.0
	Laurel	26.8	15.6	30.9	14.5	0.0	0.0	10.0
	Olive	125.0	0.0	0.0	0.0	0.0	0.0	0.0
	Willow	97.7	0.0	0.0	0.0	0.0	0.0	0.0
Full Build Out	Arbutus	52.3	0.0	0.0	0.0	0.0	0.0	0.0
	Bennett	70.3	16.1	0.3	0.0	2.6	3.1	0.0
	Broadway	283.1	55.7	34.1	0.0	14.2	6.6	0.0
	Cedar	10.4	10.7	0.0	64.8	7.3	0.3	0.0
	C St	6.1	37.3	44.3	0.0	0.0	0.0	0.0
	Ellsworth	64.5	13.3	1.3	0.0	1.6	12.8	0.0
	Laurel	0.0	44.2	29.2	19.2	5.3	0.0	0.0
	Olive	123.7	1.3	0.0	0.0	0.0	0.0	0.0
	Willow	97.7	0.0	0.0	0.0	0.0	0.0	0.0

Table 3. Effective impervious areas by basin for existing and full build-out land-use scenarios

Basin Name	Area (AC)	Existing Conditions Percent Effective Impervious	Full Build-Out Percent Effective Impervious	Change from Existing
Arbutus	52.3	15%	28%	+13%
Bennett	92.4	23%	36%	+13%
Broadway	393.7	24%	39%	+15%
Cedar	93.5	28%	35%	+7%
C St.	87.7	62%	79%	+17%
Ellsworth	93.5	33%	38%	+5%
Laurel	97.9	48%	67%	+19%
Olive	125.0	18%	29%	+11%
Willow	97.7	18%	28%	+10%

The amount of effective impervious area is very important for hydrologic modeling, yet estimation of EIA is subject to considerable judgement. For example, the EIA percentage used in this study for single family residential development in existing conditions (18%) or full build-out conditions (28%) was assumed to be substantially lower than the 70% maximum total impervious area that is allowed by current City zoning codes for residential redevelopment (personal communication with Chad Schulhauser, City Engineer). When considering EIA assumptions used in the modeling it is important to first understand the terminology being used. The two main terms used to describe imperviousness are Total Impervious Area (TIA) and Effective Impervious Area (EIA). As the name implies, total impervious area is the total amount of impervious surface (roofs, driveways, sidewalks, paved paths, etc.) as a percentage of the gross parcel area. Effective impervious area, on the other hand, attempts to quantify the portion of the TIA that is directly (or effectively) connected to the storm drainage system. This is typically done by adjusting the TIA based on a percent effective multiplier. This multiplier accounts for a range of factors that reduce EIA including things such as roof downspouts draining onto splash blocks or lawns, dry wells or other onsite detention, areas such as paths or driveways not effectively connected to storm drains, stormwater discharge to rain gardens or other low impact development (LID) facilities, subdivision-scale detention facilities, and any other feature that "disconnects" or delays runoff from impervious surfaces from directly entering the stormwater conveyance system. Areas not effectively connected to the storm drainage system are assumed to perform hydrologically more similar to grass than to impervious surfaces (i.e. with a delayed response and lower peak runoff).

Accurately estimating EIA for full build-out conditions is further complicated by many factors including the amount of redevelopment that will actually occur, the density of development, whether redevelopment takes place on a site by site basis or at a subdivision scale, the level of LID implemented, the City stormwater standards in place at the time of redevelopment, and numerous other factors. Since one can never be sure of any of these factors the goal of the selection of percent EIA becomes to provide a reasonable estimate consistent with the objectives of the analysis. The EIA percentages used in this analysis (Table 1) are consistent with WSE's engineering judgement and past practice including modeling done previously for Snohomish County and other local jurisdictions.

Soils data used in this study were obtained from the Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO). SSURGO soils are classified by hydrologic soil group (B, C, D), and these classifications were used when importing to WWHM. Ground surface slopes were calculated using the 2013 City of Bellingham LiDAR ground surface elevation. ArcGIS was used to create polygons for each unique combination of sub-basin, land-use type, soil type, and ground surface slope. These data were then summed for each sub-basin and percentages of pervious and impervious land cover in Table 1 were applied to determine the acreage of impervious surface and the acreage of each pervious land type in each sub-basin. WWHM utilizes the user-defined project location to create a local long-term precipitation record by scaling precipitation from the closest long-term gage (in Blaine, WA). For Bellingham the factor of 0.857 is used, which corresponds to the ratio of 24-hour 25-year precipitation rate at the project and long-term gage locations.

Hydrologic Model Results

Flow frequency analysis was performed on the WWHM simulated annual maximum 15-minute flows for each sub-basin for the period of record (1948-2012). Table 4 shows the simulated flow quantiles for each basin for the two land-use scenarios and the percent increase from existing to full build-out conditions.

Design Storm Hydrograph Development

Design storm inflow hydrographs for the hydraulic modeling were created by selecting a simulated historical storm event hydrograph ("pattern" storm) from the long term WWHM generated flow record and then scaling the pattern event flows such that the maximum event flow matched the flow quantile of the corresponding design storm (e.g. 2-, 10-, 25-, 100-year). Design storm inflow hydrographs were developed for the 23 sub-basins for the 2-, 10-, 25-, and 100-year storm events for both the existing and full build-out land-use scenarios (total 184 hydrographs) using the following procedure:

1. *Flood frequency analysis* – for each basin, flow frequency analyses were performed at multiple durations (15-minutes, 1-hour, 3-hours, 6-hours, and 24-hours) to determine flow quantiles (2-, 10-, 25-, and 100-year) for each duration.
2. *Identify candidate pattern storms* – for each basin, a historical event with simulated runoff at the 15-minute, 1-hour, 3-hour, and 6-hour time windows closely matching the corresponding event target quantiles was selected. An ideal pattern storm would have flows matching the target flow quantiles at all durations.
3. *Select pattern storm* – because no actual storm matches the computed flow quantiles at all durations, engineering judgement was needed to select a pattern storm that best matched the flow frequency data across the broadest range of durations. For each design event, a pattern storm was selected for each basin.
4. *Determine scaling factor* – The selected pattern storm was then scaled to match the corresponding target flow quantiles. The scaling factor was determined by dividing the 15-minute quantile from step 1 by the pattern storm (selected in step 3) simulated peak flow. Unique scaling factors were thus determined for each basin for each design event
5. *Scale pattern storm to develop design storm hydrograph* – pattern storm hydrographs for each of the 23 sub-basins were multiplied by the scaling factors determined in step 4 to develop design storm hydrographs for input into the hydraulic model. A total of 184 hydrographs were developed to simulate the four design flood events (2-, 10-, 25-, 100-year) for existing and full build-out conditions.

Table 4. Peak simulated flow from each basin.

Basin Name	2-year Event			10-year Event			25-year Event			100-year Event		
	Existing Conditions Runoff (cfs)	Full Build-Out Runoff (cfs)	Change	Existing Conditions Runoff (cfs)	Full Build-Out Runoff (cfs)	Change	Existing Conditions Runoff (cfs)	Full Build-Out Runoff (cfs)	Change	Existing Conditions Runoff (cfs)	Full Build-Out Runoff (cfs)	Change
Arbutus	5	7	+2	9	13	+4	11	16	+5	16	21	+5
Bennett	9	14	+5	15	23	+8	19	27	+8	24	34	+10
Broadway	45	65	+20	82	109	+27	103	132	+29	136	169	+33
Cedar	11	14	+3	18	23	+5	21	28	+7	26	35	+9
C St.	21	26	+5	35	42	+7	42	50	+8	53	63	+10
Ellsworth	14	16	+2	25	27	+2	32	34	+2	41	43	+2
Laurel	18	26	+8	30	42	+12	35	50	+15	44	63	+19
Olive	10	16	+6	18	26	+8	22	32	+10	30	40	+10
Willow	8	12	+4	14	20	+6	17	24	+7	23	30	+7

HYDRAULIC MODELING

The Environmental Protection Agency's EPA SWMM model (version 5.1.012) was used to model the marine outfall drainage networks. The models were build using the PCSWMM software package (version 7.2.2780). The SWMM model was run for the 2-, 10-, 25-, and 100-year flood events for both existing and full build-out land-use conditions.

GIS PREPROCESSING

GIS layers depicting the stormwater drainage network conduits and nodes were provided to WSE by the City. A line shapefile depicting conduits also contained information specifying the pipe diameter, material type, and upstream and downstream nodes. Point shapefiles depicting nodes (manholes, catch basins, fittings and pipe ends) included node identification and measure down depth. Only one measure down depth was specified per node and the layer attributes did not specify the corresponding pipe inlet/outlet, so for each node the pipe inlet(s) and outlet(s) were assumed to be at the same elevation. To calculate the pipe invert elevation for each node, the measure down depth was subtracted from the 2013 LiDAR ground surface elevation (NAVD88 vertical datum) at the location of the node. Pipes with diameter less than 12-inches were excluded from further analysis.

WSE reviewed the City GIS layers and identified missing data (pipe diameter, pipe material type, measure down depth) and potentially incorrect data (adverse conduit slopes or downstream reduction in conduit diameter). City staff revisited most locations with missing/incorrect data to update/verify the data. For sites not visited by the City, the City provided as-built design plans showing invert elevations and conduit material type.

For each of the marine outfall systems the actual outfall elevation at Bellingham Bay was required for input to the model. Surveyed invert elevations were provided by the City for the Broadway, Cedar, and Olive Street marine outfalls. For other locations the outfall elevation was obtained from as-built or design plans, or from LiDAR ground elevations. Table 5 summarizes the data sources used for outfall elevations.

Table 5. Marine outfall invert elevations

Basin Name	Marine Outfall Invert Elevation (ft, NAVD88)	Elevation Source
Arbutus	14.53	As-built plans
Bennett	4.45	LiDAR minus measure-down
Broadway	4.56	City Survey
Cedar	7.82	City Survey
C St.	3.13	Lidar minus measure-down
Ellsworth	36.32	LiDAR
Laurel	1.40	Design plans
Olive	7.99	City Survey
Willow	34.38	LiDAR

Pipe entrance and exit losses were assigned according to guidance in the Federal Highway Administration's Urban Drainage Design Manual (Federal Highway Administration, 1996). Pipe exit losses vary due to the pipe's intersection angle with the next pipe downstream. The pipe intersection angle was calculated in ArcGIS and exit losses were assigned prior to importing into PCSWMM.

SWMM Model Development

The updated conduit and node GIS layers were imported directly into PCSWMM to create the SWMM model. In the SWMM model, each node (manhole, catch basin, pipe end, and junction) is identified by a unique identification number provided by the City. Pipe segments in the model were assigned arbitrary identification codes because unique identification codes were not included in the City's database.

Inflow locations (a total of 116) were defined at the upstream-most node of each drainage branch and at nodes where significant additional inflow to the modeled system would occur (i.e. where significant side drainage systems meet the modeled drainage network). Inflow hydrographs in the model were created by apportioning the design storm hydrographs developed as described above based on the contributing area to that node as a percentage of the entire sub-basin area.

Six of the marine outfalls (Bennett, Broadway, Cedar, C St., Laurel and Olive) are influenced by tidal water levels. The other three outfalls (Arbutus, Ellsworth, and Willow) are at higher elevation and have free flowing downstream boundary conditions. The downstream boundary water surface elevation for the tidal outfalls were set at a constant elevation corresponding the mean higher high water (MHHW) tide level (8.03 feet NAVD88). MHHW provides a relatively conservative estimate of the tide level as it assumes that high tide corresponds with the peak of the flow hydrograph. This approach is what is used by FEMA when evaluating systems with tidally influenced tailwater conditions.

Pipe roughness values were assigned based on the pipe material. A Manning's roughness value of 0.011 was assigned for concrete (CON) and PVC pipes, 0.013 for ductile iron (DI), 0.014 for vitreous clay (VIT), 0.020 for corrugated polyethylene pipes (CPP), and 0.024 for corrugated metal pipes (CMP) based on Chow (1959).

Secondary overflow conduits were added to the SWMM model as necessary at locations where storm flows could overflow at one node and subsequently re-enter the conveyance system at a downstream node (note that the representation of overflow conduits in the SWMM model is schematic only and does not attempt to define a specific flowpath between nodes). Overflow conduits were added to all model nodes that flood during the largest modeled flood event (the 100-year full build-out scenario). The location of reentry of each overflow conduit was determined by analyzing the local ground surface elevations and the drainage network map. Generally, the drainage network is oriented in the direction of maximum slope, so that surface overflow exiting one node would flow (in a gutter or roadside ditch) to the next node downstream. However, in some locations the drainage network is oriented transverse to the slope, so overflows would follow the topography and enter a different branch in the same basin (i.e. Meridian Street to Kulshan Street, both within the Broadway basin) or into a different drainage basin entirely (i.e. Ellsworth Street in Ellsworth basin to Astor Street in C Street basin). To address these inter-basin transfers, WSE developed a single, comprehensive SWMM model encompassing all nine marine outfall basins instead of nine independent models. Also note that in some locations the topography indicates that surface overflows would exit the modeled system entirely. Flow that leaves the modeled system was not evaluated any further although the volume of flow leaving was computed in SWMM.

Storage nodes were added to the SWMM model to represent areas where significant surface ponding might occur based on the surrounding topography. As opposed to the overflow conduits described above, locations of surface ponding are assumed to reenter the drainage system at the same location, once flood water levels have receded to the elevation of the catch basin inlet. In total, 15 storage nodes were defined in all basins, with the majority (nine) of the storage nodes in the Broadway basin. A stage-storage curve for each ponding area was developed in PCSWMM using topographic data.

HYDRAULIC MODEL RESULTS

The hydraulic model was run for eight scenarios – the 2-, 10-, 25-, and 100-year flood events for both existing and full build-out conditions. Flooding, defined as water above the rim elevation of any model node, occurs during each of the simulated events. Table 6 summarizes the number of locations with flooding for each simulated design event. The number of flooding location includes all active overflow paths, flooded storage nodes, and flooded nodes with flow leaving the modeled system. The results show that the Broadway system is most prone to flooding, likely due to the low topographic gradient and prevalence of old and undersized pipes. WSE's analysis shows that one location in particular, the drainage conduit under Meridian Street, floods in each of the simulated events.

Table 6. Number of flooding locations during each modeled flood event.

Basin Name	Number of Flooding Locations During Existing Conditions				Number of Flooding Locations During Full Build-Out Scenario			
	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year
Arbutus	0	0	0	1	0	1	1	4
Bennett	0	0	0	0	0	0	0	0
Broadway	5	14	21	38	8	23	33	60
Cedar	0	0	0	1	0	0	0	5
C St	0	1	5	13	0	5	11	13
Ellsworth	0	0	3	13	0	0	4	14
Laurel	0	4	4	5	0	10	11	13
Olive	0	0	0	0	0	1	1	3
Willow	0	1	1	4	0	4	4	7
Interbasin Overflow Paths	**Number of Active Overflow Paths During Existing Conditions**				**Number of Active Overflow Paths During Full Build-Out Scenario**			
Broadway to Ellsworth	0	0	0	1	0	0	1	1
Ellsworth to C St	0	0	2	2	0	1	2	3

Discussion of 25-Year Flood with Full Build-out Model Results

The City's criteria for identifying drainage system capacity problems is based on the full build-out 25-year flood. Therefore, the discussion below focuses on results from that scenario, which shows flooding in seven of the nine marine outfall system. Details of flooding in each system are provided below. There is no simulated flooding in the Bennett or Cedar basins during this event.

Arbutus

Flooding in the Arbutus network is limited to one model node (7214NE-78) at the intersection of Fieldston Road and Clarkwood Drive. Flooding from this node would flow south along Fieldston Road and re-enter the system at the next catch basin downstream. Flooding at this location is likely due to the increase in pipe roughness at node 7214NE-78, which has a 12-inch concrete pipe upstream (n=0.011) and a 12-inch corrugated metal pipe (n=0.024) downstream.

Broadway

The Broadway basin has more extensive flooding than any other basin, with flooding from the drainage branches beneath Meridian Street, Peabody Street, Kulshan Street, Utter Street, Lynn Street, and H Street. Figure 6 provides a schematic showing active overflow paths during the 25-year flood[1]. The most significant flooding is along the Meridian Street drainage line. Surface flooding flows south along Meridian Street to Monroe Street, then west to a topographic depression at the intersection of Monroe Street and Kulshan Street. A storage node at manhole 8224SE-360 simulates ponding at this intersection, with flood flows overflowing south along Kulshan Street to the main drainage line beneath Broadway once the storage area fills. Surface flooding along the Utter Street drainage line splits at Monroe Street, with some flow continuing south along Utter Street and a portion of the flow traveling west along Monroe Street to Williams Street. This contributes to the flooding along Williams Street. Surface flooding along the Lynn Street drainage line flows west after intersecting Eldridge Avenue. A storage basin at node 8225NW-42 simulates ponding on the north side of Eldridge Avenue at the intersection with Jaeger Street. Once this storage basin fills, overflows cross south over Eldridge Avenue and flow downhill out of the basin and out of the study area. Surface flooding at the intersection of H Street and Jenkins Street would also flow out of the Broadway basin, but these overflows would flow southwest along H Street into the Ellsworth basin.

C Street

In the C Street basin, flooding along Astor Street would flow down F Street and enter catch basins at the intersection of F Street and Holly Street. Several model nodes flood along the drainage line between Holly Street and the railroad. Some ponding would occur between the railroad and Holly Street northwest of F Street, and some flow would cross the railroad then northwest along Roeder Avenue toward Hilton Avenue and out of the C Street basin.

[1] Similar figures for other basins are provided in Appendix A.

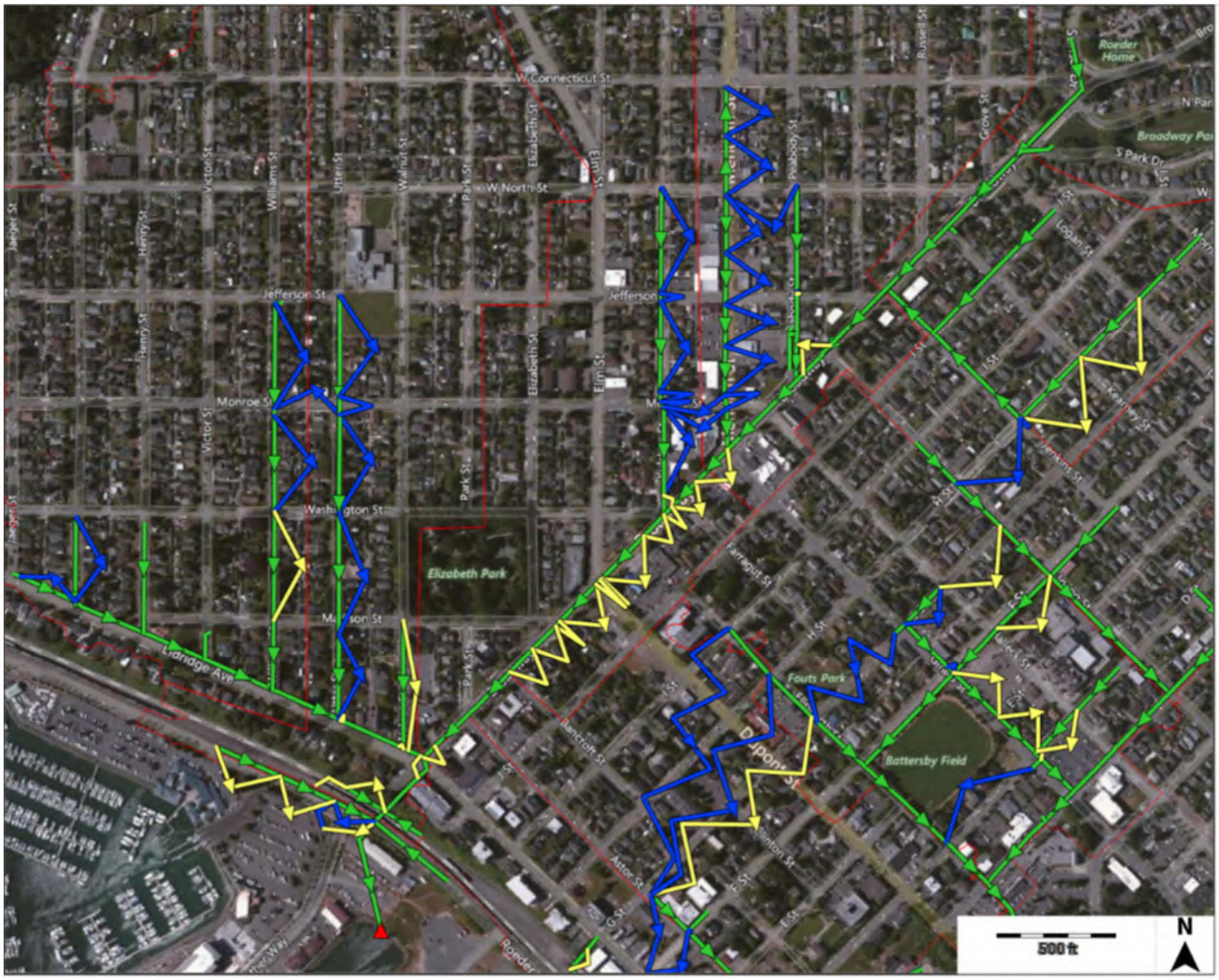

Figure 6. Schematic diagram showing the Broadway drainage network (green), active overflow paths (blue), and inactive overflow paths (yellow) during the 25-year flood event under full build-out land-use conditions. Overflow path locations are intended to be schematic only and do not indicate actual flowpaths. The Broadway system outfall is shown as a red triangle.

Ellsworth

In the Ellsworth basin, simulations show flooding at several locations under the 25-year full build-out design flood. Catch basin 8330NW-37 at the intersection of Halleck Street and G Street would flood with overflows traveling southwest along G Street to the intersection with Girard Street. Overflows would enter the catch basins connected to model node 8330NW-50, but due to limited capacity in the drainage network under Girard Street, flow would overflow from the catch basin 8330NW-60 on the south side of Girard Street which has a lower rim elevation than the catch basins on the north side of Girard. This flow would continue traveling southwest on G Street until reaching Ellsworth Street and entering the main trunk line. Flooding also occurs at the intersections of Girard and F Streets and Girard and D Streets. The intersection of Girard Street and D Street is a topographic low, and ponding is simulated by a storage node 8330NW-105A. Similar to the situation at the intersection of Girard and G Streets, catch basin 8330NW-118 on the south side of Girard Street has a lower rim elevation than catch basins on the north, and would flood due to limited capacity in the Girard Street drainage line. Limited capacity in the Ellsworth street drainage line would result in overflows near I and H Streets that would flow southwest out of the Ellsworth system and into the C Street basin.

Laurel

In the Laurel Basin, all nodes along N Forest Street would overflow and flow down to the intersection with Laurel Street. Node 8330SW-407 on East Maple Street would flood and overflows would travel southwest along the alleyway before draining down the slope towards Cornwall Avenue and out of the basin. Nodes 8330SW-442, 8330SW-439, and 8330SW-521 at the base of the hill southeast of Cornwall Avenue would all overflow into the low area between the hillside and the rail yard. Node 8331NW-310 would overflow and travel NW down E Laurel St.

Olive

The only modeled flooding in the Olive basin occurs at manhole 8236SW-25 east of the railroad, immediately upstream from the marine outfall. The pipe segment downstream of the manhole has lower slope and thus lower capacity than the upstream segments. Simulated flooding at this manhole is minimal – during the 25-year full build-out event the model indicates this manhole floods for only 6 minutes with a peak overflow discharge of about 0.6 cfs.

Willow

In the Willow basin, flooding is limited to the roadside ditch on the east side of Bayside Road. The upstream most node to flood is 7211SE-20 at the intersection of Bayside and Linden Road. Overflow would travel down the east side of Bayside road until it enters the culvert at node 7211SE-10.

FLOOD REDUCTION ALTERNATIVES

The preceding section describes locations of flooding for the 25-year full build-out design event. Following the identification of flooding locations the SWMM model was used to determine conveyance system improvements needed to eliminate this flooding. In some locations, it was obvious that an undersized pipe or series of pipes was the cause of flooding, and upsizing these pipes eliminated the flooding. In other locations, flooding was more complex resulting in several potential alternatives – for example, upsizing one or more pipes right near the location of flooding versus increasing pipe sizes in the trunk line downstream of the flooding location. The approach used to develop flood reduction alternatives, and the recommended alternatives are described below.

APPROACH

To minimize the cost of the proposed improvements, WSE sought solutions that required replacing the shortest total length of pipe. In some instances, however, several different alternatives were identified to achieve the desired level of flood reduction. In these cases, two alternatives are presented.

When testing pipe upsizing alternatives, the invert elevations for upsized pipes were kept at the existing invert elevations except in instances where the new pipe would have less than one foot of cover over the pipe crown to the ground surface at either end of the pipe. In these cases the invert elevations for the new pipe were lowered such that there would be at least one-foot of cover. If the cover was between 1 and 2 feet, then ductile iron pipe material was specified. Concrete pipe was recommended for all pipes with more than 2 feet of cover. The alternatives analysis assumed that replacement pipes would have one of the following diameters: 12-, 15-, 18-, 21-, 24-, 30-, 36-, 42-, 48-, or 54- inches.

SUMMARY OF RESULTS

Table 7 summarizes WSE's recommended alternatives to eliminate flooding for the 25-year design flood event with full build-out land-use. Brief discussions of the solution alternatives are provided below:

Arbutus

Within the Arbutus basin, one node (7214NE-78) floods during the 25-year flood event; two alternatives are presented to eliminate this flooding. Alternative 1 replaces the existing 12-inch CMP pipe with a 12-inch concrete pipe. The reduction in roughness between these two pipe materials is sufficient to eliminate flooding at this location. If the City prefers to also increase the pipe size, alternative 2 recommends installing a 15-inch concrete pipe.

Broadway

Flooding within the Broadway basin is extensive, with flooding along both the Broadway branch and Eldridge branch of the drainage network. To eliminate flooding along the Broadway branch (Meridian, Kulshan, and Peabody Streets), WSE identified 49 pipe segments that need to be enlarged (total length 6575 feet). These modifications also act to reduce water levels upstream in the drainage network and eliminate the inter-basin flooding from node 8319SW-305 (at the intersection of H and Jenkins Streets) to the Ellsworth basin. Ductile iron is recommended for some of the replacement pipes because they have less than 2 feet of ground cover above the pipe crown. To eliminate flooding along the Eldridge branch, two alternatives are presented. Alternative 1 recommends more significant modifications to the main branch beneath Eldridge Street and less modifications to the smaller branches than alternative 2. In total, alternative 1 calls for replacing 2855 feet of pipe, while alternative 2 calls for replacing 3181 feet of pipe.

C Street

Flooding in the C Street basin can be eliminated by upsizing 13 pipes with a total length of 1421 feet. If the recommended pipe sizes at node 8330NW-355 are used the pipes will have to be installed at a lower invert elevation to maintain a minimum of 1-foot of cover (the existing concrete pipes have less than 1 foot of cover at this location). Ductile iron is recommended for these and three other replacement pipes in the basin because they will have less than 2 feet of cover.

Ellsworth

Flooding within the Ellsworth basin can be eliminated by upsizing eight pipes with a total length of 1509 feet. One of the pipes (C1518) included in Table 7 for the Ellsworth alternative is actually part the Broadway system, but is included with the Ellsworth alternative because it causes flooding that overflows from Broadway into the Ellsworth basin. Modifying pipe C1518 will eliminate interbasin overflows from the Broadway basin into Ellsworth basin. It should be noted, however, that if the more comprehensive solution recommended for the Broadway system is implemented first, then interbasin flooding would be eliminated and this pipe would not need to be upsized at all.

Laurel

Two alternatives are presented in Table 7 to eliminate flooding in the Laurel basin. The primary difference between the two alternatives is the conversion of the catch basin at node 8330SW-521 to a pressure lid in alternative 2 (and thus the elimination of inflows to the drainage system at that location). Node 8330SW-521 sits in a topographic low between Cornwall Avenue and the hill to the southeast and captures runoff from the surrounding area. If the City does not want to eliminate this catch basin, alternative 1, which includes modifying three additional pipe segments to eliminate flooding in the Laurel system, would be recommended.

Olive

The only simulated flooding in the Olive basin occurs from manhole 8236SW-25 east of the railroad and immediately upstream from the outfall. Surface flooding may not be much of a problem at this location, in which case no action would be needed. However, if the City wants to eliminate any flooding, one pipe segment would need to be upsized.

Willow

In the Willow basin, four pipes need to be replaced to eliminate flooding along Bayside Road. Alternative 1 eliminates flooding by installing the same sized concrete (CON) pipes, which have a lower roughness value than the existing corrugated metal pipe (CMP). The reduced roughness with concrete pipes is enough to eliminate flooding at this location. If the City prefers to also increase the pipe size, alternative 2 recommends installing three 24-inch concrete pipes. In both alternatives, one ductile iron pipe is recommended due to limited cover at node 7211SE-20.

EVALUATION OF POTENTIAL EFFECTS OF SEA LEVEL RISE

As part of WSE's scope for this project, the City requested a review of the effect that sea level rise might have on the proposed conveyance system improvements. The time horizon used for this analysis was set at 50 years in the future (e.g. 2070). Recent work by the University of Washington Climate Impacts Group (CIG) estimates that the median value of relative sea level rise in Bellingham Bay will be between 0.9 and 1.1 feet by 2070[23]. The SWMM model of flood reduction alternatives was therefore rerun assuming the tidal boundary condition was raised by 1.1 feet. While the higher tailwater condition results in increased water levels upstream of the outfalls, this analysis found that no additional flooding would result from the predicted sea level rise. The conveyance system improvements shown in Table 7 are robust enough to handle at least 1.1 feet of future sea level rise.

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[2] https://www.washington.edu/news/2018/07/30/sea-level-rise-report-contains-best-projections-yet-for-washingtons-coasts/

[33] City Code 16.30.3.A.3-1 states "In areas south of the Whatcom Waterway, new stormwater outfalls shall be designed and constructed to protect against long-term sea level rise appropriate to the lifetime of the project". The value of 1.1 feet used in this study was deemed appropriate for the current work, and was based on the best currently available science regarding future relative sea level rise. As individual conveyance system improvements are designed in the future, the latest guidance regarding sea level rise should be reviewed and the anticipated project life should be considered in determining an appropriate estimate of sea level rise for use in design.

Table 7. Proposed pipe size and materials required to eliminate flooding during the 25-year full build-out land-use scenario.

Outfall	Alternative	Location	SWMM Pipe Name	Inlet Node	Outlet Node	Existing System				Proposed Change				Inlet Invert Depth (ft)	Outlet Invert Depth (ft)	Inlet Cover (ft)	Outlet Cover (ft)	Length (ft)	Notes
						Material	Dia (in)	Dia (ft)	Roughness	Material	Dia (in)	Dia (ft)	Roughness						
Arbutus	1	Fieldston Rd	C1541	7214NE-78	7214NE-64	CMP	12	1.00	0.024	CON	12	1.25	0.011	5.50	5.00	4.25	3.75	114	Change in material/roughness is enough to eliminate flooding without upsizing.
	2	Fieldston Rd	C1541	7214NE-78	7214NE-64	CMP	12	1.00	0.024	CON	15	1.00	0.011	5.50	5.00	4.50	4.00	114	Alternative 2 provided in case an increase in pipe size is preferred
Broadway	1 - Broadway Branch	Kulshan (Broadway to Monroe)	C1842	8224NE-A	8225NE-348	CON	18	1.50	0.011	CON	24	2.00	0.011	7.10	8.00	5.10	6.00	83	
			C1993	8224SE-360	8224NE-A	CON	15	1.25	0.011	CON	24	2.00	0.011	9.39	7.10	7.39	5.10	376	
		Kulshan (Monroe to Jefferson)	C1879	W0182-CB42	8224SE-360	PVC	12	1.00	0.011	CON	24	2.00	0.011	5.00	9.39	3.00	7.39	26	
			C1878	8224SE-210	W0182-CB42	PVC	12	1.00	0.011	CON	24	2.00	0.011	5.10	5.00	3.10	3.00	39	
			C1994	8224SE-161	8224SE-210	CON	15	1.25	0.011	CON	24	2.00	0.011	4.70	5.10	2.70	3.10	389	
			C1987	8224SE-152	8224SE-161	CON	12	1.00	0.011	CON	18	1.50	0.011	4.72	4.70	3.22	3.20	34	
		Kulshan (Jefferson to North)	C1952	8224SE-113	8224SE-152	CON	12	1.00	0.011	CON	18	1.50	0.011	5.00	4.72	3.50	3.22	450	
		Peabody (Jefferson to North)	C2016	8319SW-F002	8319SW-170	CON	15	1.25	0.011	DI	21	1.75	0.013	3.50	4.00	1.75*	2.25	30	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
			C1969	8319SW-170	8319SW-222	CON	15	1.25	0.011	CON	21	1.75	0.011	4.00	4.02	2.25	2.27	418	
			C1803	8319SW-222	8319SW-225	CON	15	1.25	0.011	CON	21	1.75	0.011	4.02	4.20	2.27	2.45	9	
			C1968	8319SW-225	8319SW-229	CON	15	1.25	0.011	CON	21	1.75	0.011	4.20	4.67	2.45	2.92	5	
		Peabody (Broadway to Jefferson)	C1892	S0505-CB02	S0505-CB06	CPP	12	1.00	0.02	CON	15	1.25	0.011	4.40	5.00	3.15	3.75	32	
			C1525	S0505-CB07	8319SW-280	CON	18	1.50	0.011	CON	24	2.00	0.011	5.35	6.30	3.35	4.30	154	
			C1893	S0505-CB06	S0505-CB07	CON	18	1.50	0.011	CON	24	2.00	0.011	5.00	5.35	3.00	3.35	45	
			C1891	8319SW-243	S0505-CB06	CON	18	1.50	0.011	CON	21	1.75	0.011	4.38	5.00	2.63	3.25	138	
			C1804	8319SW-229	8319SW-243	CON	18	1.50	0.011	CON	21	1.75	0.011	4.67	4.38	2.92	2.63	33	
		Broadway (Meridian to Peabody)	C1813	8319SW-F006	8224SE-356	CON	27	2.25	0.011	CON	30	2.50	0.011	7.52	9.00	5.02	6.50	218	
			C1900	8319SW-296	8319SW-F006	CON	27	2.25	0.011	CON	30	2.50	0.011	7.26	7.52	4.76	5.02	30	
			C2010	8319SW-280	8319SW-296	CON	27	2.25	0.011	CON	30	2.50	0.011	6.30	7.26	3.80	4.76	165	
		Meridian (North to Connecticut)	C1571	8224SE-62	8224SE-55	CON	12	1.00	0.011	CON	24	2.00	0.011	4.89	5.60	2.89	3.60	204	
			C1821	8224SE-116	8224SE-62	CON	12	1.00	0.011	CON	24	2.00	0.011	4.50	4.89	2.50	2.89	257	
		Meridian (Jefferson to North)	C1805	8224SE-118	8224SE-163	CON	12	1.00	0.011	CON	24	2.00	0.011	4.35	4.30	2.35	2.30	220	
			C1623	8224SE-116	8224SE-118	CON	12	1.00	0.011	CON	24	2.00	0.011	4.50	4.35	2.50	2.35	242	
		Meridian (Broadway to Jefferson)	C1779	8224SE-199	8224SE-356	CON	12	1.00	0.011	DI	30	2.50	0.013	4.30	9.00	1.80*	6.50	172	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
			C1744	W0182-CB46	8224SE-199	CON	12	1.00	0.011	DI	30	2.50	0.013	3.70	4.30	1.20*	1.80*	57	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
			C1778	8224SE-168	W0182-CB46	CON	12	1.00	0.011	DI	30	2.50	0.013	4.04	3.70	1.54*	1.20*	209	Cover less than 2 ft threshold; Ductile Iron pipe recommended.

Outfall	Alternative	Location	SWMM Pipe Name	Inlet Node	Outlet Node	Existing System Material	Existing System Dia (in)	Existing System Dia (ft)	Existing System Roughness	Proposed Change Material	Proposed Change Dia (in)	Proposed Change Dia (ft)	Proposed Change Roughness	Inlet Invert Depth (ft)	Outlet Invert Depth (ft)	Inlet Cover (ft)	Outlet Cover (ft)	Length (ft)	Notes
			C1726	8224SE-163	8224SE-168	CON	12	1.00	0.011	DI	30	2.50	0.013	4.30	4.04	1.80*	1.54*	178	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
			C1984	8225NE-347	8225NE-348	CON	30	2.50	0.011	CON	36	3.00	0.011	7.67	8.00	4.67	5.00	50	
		Broadway (Washington to Girard)	C1799	8224SE-358	8225NE-347	CON	30	2.50	0.011	CON	36	3.00	0.011	7.50	7.67	4.50	4.67	148	
			C1794	8224SE-356	8224SE-358	CON	30	2.50	0.011	CON	48	4.00	0.011	9.00	7.50	5.00	3.50	192	
			C1642	8225NE-26	8225NE-28	CON	30	2.50	0.011	CON	48	4.00	0.011	8.48	8.40	4.48	4.40	22	
		Broadway (Dupont to Washington)	C1643	8225NE-25	8225NE-26	CON	30	2.50	0.011	CON	48	4.00	0.011	8.43	8.48	4.43	4.48	10	
			C1812	8225NE-350	8225NE-25	CON	30	2.50	0.011	CON	48	4.00	0.011	7.90	8.43	3.90	4.43	254	
			C1823	8225NE-348	8225NE-350	CON	36	3.00	0.011	CON	48	4.00	0.011	8.00	7.90	4.00	3.90	126	
			C1697	8225NE-28	8225NE-46	CON	36	3.00	0.011	CON	48	4.00	0.011	8.40	7.39	4.40	3.39	223	
		Broadway (Bancroft to Dupont)	C1641	8225NE-46	8225NE-52	CON	36	3.00	0.011	CON	48	4.00	0.011	7.39	7.39	3.39	3.39	28	
			C1930	8225NE-52	8225NE-63	CON	36	3.00	0.011	CON	48	4.00	0.011	7.39	6.40	3.39	2.40	138	
Broadway	1 - Broadway Branch (cont.)		C1681	8225NE-63	8225NE-73	CON	36	3.00	0.011	DI	42	3.50	0.013	6.40	5.10	2.90	1.60*	138	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
		Broadway (Astor to Bancroft)	C1692	8225NE-73	8225NE-93	CON	36	3.00	0.011	DI	42	3.50	0.013	5.10	6.08	1.60*	2.58	194	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
			C1928	8225NE-93	8225NE-94	CON	36	3.00	0.011	CON	42	3.50	0.011	6.08	6.33	2.58	2.83	41	
			C1929	8225NE-94	8225NE-103	CON	36	3.00	0.011	CON	42	3.50	0.011	6.33	6.30	2.83	2.80	40	
			C1520	8225NE-103B	8225NE-132	CON	36	3.00	0.011	CON	48	4.00	0.011	6.98	7.20	2.98	3.20	70	
		Broadway (Holly to Astor)	C1909	8225NE-130	8225NE-132	CON	36	3.00	0.011	CON	48	4.00	0.011	6.78	7.20	2.78	3.20	16	
			C1908	8225NE-128	8225NE-130	CON	36	3.00	0.011	CON	42	3.50	0.011	6.93	6.78	3.43	3.28	57	
			C1524	8225NE-132	8225NE-147	CON	36	3.00	0.011	CON	42	3.50	0.011	7.20	8.00	3.70	4.50	53	
		Broadway (Roeder to Eldridge)	C1543	8225NE-177	8225NE-182	DI	36	3.00	0.013	DI	48	4.00	0.013	8.90	7.80	4.90	3.80	60	
			C1793	8225NE-191	8225NE-341	CON	36	3.00	0.011	CON	48	4.00	0.011	9.30	6.25	5.30	2.25	401	
		Bellweather Way	C1792	8225NE-183	8225NE-191	CON	36	3.00	0.011	CON	54	4.50	0.011	8.00	9.30	3.50	4.80	85	
			C1674	8225NE-182	8225NE-183	CON	36	3.00	0.011	CON	54	4.50	0.011	7.80	8.00	3.30	3.50	16	
		Williams St (Jefferson to Madison)	C1958	8225NE-40	8225NE-83	VIT	12	1.00	0.014	CON	15	1.25	0.011	10.00	7.50	8.75	6.25	298	Alternative 1 pipe length total = 2855 ft
			C1939	8225NE-314	8225NE-318	CON	12	1.00	0.011	CON	15	1.25	0.011	5.00	5.20	3.75	3.95	517	
		Utter St (Jefferson to Eldridge)	C1941	8225NE-318	8225NE-98	CON	8	0.67	0.011	CON	15	1.25	0.011	5.20	7.50	3.95	6.25	361	
Broadway	1 - Eldridge Ave Branch		C1959	8224SE-171	8224SE-194	CON	8	0.67	0.011	CON	12	1.00	0.011	5.05	5.50	4.05	4.50	81	
			C1910	8225NE-124	8225NE-126	CON	24	2.00	0.011	CON	36	3.00	0.011	6.66	7.00	3.66	4.00	18	
		Eldridge Ave (Walnut to Utter)	C1911	8225NE-115	8225NE-124	CON	24	2.00	0.011	CON	36	3.00	0.011	7.42	6.66	4.42	3.66	134	
			C1926	8225NE-106	8225NE-115	CON	24	2.00	0.011	CON	36	3.00	0.011	7.46	7.42	4.46	4.42	128	
			C1927	8225NE-101	8225NE-106	CON	24	2.00	0.011	CON	36	3.00	0.011	7.43	7.46	4.43	4.46	13	

Outfall	Alternative	Location	SWMM Pipe Name	Inlet Node	Outlet Node	Existing System				Proposed Change				Inlet Invert Depth (ft)	Outlet Invert Depth (ft)	Inlet Cover (ft)	Outlet Cover (ft)	Length (ft)	Notes
						Material	Dia (in)	Dia (ft)	Roughness	Material	Dia (in)	Dia (ft)	Roughness						
Broadway	1 - Eldridge Ave Branch (cont.)	Eldridge Ave (Utter to Williams)	C1923	8225NE-83	8225NE-85	CON	24	2.00	0.011	CON	30	2.50	0.011	7.50	7.62	5.00	5.12	27	
			C1942	8225NE-85	8225NE-326	CON	24	2.00	0.011	CON	36	3.00	0.011	7.62	7.73	4.62	4.73	127	
			C1943	8225NE-326	8225NE-98	CON	24	2.00	0.011	CON	36	3.00	0.011	7.73	7.50	4.73	4.50	151	
		Eldridge Ave (Williams to Victor)	C1749	8225NE-68	8225NE-83	CON	21	1.75	0.011	CON	30	2.50	0.011	6.72	7.50	4.22	5.00	277	
			C1951	8225NE-65	8225NE-68	CON	21	1.75	0.011	CON	30	2.50	0.011	6.20	6.72	3.70	4.22	41	
		Eldridge Ave (Henry to Jaeger)	C1521	8225NE-47A	8225NE-48	CON	12	1.00	0.011	CON	18	1.50	0.011	6.31	6.50	4.81	5.00	16	
			C1519	8225NW-57	8225NE-47A	CON	12	1.00	0.011	CON	18	1.50	0.011	6.50	6.31	5.00	4.81	267	
			C1998	8225NW-51	8225NW-57	CON	12	1.00	0.011	CON	15	1.25	0.011	5.00	6.50	3.75	5.25	39	
		Lynn St (Eldridge to Washington)	C2000	8225NW-16	8225NW-51	CON	12	1.00	0.011	CON	21	1.75	0.011	4.90	5.00	3.15	3.25	361	
	2 - Eldridge Ave Branch	Williams St (Jefferson to Madison)	C1958	8225NE-40	8225NE-83	VIT	12	1.00	0.014	CON	15	1.25	0.011	10.00	7.50	8.75	6.25	298	Alternative 2 pipe length total = 3181 ft
			C1947	8225NE-7	8225NE-40	VIT	12	1.00	0.014	CON	15	1.25	0.011	5.70	10.00	4.45	8.75	461	
		Utter St (Jefferson to Eldridge)	C1941	8225NE-318	8225NE-98	CON	8	0.67	0.011	CON	15	1.25	0.011	5.20	7.50	3.95	6.25	361	
			C1939	8225NE-314	8225NE-318	CON	12	1.00	0.011	CON	15	1.25	0.011	5.00	5.20	3.75	3.95	517	
			C1959	8224SE-171	8224SE-194	CON	8	0.67	0.011	CON	12	1.00	0.011	5.05	6.00	4.05	5.00	81	
		Eldridge Ave (Walnut to Broadway)	C1908	8225NE-128	8225NE-130	CON	36	3.00	0.011	CON	42	3.50	0.011	6.93	6.78	3.43	3.28	57	
		Eldridge Ave (Walnut to Utter)	C1910	8225NE-124	8225NE-126	CON	24	2.00	0.011	CON	30	2.50	0.011	6.66	7.00	4.16	4.50	18	
			C1911	8225NE-115	8225NE-124	CON	24	2.00	0.011	CON	30	2.50	0.011	7.42	6.66	4.92	4.16	134	
		Eldridge Ave (Victor to Henry)	C1710	8225NE-51	8225NE-65	CON	18	1.50	0.011	CON	24	2.00	0.011	7.31	6.20	5.31	4.20	262	
			C1627	8225NE-48	8225NE-51	CON	18	1.50	0.011	CON	24	2.00	0.011	6.50	7.31	4.50	5.31	23	
		Eldridge Ave (Henry to Jaeger)	C1521	8225NE-47A	8225NE-48	CON	12	1.00	0.011	CON	24	2.00	0.011	6.31	6.50	4.31	4.50	16	
			C1519	8225NW-57	8225NE-47A	CON	12	1.00	0.011	CON	24	2.00	0.011	6.50	6.31	4.50	4.31	267	
			C1998	8225NW-51	8225NW-57	CON	12	1.00	0.011	CON	24	2.00	0.011	5.00	6.50	3.00	4.50	39	
			C2001	8225NW-42	8225NW-51	CON	12	1.00	0.011	CON	24	2.00	0.011	4.71	5.00	2.71	3.00	257	
			C1981	8225NW-39	8225NW-42	CON	12	1.00	0.011	CON	24	2.00	0.011	4.00	4.71	2.00	2.71	29	
		Lynn St (Eldridge to Washington)	C2000	8225NW-16	8225NW-51	CON	12	1.00	0.011	CON	21	1.75	0.011	4.90	5.00	3.15	3.25	361	
C Street	1	Astor St (C to D St)	C1932	8330NW-384	V0058-M01	CON	15	1.25	0.011	CON	18	1.50	0.011	3.50	8.60	2.00	7.10	97	
			C1931	8330NW-355	8330NW-384	CON	15	1.25	0.011	DI	18	1.50	0.013	2.50	3.50	1.00**	2.00	142	Cover less than 1ft threshold, invert elevation needs to be minumum 20.215 ft at node 8330NW-355.

Outfall	Alternative	Location	SWMM Pipe Name	Inlet Node	Outlet Node	Existing System				Proposed Change				Inlet Invert Depth (ft)	Outlet Invert Depth (ft)	Inlet Cover (ft)	Outlet Cover (ft)	Length (ft)	Notes
						Material	Dia (in)	Dia (ft)	Roughness	Material	Dia (in)	Dia (ft)	Roughness						
C Street	1 (cont.)	Astor St (D to E St)	C1816	8330NW-316	8330NW-355	CON	15	1.25	0.011	DI	18	1.50	0.013	6.98	2.50	5.48	1.00**	253	Cover less than 1ft threshold, invert elevation needs to be minumum 20.215 ft at node 8330NW-355.
		Astor St (E to F St)	C1614	8225NE-239	8330NW-315	CON	12	1.00	0.011	CON	15	1.25	0.011	5.60	7.10	4.35	5.85	261	
		Astor St (F to G St)	C2005	8225NE-228	8225NE-239	CON	12	1.00	0.011	CON	15	1.25	0.011	11.90	5.60	10.65	4.35	222	
		Railroad Access (C to D St)	C1992	8330NW-467	8330NW-470	CON	18	1.50	0.011	CON	21	1.75	0.011	7.70	10.03	5.95	8.28	16	
			C1913	8330NW-459	8330NW-467	CON	18	1.50	0.011	CON	21	1.75	0.011	6.86	7.70	5.11	5.95	64	
			C1919	8330NW-435	8330NW-459	CON	15	1.25	0.011	CON	18	1.50	0.011	6.80	6.86	5.30	5.36	55	
			C1918	8330NW-413	8330NW-435	CON	15	1.25	0.011	CON	18	1.50	0.011	6.49	6.80	4.99	5.30	64	
		Railroad Access (F to G St)	C1912	8225NE-247	8225NE-248	CON	12	1.00	0.011	DI	18	1.50	0.013	3.00	3.50	1.50*	2.00	7	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
			C1934	8225NE-271	8225NE-274	CON	15	1.25	0.011	CON	18	1.50	0.011	3.74	4.50	2.24	3.00	59	
			C1933	8225NE-259	8225NE-271	CON	15	1.25	0.011	DI	18	1.50	0.013	3.40	3.74	1.90*	2.24	93	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
			C1963	8225NE-248	8225NE-259	CON	15	1.25	0.011	DI	18	1.50	0.013	3.50	3.40	2.00	1.90*	88	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
Ellsworth	1	Girard St (C to D St)	C1578	8330NW-114	8330NW-131	CON	15	1.25	0.011	CON	21	1.75	0.011	4.80	6.40	3.05	4.65	194	
		Girard St (F to G St)	C1579	8330NW-50	8330NW-69	CON	15	1.25	0.011	CON	18	1.50	0.011	5.50	6.00	4.00	4.50	258	
		Ellsworth St (D to F St)	C1581	8330NW-140	8330NW-179	CON	15	1.25	0.011	CON	18	1.50	0.011	6.90	4.50	5.40	3.00	248	
			C1638	8330NW-115	8330NW-140	CON	15	1.25	0.011	CON	18	1.50	0.011	6.90	6.90	5.40	5.40	231	
		Ellsworth St (F to G St)	C1817	8330NW-99	8330NW-115	CON	12	1.00	0.011	CON	15	1.25	0.011	7.13	6.90	5.88	5.65	147	
			C1616	8330NW-88A	8330NW-99	CON	12	1.00	0.011	CON	15	1.25	0.011	5.95	7.13	4.70	5.88	126	
			C1830	8330NW-89	8330NW-88A	CON	12	1.00	0.011	CON	15	1.25	0.011	5.50	5.95	4.25	4.70	30	
		Jenkins St	C1518	8319SW-259	8319SW-219	CON	18	1.50	0.011	CON	24	2.00	0.011	8.40	6.90	6.40	4.90	275	Pipe is in the Broadway system, but upsize is only required to fix overflow into Ellsworth system if Ellsworth work is performed first. If Broadway system is fixed first, upsizing in the lower Broadway system solves the flooding in the Ellsworth system without needing to upsize this pipe.
Laurel	1	Laurel St (State to Cornwall)	C1634	8330SW-426	8330SW-424	CON	30	2.50	0.011	CON	36	3.00	0.011	11.03	11.13	8.03	8.13	62	Alternative 1 - upsize all pipes necessary to eliminate flooding
			C1559	8330SW-431	8330SW-426	CON	30	2.50	0.011	CON	36	3.00	0.011	10.79	11.03	7.79	8.03	37	
			C1576	8330SW-521	8330SW-431	CMP	30	2.50	0.024	CON	36	3.00	0.011	5.50	10.79	2.50	7.79	108	
			C1898	8330SW-439	8330SW-521	CON	30	2.50	0.011	CON	36	3.00	0.011	5.10	5.50	2.10	2.50	25	
			C1575	8330SW-442	8330SW-439	CON	30	2.50	0.011	CON	36	3.00	0.011	10.35	5.10	7.35	2.10	58	

Outfall	Alternative	Location	SWMM Pipe Name	Inlet Node	Outlet Node	Existing System				Proposed Change				Inlet Invert Depth (ft)	Outlet Invert Depth (ft)	Inlet Cover (ft)	Outlet Cover (ft)	Length (ft)	Notes
						Material	Dia (in)	Dia (ft)	Roughness	Material	Dia (in)	Dia (ft)	Roughness						
Laurel	1 (cont.)	Laurel St (Forest to State)	C1859	8331NW-310	8331NW-38	CON	12	1.00	0.011	CON	18	1.50	0.011	12.00	7.50	10.50	6.00	139	
		Forest St (Maple to Laurel)	C1866	W0168-M02	W0168-M01	PVC	12	1.00	0.011	CON	15	1.25	0.011	8.20	9.40	6.95	8.15	55	
			C1867	8331NW-303	W0168-M02	PVC	12	1.00	0.011	CON	15	1.25	0.011	5.00	8.20	3.75	6.95	163	
		E Maple St to Laurel trunk line	C1850	8330SW-439A	8330SW-439	CMP	15	1.25	0.024	CON	15	1.25	0.011	5.00	5.10	3.75	3.85	202	Change in material/roughness is enough to eliminate flooding without upsizing.
			C1574	S0301-CB06	8330SW-439A	CMP	15	1.25	0.024	CON	15	1.25	0.011	5.00	5.00	3.75	3.75	211	
			C1841	8330SW-407	S0301-CB06	CMP	15	1.25	0.024	CON	15	1.25	0.011	6.60	5.00	5.35	3.75	102	
Laurel	2	Laurel St (State to Cornwall)		8330SW-521															Alternative 2: rather than upsizing pipes C1634, C1898, C1575 - add a pressure lid to node 8330SW-521.
			C1559	8330SW-431	8330SW-426	CON	30	2.50	0.011	CON	36	3.00	0.011	10.79	11.03	7.79	8.03	37	
			C1576	8330SW-521	8330SW-431	CMP	30	2.50	0.024	CON	36	3.00	0.011	5.50	10.79	2.50	7.79	108	
		Laurel St (Forest to State)	C1859	8331NW-310	8331NW-38	CON	12	1.00	0.011	CON	18	1.50	0.011	12.00	7.50	10.50	6.00	139	
		Forest St (Maple to Laurel)	C1866	W0168-M02	W0168-M01	PVC	12	1.00	0.011	CON	15	1.25	0.011	8.20	9.40	6.95	8.15	55	
			C1867	8331NW-303	W0168-M02	PVC	12	1.00	0.011	CON	15	1.25	0.011	5.00	8.20	3.75	6.95	163	
		E Maple St to Laurel trunk line	C1850	8330SW-439A	8330SW-439	CMP	15	1.25	0.024	CON	15	1.25	0.011	5.00	5.10	3.75	3.85	202	Change in material/roughness is enough to eliminate flooding without upsizing.
			C1574	S0301-CB06	8330SW-439A	CMP	15	1.25	0.024	CON	15	1.25	0.011	5.00	5.00	3.75	3.75	211	
			C1841	8330SW-407	S0301-CB06	CMP	15	1.25	0.024	CON	15	1.25	0.011	6.60	5.00	5.35	3.75	102	
Olive	1	NW of S State St	C1871	8236SW-25	8236SW-2	CMP	18	1.50	0.024	CON	24	2.00	0.011	7.00	7.60	5.00	5.60	46	Only flooded node is first node upstream of outfall. Ponding at this location may not be an issue for COB.
Willow	1	Bayside Rd	C1582	7211SE-11	7211SE-6	CMP	18	1.50	0.024	CON	18	1.50	0.011	4.70	4.00	3.20	2.50	220	Change in material/roughness is enough to eliminate flooding without upsizing.
			C1583	7211SE-17	7211SE-11	CMP	18	1.50	0.024	CON	18	1.50	0.011	5.30	4.70	3.80	3.20	331	
			C1679	7211SE-16	7211SE-17	CMP	18	1.50	0.024	CON	18	1.50	0.011	5.20	5.30	3.70	3.80	127	
			C1631	7211SE-20	7211SE-16	CMP	18	1.50	0.024	DI	21	1.75	0.013	3.00	5.20	1.25*	3.45	346	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
	2	Bayside Rd	C1582	7211SE-11	7211SE-6	CMP	18	1.50	0.024	CON	24	2.00	0.011	4.70	4.00	2.70	2.00	220	Alternative 2 provided in case an increase in pipe size is preferred
			C1583	7211SE-17	7211SE-11	CMP	18	1.50	0.024	CON	24	2.00	0.011	5.30	4.70	3.30	2.70	331	
			C1679	7211SE-16	7211SE-17	CMP	18	1.50	0.024	CON	24	2.00	0.011	5.20	5.30	3.20	3.30	127	
			C1631	7211SE-20	7211SE-16	CMP	18	1.50	0.024	DI	21	1.75	0.013	3.00	5.20	1.25*	3.45	346	Cover less than 2 ft threshold; Ductile Iron pipe recommended.

SUMMARY AND CONCLUSIONS

Watershed Science and Engineering developed hydrologic and hydraulic models and conducted detailed analyses to characterize current and future conditions flooding in nine direct discharge marine outfall systems in the City of Bellingham. WWHM hydrologic models covering the nine drainage basins were developed and used to generate hydrologic inputs for existing and full build-out land-use conditions. A comprehensive SWMM hydraulic model of the nine systems was constructed and used to characterize current and full build-out conditions flooding for four design flood events. The hydraulic model was then used to develop and evaluate potential flood reduction alternatives with the goal of eliminating flooding during the 25-year full build-out conditions flood event. The recommended system improvements to achieve the desired level of flood reduction are presented in Table 7.

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Chow, V.T. (1959). *Open Channel Hydraulics*. McGraw-Hill, New York.

Federal Highway Administration (1996). *Urban Drainage Design Manual*: *Hydraulic Engineering Circular No. 22* (No. FHWA-SA-96-078).

Snohomish County (2002). *DRAFT Hydrologic Modeling Protocols, Version 1.4.* Prepared for Snohomish County Public Works, Surface Water Management Division, Everett WA.

APPENDIX A – SCHEMATIC FIGURES OF DRAINAGE NETWORK SYSTEMS

ARBUTUS SYSTEM

Figure A1. Schematic diagram showing the Arbutus drainage network (green), active overflow paths (blue), and inactive overflow paths (yellow) during the 25-year flood event under full build-out land-use conditions. Overflow path locations are intended to be schematic only and do not indicate actual flowpaths. Drainage boundary is shown in red. The Arbutus system outfall is shown as a red triangle.

BENNETT SYSTEM

Figure A2. Schematic diagram showing the Bennett drainage network (green) during the 25-year flood event under full build-out land-use conditions. No overflow paths were identified in the Bennett system. Drainage boundary is shown in red. The Bennett system outfall is shown as a red triangle.

BROADWAY SYSTEM

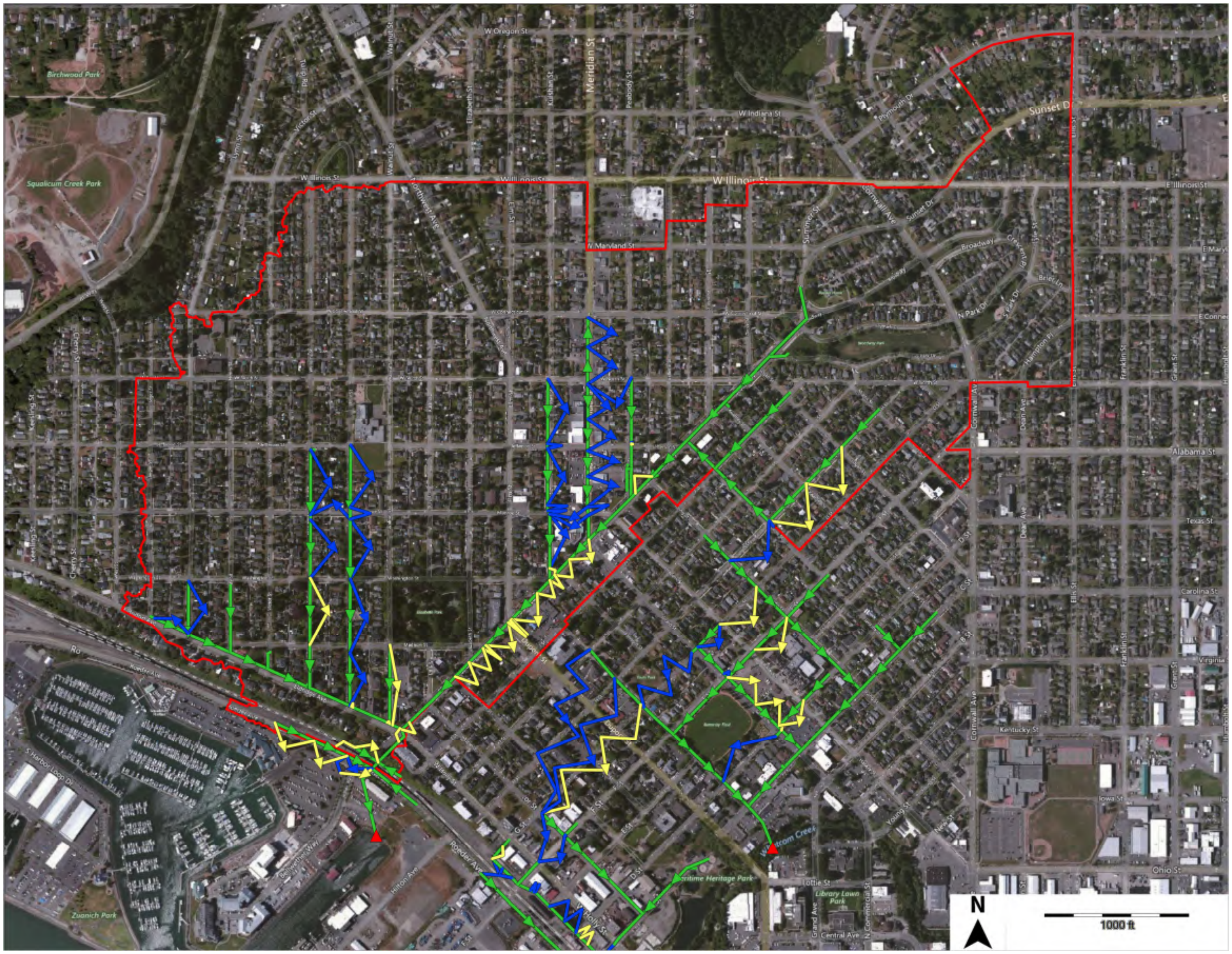

Figure A3. Schematic diagram showing the Broadway drainage network (green), active overflow paths (blue), and inactive overflow paths (yellow) during the 25-year flood event under full build-out land-use conditions. Overflow path locations are intended to be schematic only and do not indicate actual flowpaths. Drainage boundary is shown in red. The Broadway system outfall is shown as a red triangle. Note the active overflow path into the Ellsworth system.

CEDAR SYSTEM

Figure A4. Schematic diagram showing the Cedar drainage network (green), active overflow paths (blue), and inactive overflow paths (yellow) during the 25-year flood event under full build-out land-use conditions. Overflow path locations are intended to be schematic only and do not indicate actual flowpaths. Drainage boundary is shown in red. The Cedar system outfall is shown as a red triangle.

C STREET SYSTEM

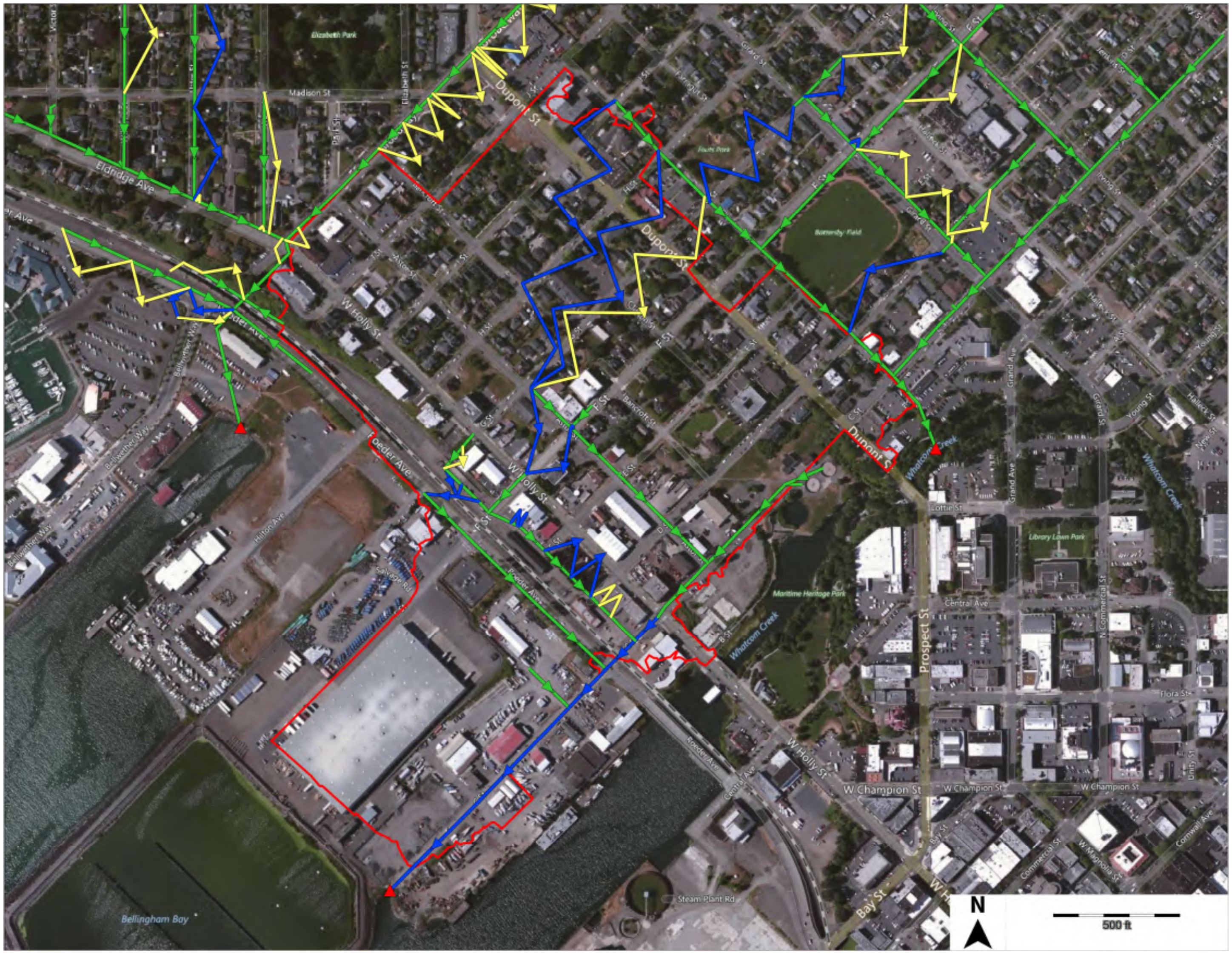

Figure A5. Schematic diagram showing the C Street drainage network (green), active overflow paths (blue), and inactive overflow paths (yellow) during the 25-year flood event under full build-out land-use conditions. Overflow path locations are intended to be schematic only and do not indicate actual flowpaths. Drainage boundary is shown in red. The C Street system outfall is shown as a red triangle. Note the active overflow path into the C Street system from the Ellsworth system.

Ellsworth System

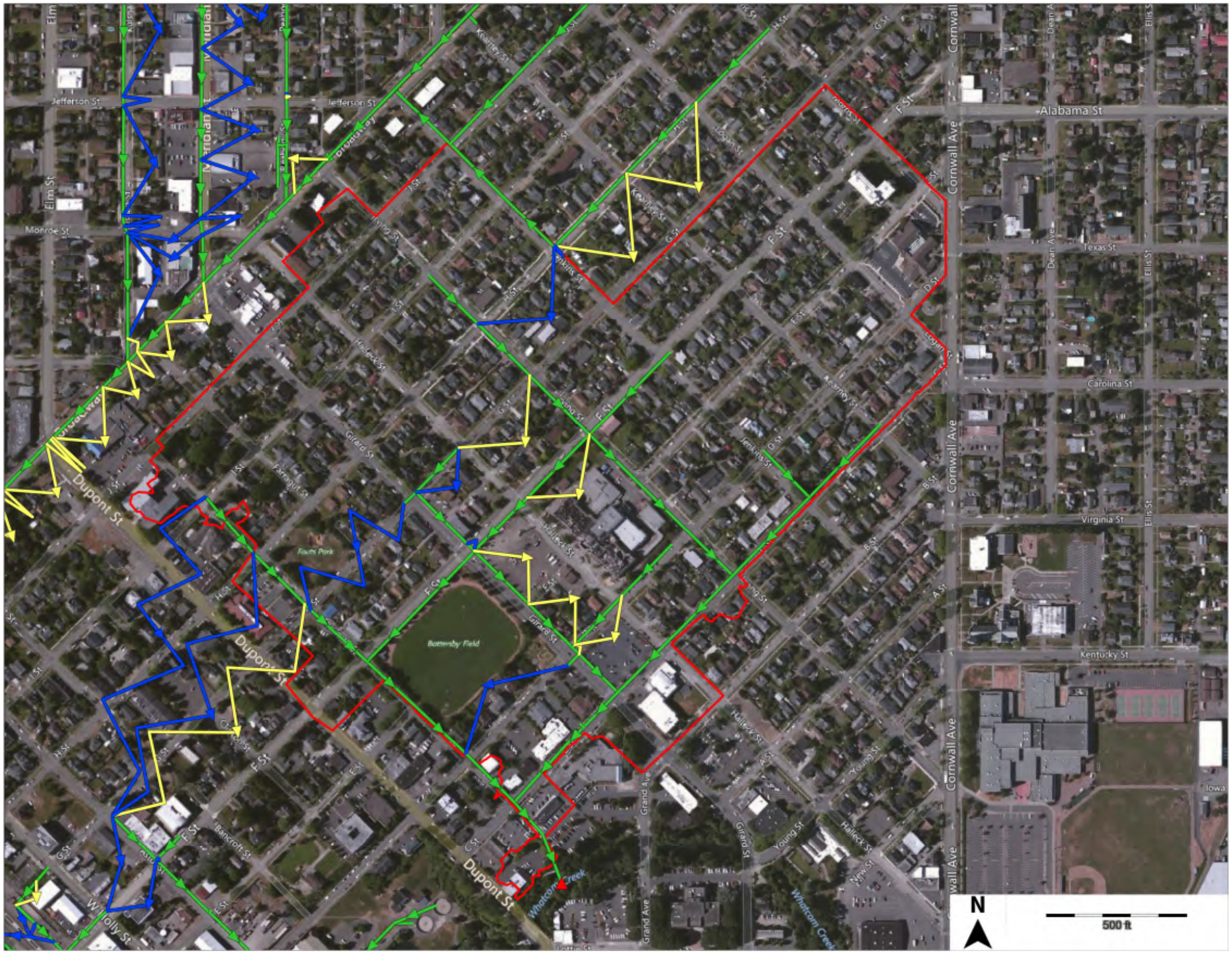

Figure A6. Schematic diagram showing the Ellsworth drainage network (green), active overflow paths (blue), and inactive overflow paths (yellow) during the 25-year flood event under full build-out land-use conditions. Overflow path locations are intended to be schematic only and do not indicate actual flowpaths. Drainage boundary is shown in red. The Ellsworth system outfall is shown as a red triangle. Note the active overflow path into the Ellsworth system from the Broadway system to the north, and the active overflow path from the Ellsworth system into the C Street system to the southwest.

LAUREL SYSTEM

Figure A7. Schematic diagram showing the Laurel drainage network (green), active overflow paths (blue), and inactive overflow paths (yellow) during the 25-year flood event under full build-out land-use conditions. Overflow path locations are intended to be schematic only and do not indicate actual flowpaths. Drainage boundary is shown in red. The two Laurel system outfalls are shown as red triangles.

OLIVE SYSTEM

Figure A8. Schematic diagram showing the Olive drainage network (green) during the 25-year flood event under full build-out land-use conditions. The only overflow path identified in the Olive system is not shown; it is immediately upstream of the outfall. Drainage boundary is shown in red. The Olive system outfall is shown as a red triangle.

Willow System

Figure A9. Schematic diagram showing the Willow drainage network (green), active overflow paths (blue), and inactive overflow paths (yellow) during the 25-year flood event under full build-out land-use conditions. Overflow path locations are intended to be schematic only and do not indicate actual flowpaths. Drainage boundary is shown in red. The Willow system outfall is shown as a red triangle.

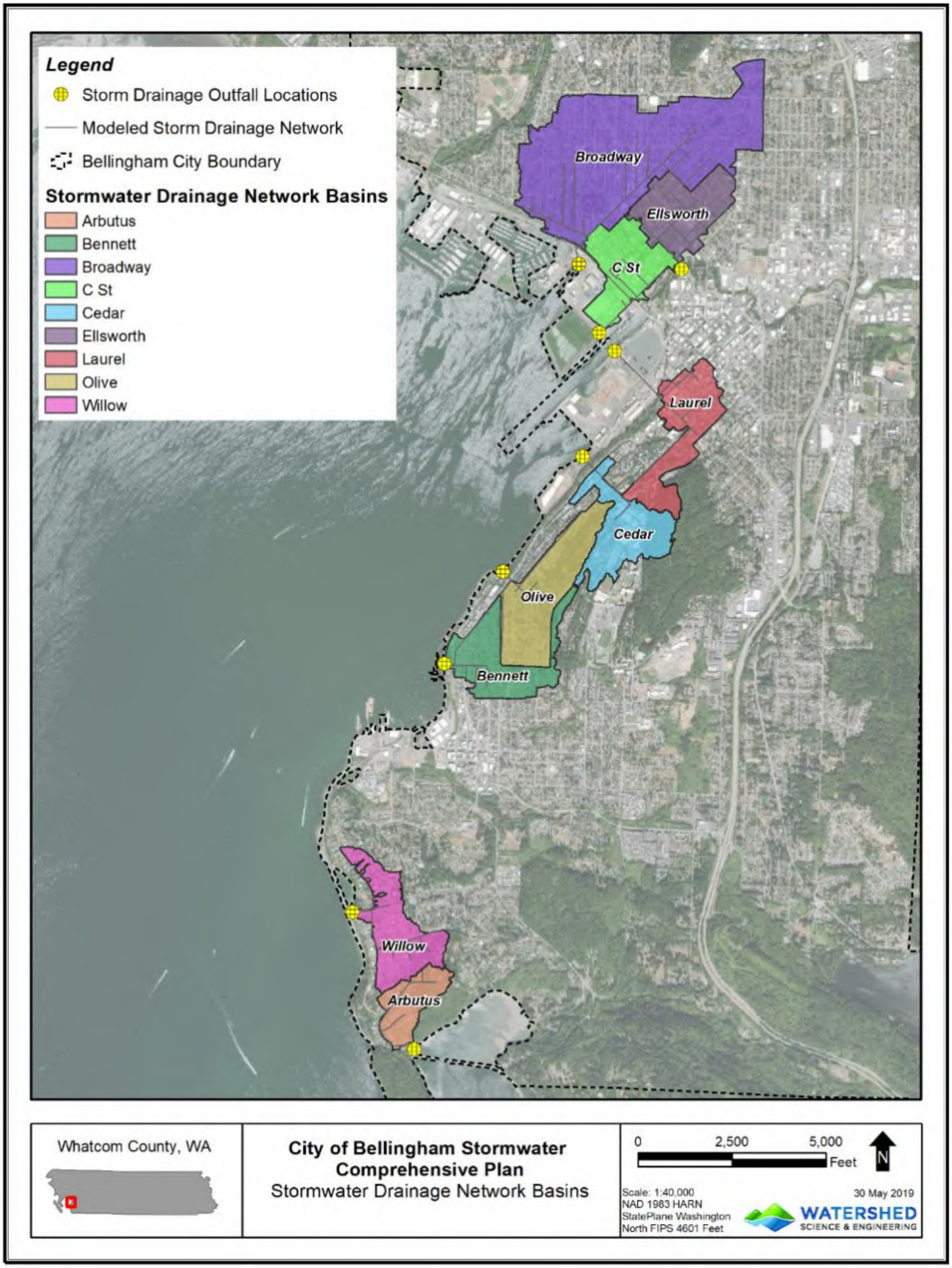

Figure 1. Location map of the nine marine outfall basins.

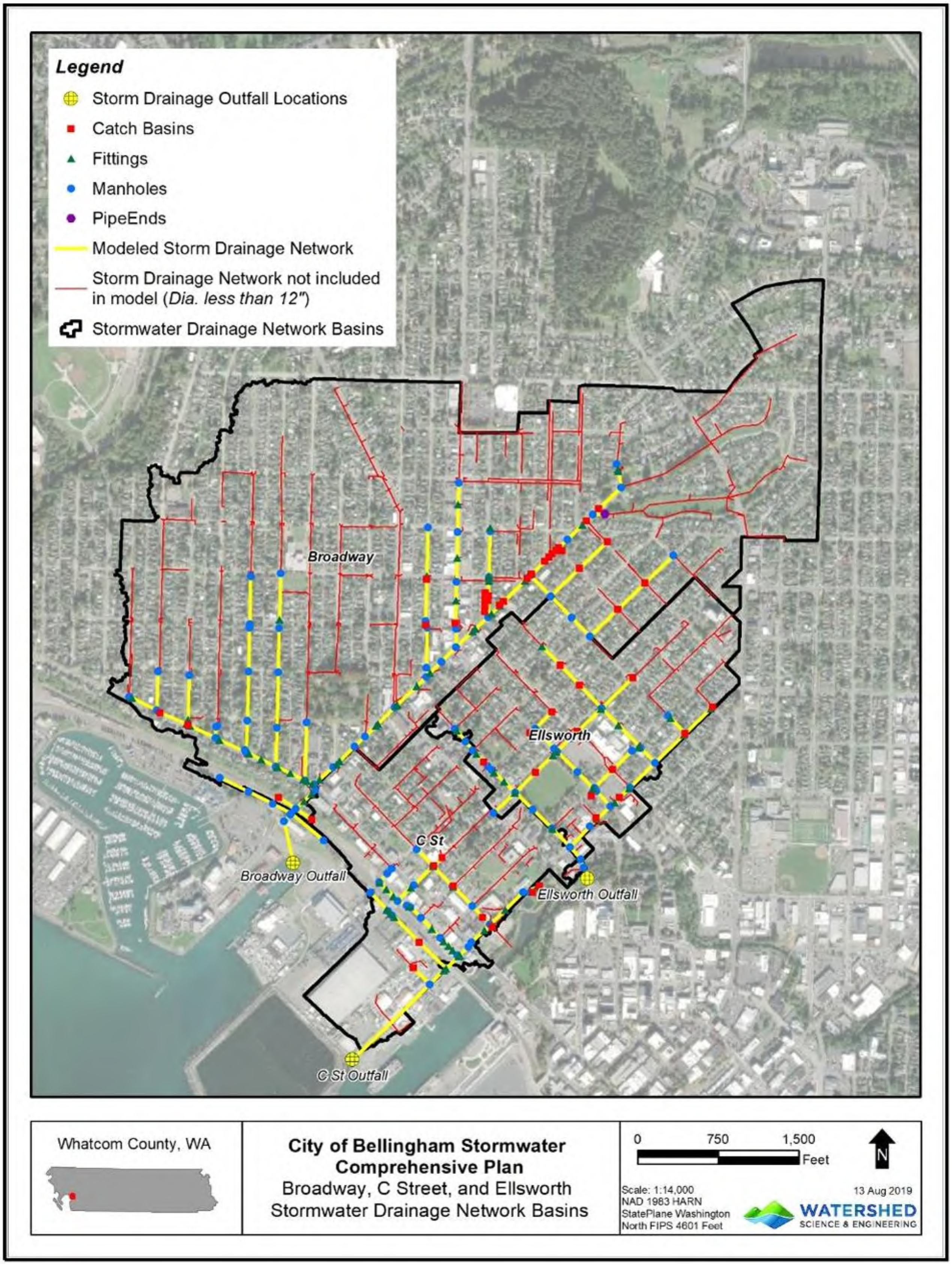

Figure 2. Broadway, C Street, and Ellsworth storm drainage network and sub-basins.

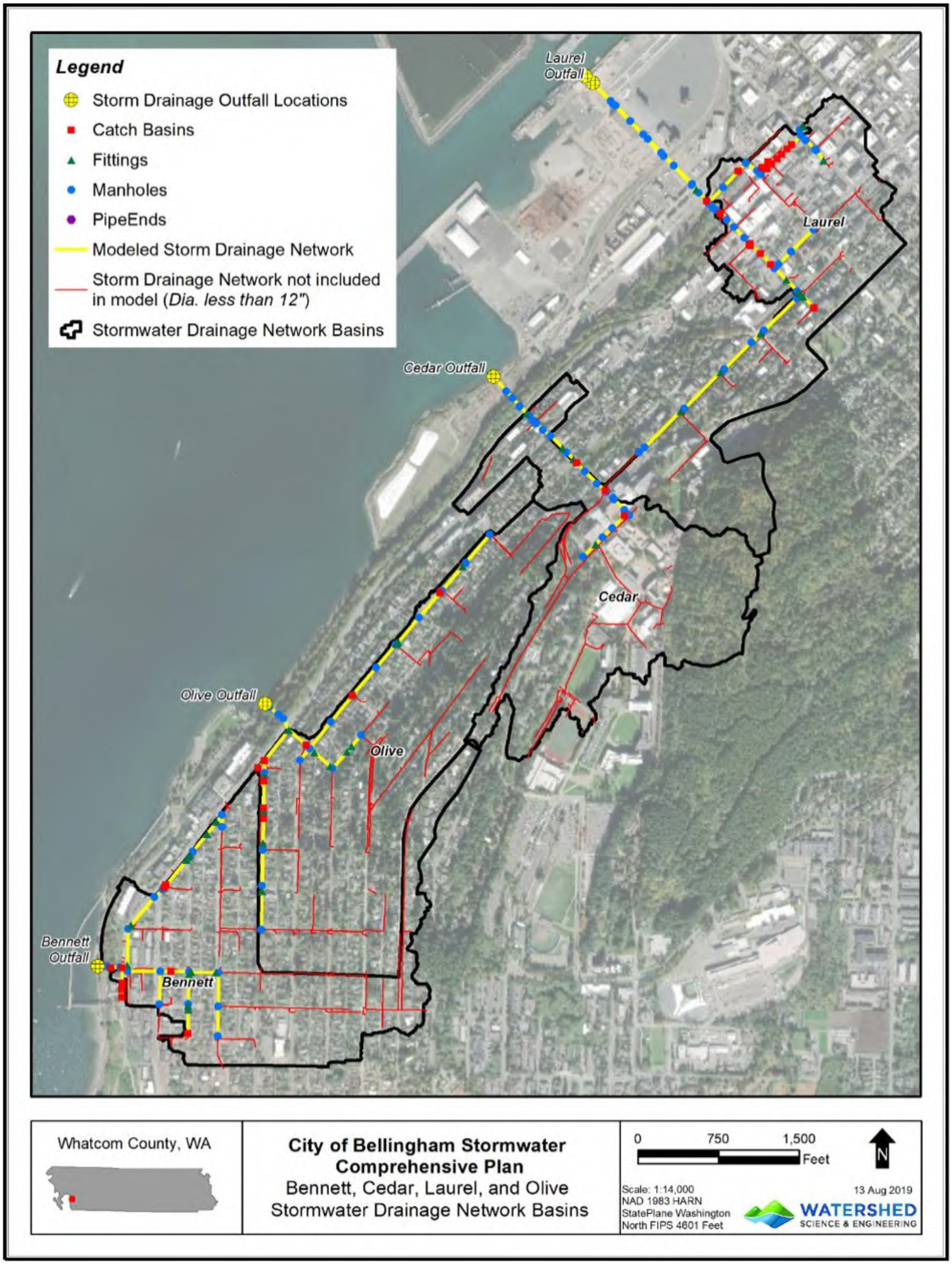

Figure 3. Bennett, Cedar, Laurel, and Olive storm drainage network and sub-basins.

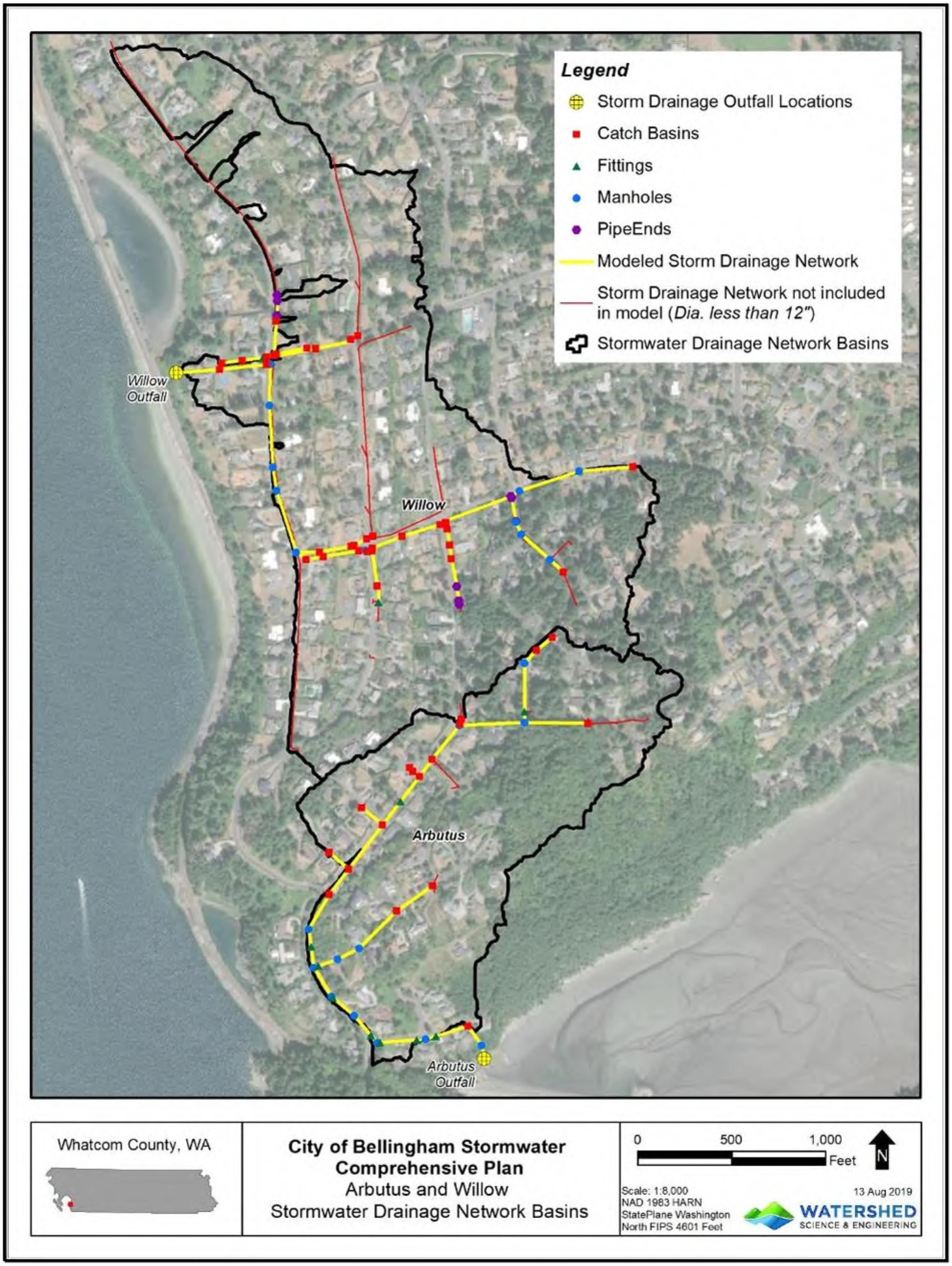

Figure 4. Arbutus and Willow storm drainage network and sub-basins

Land-use analyses were conducted for two development scenarios -- existing conditions and full build-out to the current zoned density. For the existing conditions scenario, the land-use analysis used the City's zoning map as a starting point for land-use types in each basin. These were then modified to reflect differences between the zoning and the actual current land-use (e.g. areas zoned as multi-family residential but currently containing single-family homes were reclassified as single family residential and areas not presently developed were reclassified as forest) based on 2018 aerial imagery and 2018 Google Street View imagery (where available). For the full build-out scenario the land-use was assumed to match current City zoning. The City's zoning classifications were grouped into seven general categories by combining classifications with similar ratios of pervious and impervious land cover as shown in Table 1. Figure 5 summarizes the results of the land-use analysis.

The relative percentages of land cover type (effective impervious area, lawn, or forest) for each land-use category were determined based on WSE's engineering judgement and in accordance with previous detailed hydrologic model studies in this region (Snohomish Co., 2002). The percentage effective impervious area (EIA) used in this study ranges from 18% for existing conditions single-family residential to 90% for full build-out commercial/industrial. For residential, commercial, and industrial land-use areas, the percentage EIA increases from existing conditions to full build-out conditions to reflect future infill of undeveloped parcels and potentially higher density redevelopment. Institutional and public parcels are assumed to have similar EIA percentages in both the existing and full build-out scenarios. Table 2 shows the land-use by category for each basin for existing and full build-out conditions and Table 3 shows estimated total effective impervious area by basin and the projected percent increase from existing conditions.

Table 1. Assumed impervious and pervious land cover percentages based on land-use/zoning

	Existing Conditions Land Cover			Full Build-Out Land Cover		
Land-Use Category (Zoning Classifications)	Effective Impervious (%)	Lawn (%)	Forest (%)	Effective Impervious (%)	Lawn (%)	Forest (%)
Single Family Residential (Low & Medium Density)	18	82	0	28	72	0
Multi-Family Residential (Medium & High Density), Urban Village Residential Transition 1 & 2	66.5	33.5	0	75	25	0
Commercial, Industrial, Urban Village Commercial Core, Urban Village Commercial Transition	85.5	14.5	0	90	10	0
Institutional	34	33	33	34	33	33
Public - Park	0	50	50	0	50	50
Public - School/Church	50	50	0	50	50	0
Undeveloped Forest	0	0	100	NA	NA	NA

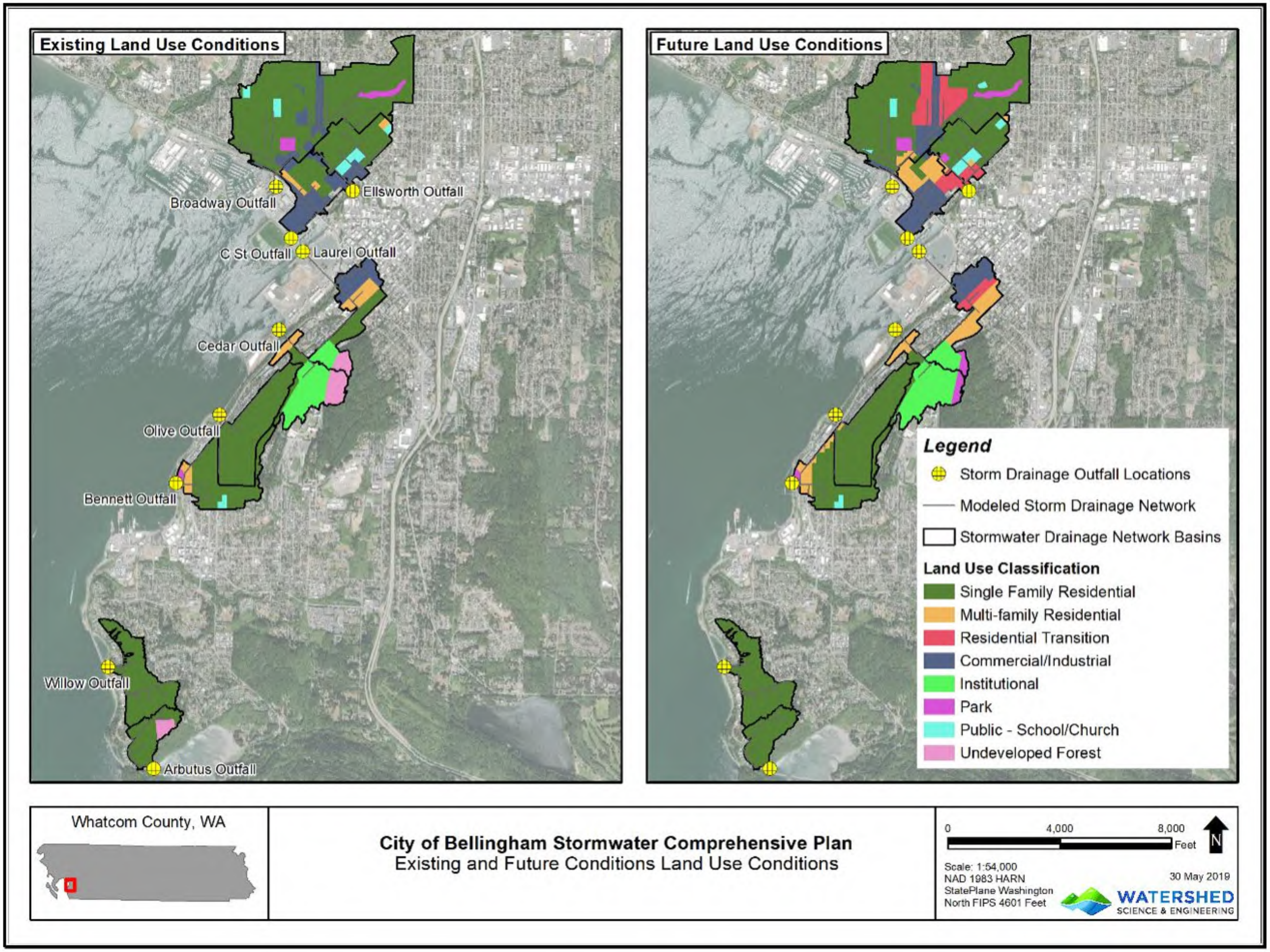

Figure 5. Existing and future full build-out conditions land-use.

Table 2. Summary of Existing and Future land-use

	Basin	SFR (ac)	MFR, Urban Village Residential Transition (ac)	Commerical, Industrial (ac)	Institutional (ac)	Public, Park (ac)	School, Church (ac)	Forest (ac)
Existing	Arbutus	43.7	0.0	0.0	0.0	0.0	0.0	8.6
	Bennett	77.9	8.8	0.0	0.0	2.6	3.1	0.0
	Broadway	338.2	0.6	34.3	0.0	13.9	6.7	0.0
	Cedar	12.5	9.5	0.0	52.1	0.0	0.0	19.3
	C St	28.7	6.4	52.5	0.0	0.0	0.0	0.0
	Ellsworth	66.0	2.1	12.8	0.0	0.0	12.6	0.0
	Laurel	26.8	15.6	30.9	14.5	0.0	0.0	10.0
	Olive	125.0	0.0	0.0	0.0	0.0	0.0	0.0
	Willow	97.7	0.0	0.0	0.0	0.0	0.0	0.0
Full Build Out	Arbutus	52.3	0.0	0.0	0.0	0.0	0.0	0.0
	Bennett	70.3	16.1	0.3	0.0	2.6	3.1	0.0
	Broadway	283.1	55.7	34.1	0.0	14.2	6.6	0.0
	Cedar	10.4	10.7	0.0	64.8	7.3	0.3	0.0
	C St	6.1	37.3	44.3	0.0	0.0	0.0	0.0
	Ellsworth	64.5	13.3	1.3	0.0	1.6	12.8	0.0
	Laurel	0.0	44.2	29.2	19.2	5.3	0.0	0.0
	Olive	123.7	1.3	0.0	0.0	0.0	0.0	0.0
	Willow	97.7	0.0	0.0	0.0	0.0	0.0	0.0

Table 3. Effective impervious areas by basin for existing and full build-out land-use scenarios

Basin Name	Area (AC)	Existing Conditions Percent Effective Impervious	Full Build-Out Percent Effective Impervious	Change from Existing
Arbutus	52.3	15%	28%	+13%
Bennett	92.4	23%	36%	+13%
Broadway	393.7	24%	39%	+15%
Cedar	93.5	28%	35%	+7%
C St.	87.7	62%	79%	+17%
Ellsworth	93.5	33%	38%	+5%
Laurel	97.9	48%	67%	+19%
Olive	125.0	18%	29%	+11%
Willow	97.7	18%	28%	+10%

The amount of effective impervious area is very important for hydrologic modeling, yet estimation of EIA is subject to considerable judgement. For example, the EIA percentage used in this study for single family residential development in existing conditions (18%) or full build-out conditions (28%) was assumed to be substantially lower than the 70% maximum total impervious area that is allowed by current City zoning codes for residential redevelopment (personal communication with Chad Schulhauser, City Engineer). When considering EIA assumptions used in the modeling it is important to first understand the terminology being used. The two main terms used to describe imperviousness are Total Impervious Area (TIA) and Effective Impervious Area (EIA). As the name implies, total impervious area is the total amount of impervious surface (roofs, driveways, sidewalks, paved paths, etc.) as a percentage of the gross parcel area. Effective impervious area, on the other hand, attempts to quantify the portion of the TIA that is directly (or effectively) connected to the storm drainage system. This is typically done by adjusting the TIA based on a percent effective multiplier. This multiplier accounts for a range of factors that reduce EIA including things such as roof downspouts draining onto splash blocks or lawns, dry wells or other onsite detention, areas such as paths or driveways not effectively connected to storm drains, stormwater discharge to rain gardens or other low impact development (LID) facilities, subdivision-scale detention facilities, and any other feature that "disconnects" or delays runoff from impervious surfaces from directly entering the stormwater conveyance system. Areas not effectively connected to the storm drainage system are assumed to perform hydrologically more similar to grass than to impervious surfaces (i.e. with a delayed response and lower peak runoff).

Accurately estimating EIA for full build-out conditions is further complicated by many factors including the amount of redevelopment that will actually occur, the density of development, whether redevelopment takes place on a site by site basis or at a subdivision scale, the level of LID implemented, the City stormwater standards in place at the time of redevelopment, and numerous other factors. Since one can never be sure of any of these factors the goal of the selection of percent EIA becomes to provide a reasonable estimate consistent with the objectives of the analysis. The EIA percentages used in this analysis (Table 1) are consistent with WSE's engineering judgement and past practice including modeling done previously for Snohomish County and other local jurisdictions.

Soils data used in this study were obtained from the Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO). SSURGO soils are classified by hydrologic soil group (B, C, D), and these classifications were used when importing to WWHM. Ground surface slopes were calculated using the 2013 City of Bellingham LiDAR ground surface elevation. ArcGIS was used to create polygons for each unique combination of sub-basin, land-use type, soil type, and ground surface slope. These data were then summed for each sub-basin and percentages of pervious and impervious land cover in Table 1 were applied to determine the acreage of impervious surface and the acreage of each pervious land type in each sub-basin. WWHM utilizes the user-defined project location to create a local long-term precipitation record by scaling precipitation from the closest long-term gage (in Blaine, WA). For Bellingham the factor of 0.857 is used, which corresponds to the ratio of 24-hour 25-year precipitation rate at the project and long-term gage locations.

HYDROLOGIC MODEL RESULTS

Flow frequency analysis was performed on the WWHM simulated annual maximum 15-minute flows for each sub-basin for the period of record (1948-2012). Table 4 shows the simulated flow quantiles for each basin for the two land-use scenarios and the percent increase from existing to full build-out conditions.

DESIGN STORM HYDROGRAPH DEVELOPMENT

Design storm inflow hydrographs for the hydraulic modeling were created by selecting a simulated historical storm event hydrograph ("pattern" storm) from the long term WWHM generated flow record and then scaling the pattern event flows such that the maximum event flow matched the flow quantile of the corresponding design storm (e.g. 2-, 10-, 25-, 100-year). Design storm inflow hydrographs were developed for the 23 sub-basins for the 2-, 10-, 25-, and 100-year storm events for both the existing and full build-out land-use scenarios (total 184 hydrographs) using the following procedure:

1. *Flood frequency analysis* – for each basin, flow frequency analyses were performed at multiple durations (15-minutes, 1-hour, 3-hours, 6-hours, and 24-hours) to determine flow quantiles (2-, 10-, 25-, and 100-year) for each duration.
2. *Identify candidate pattern storms* – for each basin, a historical event with simulated runoff at the 15-minute, 1-hour, 3-hour, and 6-hour time windows closely matching the corresponding event target quantiles was selected. An ideal pattern storm would have flows matching the target flow quantiles at all durations.
3. *Select pattern storm* – because no actual storm matches the computed flow quantiles at all durations, engineering judgement was needed to select a pattern storm that best matched the flow frequency data across the broadest range of durations. For each design event, a pattern storm was selected for each basin.
4. *Determine scaling factor* – The selected pattern storm was then scaled to match the corresponding target flow quantiles. The scaling factor was determined by dividing the 15-minute quantile from step 1 by the pattern storm (selected in step 3) simulated peak flow. Unique scaling factors were thus determined for each basin for each design event
5. *Scale pattern storm to develop design storm hydrograph* – pattern storm hydrographs for each of the 23 sub-basins were multiplied by the scaling factors determined in step 4 to develop design storm hydrographs for input into the hydraulic model. A total of 184 hydrographs were developed to simulate the four design flood events (2-, 10-, 25-, 100-year) for existing and full build-out conditions.

Table 4. Peak simulated flow from each basin.

Basin Name	2-year Event			10-year Event			25-year Event			100-year Event		
	Existing Conditions Runoff (cfs)	Full Build-Out Runoff (cfs)	Change	Existing Conditions Runoff (cfs)	Full Build-Out Runoff (cfs)	Change	Existing Conditions Runoff (cfs)	Full Build-Out Runoff (cfs)	Change	Existing Conditions Runoff (cfs)	Full Build-Out Runoff (cfs)	Change
Arbutus	5	7	+2	9	13	+4	11	16	+5	16	21	+5
Bennett	9	14	+5	15	23	+8	19	27	+8	24	34	+10
Broadway	45	65	+20	82	109	+27	103	132	+29	136	169	+33
Cedar	11	14	+3	18	23	+5	21	28	+7	26	35	+9
C St.	21	26	+5	35	42	+7	42	50	+8	53	63	+10
Ellsworth	14	16	+2	25	27	+2	32	34	+2	41	43	+2
Laurel	18	26	+8	30	42	+12	35	50	+15	44	63	+19
Olive	10	16	+6	18	26	+8	22	32	+10	30	40	+10
Willow	8	12	+4	14	20	+6	17	24	+7	23	30	+7

HYDRAULIC MODELING

The Environmental Protection Agency's EPA SWMM model (version 5.1.012) was used to model the marine outfall drainage networks. The models were build using the PCSWMM software package (version 7.2.2780). The SWMM model was run for the 2-, 10-, 25-, and 100-year flood events for both existing and full build-out land-use conditions.

GIS PREPROCESSING

GIS layers depicting the stormwater drainage network conduits and nodes were provided to WSE by the City. A line shapefile depicting conduits also contained information specifying the pipe diameter, material type, and upstream and downstream nodes. Point shapefiles depicting nodes (manholes, catch basins, fittings and pipe ends) included node identification and measure down depth. Only one measure down depth was specified per node and the layer attributes did not specify the corresponding pipe inlet/outlet, so for each node the pipe inlet(s) and outlet(s) were assumed to be at the same elevation. To calculate the pipe invert elevation for each node, the measure down depth was subtracted from the 2013 LiDAR ground surface elevation (NAVD88 vertical datum) at the location of the node. Pipes with diameter less than 12-inches were excluded from further analysis.

WSE reviewed the City GIS layers and identified missing data (pipe diameter, pipe material type, measure down depth) and potentially incorrect data (adverse conduit slopes or downstream reduction in conduit diameter). City staff revisited most locations with missing/incorrect data to update/verify the data. For sites not visited by the City, the City provided as-built design plans showing invert elevations and conduit material type.

For each of the marine outfall systems the actual outfall elevation at Bellingham Bay was required for input to the model. Surveyed invert elevations were provided by the City for the Broadway, Cedar, and Olive Street marine outfalls. For other locations the outfall elevation was obtained from as-built or design plans, or from LiDAR ground elevations. Table 5 summarizes the data sources used for outfall elevations.

Table 5. Marine outfall invert elevations

Basin Name	Marine Outfall Invert Elevation (ft, NAVD88)	Elevation Source
Arbutus	14.53	As-built plans
Bennett	4.45	LiDAR minus measure-down
Broadway	4.56	City Survey
Cedar	7.82	City Survey
C St.	3.13	Lidar minus measure-down
Ellsworth	36.32	LiDAR
Laurel	1.40	Design plans
Olive	7.99	City Survey
Willow	34.38	LiDAR

Pipe entrance and exit losses were assigned according to guidance in the Federal Highway Administration's Urban Drainage Design Manual (Federal Highway Administration, 1996). Pipe exit losses vary due to the pipe's intersection angle with the next pipe downstream. The pipe intersection angle was calculated in ArcGIS and exit losses were assigned prior to importing into PCSWMM.

SWMM MODEL DEVELOPMENT

The updated conduit and node GIS layers were imported directly into PCSWMM to create the SWMM model. In the SWMM model, each node (manhole, catch basin, pipe end, and junction) is identified by a unique identification number provided by the City. Pipe segments in the model were assigned arbitrary identification codes because unique identification codes were not included in the City's database.

Inflow locations (a total of 116) were defined at the upstream-most node of each drainage branch and at nodes where significant additional inflow to the modeled system would occur (i.e. where significant side drainage systems meet the modeled drainage network). Inflow hydrographs in the model were created by apportioning the design storm hydrographs developed as described above based on the contributing area to that node as a percentage of the entire sub-basin area.

Six of the marine outfalls (Bennett, Broadway, Cedar, C St., Laurel and Olive) are influenced by tidal water levels. The other three outfalls (Arbutus, Ellsworth, and Willow) are at higher elevation and have free flowing downstream boundary conditions. The downstream boundary water surface elevation for the tidal outfalls were set at a constant elevation corresponding the mean higher high water (MHHW) tide level (8.03 feet NAVD88). MHHW provides a relatively conservative estimate of the tide level as it assumes that high tide corresponds with the peak of the flow hydrograph. This approach is what is used by FEMA when evaluating systems with tidally influenced tailwater conditions.

Pipe roughness values were assigned based on the pipe material. A Manning's roughness value of 0.011 was assigned for concrete (CON) and PVC pipes, 0.013 for ductile iron (DI), 0.014 for vitreous clay (VIT), 0.020 for corrugated polyethylene pipes (CPP), and 0.024 for corrugated metal pipes (CMP) based on Chow (1959).

Secondary overflow conduits were added to the SWMM model as necessary at locations where storm flows could overflow at one node and subsequently re-enter the conveyance system at a downstream node (note that the representation of overflow conduits in the SWMM model is schematic only and does not attempt to define a specific flowpath between nodes). Overflow conduits were added to all model nodes that flood during the largest modeled flood event (the 100-year full build-out scenario). The location of reentry of each overflow conduit was determined by analyzing the local ground surface elevations and the drainage network map. Generally, the drainage network is oriented in the direction of maximum slope, so that surface overflow exiting one node would flow (in a gutter or roadside ditch) to the next node downstream. However, in some locations the drainage network is oriented transverse to the slope, so overflows would follow the topography and enter a different branch in the same basin (i.e. Meridian Street to Kulshan Street, both within the Broadway basin) or into a different drainage basin entirely (i.e. Ellsworth Street in Ellsworth basin to Astor Street in C Street basin). To address these inter-basin transfers, WSE developed a single, comprehensive SWMM model encompassing all nine marine outfall basins instead of nine independent models. Also note that in some locations the topography indicates that surface overflows would exit the modeled system entirely. Flow that leaves the modeled system was not evaluated any further although the volume of flow leaving was computed in SWMM.

Storage nodes were added to the SWMM model to represent areas where significant surface ponding might occur based on the surrounding topography. As opposed to the overflow conduits described above, locations of surface ponding are assumed to reenter the drainage system at the same location, once flood water levels have receded to the elevation of the catch basin inlet. In total, 15 storage nodes were defined in all basins, with the majority (nine) of the storage nodes in the Broadway basin. A stage-storage curve for each ponding area was developed in PCSWMM using topographic data.

HYDRAULIC MODEL RESULTS

The hydraulic model was run for eight scenarios – the 2-, 10-, 25-, and 100-year flood events for both existing and full build-out conditions. Flooding, defined as water above the rim elevation of any model node, occurs during each of the simulated events. Table 6 summarizes the number of locations with flooding for each simulated design event. The number of flooding location includes all active overflow paths, flooded storage nodes, and flooded nodes with flow leaving the modeled system. The results show that the Broadway system is most prone to flooding, likely due to the low topographic gradient and prevalence of old and undersized pipes. WSE's analysis shows that one location in particular, the drainage conduit under Meridian Street, floods in each of the simulated events.

Table 6. Number of flooding locations during each modeled flood event.

Basin Name	Number of Flooding Locations During Existing Conditions				Number of Flooding Locations During Full Build-Out Scenario			
	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year
Arbutus	0	0	0	1	0	1	1	4
Bennett	0	0	0	0	0	0	0	0
Broadway	5	14	21	38	8	23	33	60
Cedar	0	0	0	1	0	0	0	5
C St	0	1	5	13	0	5	11	13
Ellsworth	0	0	3	13	0	0	4	14
Laurel	0	4	4	5	0	10	11	13
Olive	0	0	0	0	0	1	1	3
Willow	0	1	1	4	0	4	4	7
Interbasin Overflow Paths	**Number of Active Overflow Paths During Existing Conditions**				**Number of Active Overflow Paths During Full Build-Out Scenario**			
Broadway to Ellsworth	0	0	0	1	0	0	1	1
Ellsworth to C St	0	0	2	2	0	1	2	3

Discussion of 25-Year Flood with Full Build-out Model Results

The City's criteria for identifying drainage system capacity problems is based on the full build-out 25-year flood. Therefore, the discussion below focuses on results from that scenario, which shows flooding in seven of the nine marine outfall system. Details of flooding in each system are provided below. There is no simulated flooding in the Bennett or Cedar basins during this event.

Arbutus

Flooding in the Arbutus network is limited to one model node (7214NE-78) at the intersection of Fieldston Road and Clarkwood Drive. Flooding from this node would flow south along Fieldston Road and re-enter the system at the next catch basin downstream. Flooding at this location is likely due to the increase in pipe roughness at node 7214NE-78, which has a 12-inch concrete pipe upstream (n=0.011) and a 12-inch corrugated metal pipe (n=0.024) downstream.

Broadway

The Broadway basin has more extensive flooding than any other basin, with flooding from the drainage branches beneath Meridian Street, Peabody Street, Kulshan Street, Utter Street, Lynn Street, and H Street. Figure 6 provides a schematic showing active overflow paths during the 25-year flood[1]. The most significant flooding is along the Meridian Street drainage line. Surface flooding flows south along Meridian Street to Monroe Street, then west to a topographic depression at the intersection of Monroe Street and Kulshan Street. A storage node at manhole 8224SE-360 simulates ponding at this intersection, with flood flows overflowing south along Kulshan Street to the main drainage line beneath Broadway once the storage area fills. Surface flooding along the Utter Street drainage line splits at Monroe Street, with some flow continuing south along Utter Street and a portion of the flow traveling west along Monroe Street to Williams Street. This contributes to the flooding along Williams Street. Surface flooding along the Lynn Street drainage line flows west after intersecting Eldridge Avenue. A storage basin at node 8225NW-42 simulates ponding on the north side of Eldridge Avenue at the intersection with Jaeger Street. Once this storage basin fills, overflows cross south over Eldridge Avenue and flow downhill out of the basin and out of the study area. Surface flooding at the intersection of H Street and Jenkins Street would also flow out of the Broadway basin, but these overflows would flow southwest along H Street into the Ellsworth basin.

C Street

In the C Street basin, flooding along Astor Street would flow down F Street and enter catch basins at the intersection of F Street and Holly Street. Several model nodes flood along the drainage line between Holly Street and the railroad. Some ponding would occur between the railroad and Holly Street northwest of F Street, and some flow would cross the railroad then northwest along Roeder Avenue toward Hilton Avenue and out of the C Street basin.

[1] Similar figures for other basins are provided in Appendix A.

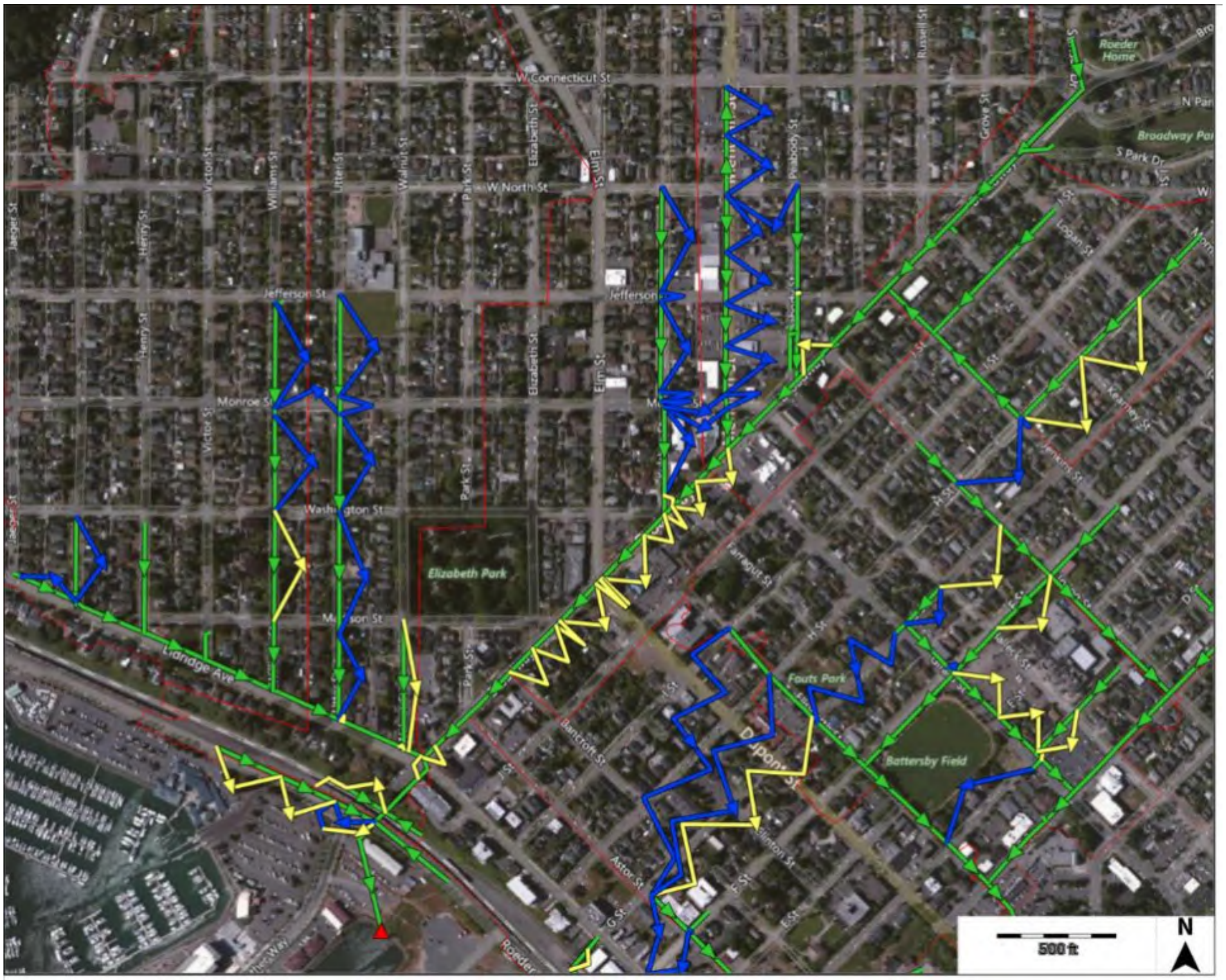

Figure 6. Schematic diagram showing the Broadway drainage network (green), active overflow paths (blue), and inactive overflow paths (yellow) during the 25-year flood event under full build-out land-use conditions. Overflow path locations are intended to be schematic only and do not indicate actual flowpaths. The Broadway system outfall is shown as a red triangle.

Ellsworth

In the Ellsworth basin, simulations show flooding at several locations under the 25-year full build-out design flood. Catch basin 8330NW-37 at the intersection of Halleck Street and G Street would flood with overflows traveling southwest along G Street to the intersection with Girard Street. Overflows would enter the catch basins connected to model node 8330NW-50, but due to limited capacity in the drainage network under Girard Street, flow would overflow from the catch basin 8330NW-60 on the south side of Girard Street which has a lower rim elevation than the catch basins on the north side of Girard. This flow would continue traveling southwest on G Street until reaching Ellsworth Street and entering the main trunk line. Flooding also occurs at the intersections of Girard and F Streets and Girard and D Streets. The intersection of Girard Street and D Street is a topographic low, and ponding is simulated by a storage node 8330NW-105A. Similar to the situation at the intersection of Girard and G Streets, catch basin 8330NW-118 on the south side of Girard Street has a lower rim elevation than catch basins on the north, and would flood due to limited capacity in the Girard Street drainage line. Limited capacity in the Ellsworth street drainage line would result in overflows near I and H Streets that would flow southwest out of the Ellsworth system and into the C Street basin.

Laurel

In the Laurel Basin, all nodes along N Forest Street would overflow and flow down to the intersection with Laurel Street. Node 8330SW-407 on East Maple Street would flood and overflows would travel southwest along the alleyway before draining down the slope towards Cornwall Avenue and out of the basin. Nodes 8330SW-442, 8330SW-439, and 8330SW-521 at the base of the hill southeast of Cornwall Avenue would all overflow into the low area between the hillside and the rail yard. Node 8331NW-310 would overflow and travel NW down E Laurel St.

Olive

The only modeled flooding in the Olive basin occurs at manhole 8236SW-25 east of the railroad, immediately upstream from the marine outfall. The pipe segment downstream of the manhole has lower slope and thus lower capacity than the upstream segments. Simulated flooding at this manhole is minimal – during the 25-year full build-out event the model indicates this manhole floods for only 6 minutes with a peak overflow discharge of about 0.6 cfs.

Willow

In the Willow basin, flooding is limited to the roadside ditch on the east side of Bayside Road. The upstream most node to flood is 7211SE-20 at the intersection of Bayside and Linden Road. Overflow would travel down the east side of Bayside road until it enters the culvert at node 7211SE-10.

FLOOD REDUCTION ALTERNATIVES

The preceding section describes locations of flooding for the 25-year full build-out design event. Following the identification of flooding locations the SWMM model was used to determine conveyance system improvements needed to eliminate this flooding. In some locations, it was obvious that an undersized pipe or series of pipes was the cause of flooding, and upsizing these pipes eliminated the flooding. In other locations, flooding was more complex resulting in several potential alternatives – for example, upsizing one or more pipes right near the location of flooding versus increasing pipe sizes in the trunk line downstream of the flooding location. The approach used to develop flood reduction alternatives, and the recommended alternatives are described below.

APPROACH

To minimize the cost of the proposed improvements, WSE sought solutions that required replacing the shortest total length of pipe. In some instances, however, several different alternatives were identified to achieve the desired level of flood reduction. In these cases, two alternatives are presented.

When testing pipe upsizing alternatives, the invert elevations for upsized pipes were kept at the existing invert elevations except in instances where the new pipe would have less than one foot of cover over the pipe crown to the ground surface at either end of the pipe. In these cases the invert elevations for the new pipe were lowered such that there would be at least one-foot of cover. If the cover was between 1 and 2 feet, then ductile iron pipe material was specified. Concrete pipe was recommended for all pipes with more than 2 feet of cover. The alternatives analysis assumed that replacement pipes would have one of the following diameters: 12-, 15-, 18-, 21-, 24-, 30-, 36-, 42-, 48-, or 54- inches.

SUMMARY OF RESULTS

Table 7 summarizes WSE's recommended alternatives to eliminate flooding for the 25-year design flood event with full build-out land-use. Brief discussions of the solution alternatives are provided below:

Arbutus

Within the Arbutus basin, one node (7214NE-78) floods during the 25-year flood event; two alternatives are presented to eliminate this flooding. Alternative 1 replaces the existing 12-inch CMP pipe with a 12-inch concrete pipe. The reduction in roughness between these two pipe materials is sufficient to eliminate flooding at this location. If the City prefers to also increase the pipe size, alternative 2 recommends installing a 15-inch concrete pipe.

Broadway

Flooding within the Broadway basin is extensive, with flooding along both the Broadway branch and Eldridge branch of the drainage network. To eliminate flooding along the Broadway branch (Meridian, Kulshan, and Peabody Streets), WSE identified 49 pipe segments that need to be enlarged (total length 6575 feet). These modifications also act to reduce water levels upstream in the drainage network and eliminate the inter-basin flooding from node 8319SW-305 (at the intersection of H and Jenkins Streets) to the Ellsworth basin. Ductile iron is recommended for some of the replacement pipes because they have less than 2 feet of ground cover above the pipe crown. To eliminate flooding along the Eldridge branch, two alternatives are presented. Alternative 1 recommends more significant modifications to the main branch beneath Eldridge Street and less modifications to the smaller branches than alternative 2. In total, alternative 1 calls for replacing 2855 feet of pipe, while alternative 2 calls for replacing 3181 feet of pipe.

C Street

Flooding in the C Street basin can be eliminated by upsizing 13 pipes with a total length of 1421 feet. If the recommended pipe sizes at node 8330NW-355 are used the pipes will have to be installed at a lower invert elevation to maintain a minimum of 1-foot of cover (the existing concrete pipes have less than 1 foot of cover at this location). Ductile iron is recommended for these and three other replacement pipes in the basin because they will have less than 2 feet of cover.

Ellsworth

Flooding within the Ellsworth basin can be eliminated by upsizing eight pipes with a total length of 1509 feet. One of the pipes (C1518) included in Table 7 for the Ellsworth alternative is actually part the Broadway system, but is included with the Ellsworth alternative because it causes flooding that overflows from Broadway into the Ellsworth basin. Modifying pipe C1518 will eliminate interbasin overflows from the Broadway basin into Ellsworth basin. It should be noted, however, that if the more comprehensive solution recommended for the Broadway system is implemented first, then interbasin flooding would be eliminated and this pipe would not need to be upsized at all.

Laurel

Two alternatives are presented in Table 7 to eliminate flooding in the Laurel basin. The primary difference between the two alternatives is the conversion of the catch basin at node 8330SW-521 to a pressure lid in alternative 2 (and thus the elimination of inflows to the drainage system at that location). Node 8330SW-521 sits in a topographic low between Cornwall Avenue and the hill to the southeast and captures runoff from the surrounding area. If the City does not want to eliminate this catch basin, alternative 1, which includes modifying three additional pipe segments to eliminate flooding in the Laurel system, would be recommended.

Olive

The only simulated flooding in the Olive basin occurs from manhole 8236SW-25 east of the railroad and immediately upstream from the outfall. Surface flooding may not be much of a problem at this location, in which case no action would be needed. However, if the City wants to eliminate any flooding, one pipe segment would need to be upsized.

Willow

In the Willow basin, four pipes need to be replaced to eliminate flooding along Bayside Road. Alternative 1 eliminates flooding by installing the same sized concrete (CON) pipes, which have a lower roughness value than the existing corrugated metal pipe (CMP). The reduced roughness with concrete pipes is enough to eliminate flooding at this location. If the City prefers to also increase the pipe size, alternative 2 recommends installing three 24-inch concrete pipes. In both alternatives, one ductile iron pipe is recommended due to limited cover at node 7211SE-20.

Evaluation of Potential Effects of Sea Level Rise

As part of WSE's scope for this project, the City requested a review of the effect that sea level rise might have on the proposed conveyance system improvements. The time horizon for this analysis was set at 50 years in the future (e.g. 2070). Recent work by the University of Washington Climate Impacts Group (CIG) estimates that the median value of relative sea level rise in Bellingham Bay will be between 0.9 and 1.1 feet by 2070[2]. The SWMM model of flood reduction alternatives was rerun assuming the tidal boundary condition was raised by 1.1 feet. While the higher tailwater condition results in increased water levels upstream of the outfalls, this analysis found that no additional flooding would result from the predicted sea level rise. The conveyance system improvements shown in Table 7 are robust enough to handle at least 1.1 feet of future sea level rise.

[2] https://www.washington.edu/news/2018/07/30/sea-level-rise-report-contains-best-projections-yet-for-washingtons-coasts/

Table 7. Proposed pipe size and materials required to eliminate flooding during the 25-year full build-out land-use scenario.

Outfall	Alternative	Location	SWMM Pipe Name	Inlet Node	Outlet Node	Existing System				Proposed Change				Inlet Invert Depth (ft)	Outlet Invert Depth (ft)	Inlet Cover (ft)	Outlet Cover (ft)	Length (ft)	Notes
						Material	Dia (in)	Dia (ft)	Roughness	Material	Dia (in)	Dia (ft)	Roughness						
Arbutus	1	Fieldston Rd	C1541	7214NE-78	7214NE-64	CMP	12	1.00	0.024	CON	12	1.25	0.011	5.50	5.00	4.25	3.75	114	Change in material/roughness is enough to eliminate flooding without upsizing.
	2	Fieldston Rd	C1541	7214NE-78	7214NE-64	CMP	12	1.00	0.024	CON	15	1.00	0.011	5.50	5.00	4.50	4.00	114	Alternative 2 provided in case an increase in pipe size is preferred
Broadway	1 - Broadway Branch	Kulshan (Broadway to Monroe)	C1842	8224NE-A	8225NE-348	CON	18	1.50	0.011	CON	24	2.00	0.011	7.10	8.00	5.10	6.00	83	
			C1993	8224SE-360	8224NE-A	CON	15	1.25	0.011	CON	24	2.00	0.011	9.39	7.10	7.39	5.10	376	
		Kulshan (Monroe to Jefferson)	C1879	W0182-CB42	8224SE-360	PVC	12	1.00	0.011	CON	24	2.00	0.011	5.00	9.39	3.00	7.39	26	
			C1878	8224SE-210	W0182-CB42	PVC	12	1.00	0.011	CON	24	2.00	0.011	5.10	5.00	3.10	3.00	39	
			C1994	8224SE-161	8224SE-210	CON	15	1.25	0.011	CON	24	2.00	0.011	4.70	5.10	2.70	3.10	389	
			C1987	8224SE-152	8224SE-161	CON	12	1.00	0.011	CON	18	1.50	0.011	4.72	4.70	3.22	3.20	34	
		Kulshan (Jefferson to North)	C1952	8224SE-113	8224SE-152	CON	12	1.00	0.011	CON	18	1.50	0.011	5.00	4.72	3.50	3.22	450	
		Peabody (Jefferson to North)	C2016	8319SW-F002	8319SW-170	CON	15	1.25	0.011	DI	21	1.75	0.013	3.50	4.00	1.75*	2.25	30	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
			C1969	8319SW-170	8319SW-222	CON	15	1.25	0.011	CON	21	1.75	0.011	4.00	4.02	2.25	2.27	418	
			C1803	8319SW-222	8319SW-225	CON	15	1.25	0.011	CON	21	1.75	0.011	4.02	4.20	2.27	2.45	9	
			C1968	8319SW-225	8319SW-229	CON	15	1.25	0.011	CON	21	1.75	0.011	4.20	4.67	2.45	2.92	5	
		Peabody (Broadway to Jefferson)	C1892	S0505-CB02	S0505-CB06	CPP	12	1.00	0.02	CON	15	1.25	0.011	4.40	5.00	3.15	3.75	32	
			C1525	S0505-CB07	8319SW-280	CON	18	1.50	0.011	CON	24	2.00	0.011	5.35	6.30	3.35	4.30	154	
			C1893	S0505-CB06	S0505-CB07	CON	18	1.50	0.011	CON	24	2.00	0.011	5.00	5.35	3.00	3.35	45	
			C1891	8319SW-243	S0505-CB06	CON	18	1.50	0.011	CON	21	1.75	0.011	4.38	5.00	2.63	3.25	138	
			C1804	8319SW-229	8319SW-243	CON	18	1.50	0.011	CON	21	1.75	0.011	4.67	4.38	2.92	2.63	33	
		Broadway (Meridian to Peabody)	C1813	8319SW-F006	8224SE-356	CON	27	2.25	0.011	CON	30	2.50	0.011	7.52	9.00	5.02	6.50	218	
			C1900	8319SW-296	8319SW-F006	CON	27	2.25	0.011	CON	30	2.50	0.011	7.26	7.52	4.76	5.02	30	
			C2010	8319SW-280	8319SW-296	CON	27	2.25	0.011	CON	30	2.50	0.011	6.30	7.26	3.80	4.76	165	
		Meridian (North to Connecticut)	C1571	8224SE-62	8224SE-55	CON	12	1.00	0.011	CON	24	2.00	0.011	4.89	5.60	2.89	3.60	204	
			C1821	8224SE-116	8224SE-62	CON	12	1.00	0.011	CON	24	2.00	0.011	4.50	4.89	2.50	2.89	257	
		Meridian (Jefferson to North)	C1805	8224SE-118	8224SE-163	CON	12	1.00	0.011	CON	24	2.00	0.011	4.35	4.30	2.35	2.30	220	
			C1623	8224SE-116	8224SE-118	CON	12	1.00	0.011	CON	24	2.00	0.011	4.50	4.35	2.50	2.35	242	
		Meridian (Broadway to Jefferson)	C1779	8224SE-199	8224SE-356	CON	12	1.00	0.011	DI	30	2.50	0.013	4.30	9.00	1.80*	6.50	172	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
			C1744	W0182-CB46	8224SE-199	CON	12	1.00	0.011	DI	30	2.50	0.013	3.70	4.30	1.20*	1.80*	57	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
			C1778	8224SE-168	W0182-CB46	CON	12	1.00	0.011	DI	30	2.50	0.013	4.04	3.70	1.54*	1.20*	209	Cover less than 2 ft threshold; Ductile Iron pipe recommended.

Outfall	Alternative	Location	SWMM Pipe Name	Inlet Node	Outlet Node	Existing System Material	Existing System Dia (in)	Existing System Dia (ft)	Existing System Roughness	Proposed Change Material	Proposed Change Dia (in)	Proposed Change Dia (ft)	Proposed Change Roughness	Inlet Invert Depth (ft)	Outlet Invert Depth (ft)	Inlet Cover (ft)	Outlet Cover (ft)	Length (ft)	Notes
			C1726	8224SE-163	8224SE-168	CON	12	1.00	0.011	DI	30	2.50	0.013	4.30	4.04	1.80*	1.54*	178	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
			C1984	8225NE-347	8225NE-348	CON	30	2.50	0.011	CON	36	3.00	0.011	7.67	8.00	4.67	5.00	50	
		Broadway (Washington to Girard)	C1799	8224SE-358	8225NE-347	CON	30	2.50	0.011	CON	36	3.00	0.011	7.50	7.67	4.50	4.67	148	
			C1794	8224SE-356	8224SE-358	CON	30	2.50	0.011	CON	48	4.00	0.011	9.00	7.50	5.00	3.50	192	
			C1642	8225NE-26	8225NE-28	CON	30	2.50	0.011	CON	48	4.00	0.011	8.48	8.40	4.48	4.40	22	
		Broadway (Dupont to Washington)	C1643	8225NE-25	8225NE-26	CON	30	2.50	0.011	CON	48	4.00	0.011	8.43	8.48	4.43	4.48	10	
			C1812	8225NE-350	8225NE-25	CON	30	2.50	0.011	CON	48	4.00	0.011	7.90	8.43	3.90	4.43	254	
			C1823	8225NE-348	8225NE-350	CON	36	3.00	0.011	CON	48	4.00	0.011	8.00	7.90	4.00	3.90	126	
			C1697	8225NE-28	8225NE-46	CON	36	3.00	0.011	CON	48	4.00	0.011	8.40	7.39	4.40	3.39	223	
			C1641	8225NE-46	8225NE-52	CON	36	3.00	0.011	CON	48	4.00	0.011	7.39	7.39	3.39	3.39	28	
		Broadway (Bancroft to Dupont)	C1930	8225NE-52	8225NE-63	CON	36	3.00	0.011	CON	48	4.00	0.011	7.39	6.40	3.39	2.40	138	
Broadway	1 - Broadway Branch (cont.)		C1681	8225NE-63	8225NE-73	CON	36	3.00	0.011	DI	42	3.50	0.013	6.40	5.10	2.90	1.60*	138	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
		Broadway (Astor to Bancroft)	C1692	8225NE-73	8225NE-93	CON	36	3.00	0.011	DI	42	3.50	0.013	5.10	6.08	1.60*	2.58	194	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
			C1928	8225NE-93	8225NE-94	CON	36	3.00	0.011	CON	42	3.50	0.011	6.08	6.33	2.58	2.83	41	
			C1929	8225NE-94	8225NE-103	CON	36	3.00	0.011	CON	42	3.50	0.011	6.33	6.30	2.83	2.80	40	
			C1520	8225NE-103B	8225NE-132	CON	36	3.00	0.011	CON	48	4.00	0.011	6.98	7.20	2.98	3.20	70	
		Broadway (Holly to Astor)	C1909	8225NE-130	8225NE-132	CON	36	3.00	0.011	CON	48	4.00	0.011	6.78	7.20	2.78	3.20	16	
			C1908	8225NE-128	8225NE-130	CON	36	3.00	0.011	CON	42	3.50	0.011	6.93	6.78	3.43	3.28	57	
			C1524	8225NE-132	8225NE-147	CON	36	3.00	0.011	CON	42	3.50	0.011	7.20	8.00	3.70	4.50	53	
		Broadway (Roeder to Eldridge)	C1543	8225NE-177	8225NE-182	DI	36	3.00	0.013	DI	48	4.00	0.013	8.90	7.80	4.90	3.80	60	
			C1793	8225NE-191	8225NE-341	CON	36	3.00	0.011	CON	48	4.00	0.011	9.30	6.25	5.30	2.25	401	
		Bellweather Way	C1792	8225NE-183	8225NE-191	CON	36	3.00	0.011	CON	54	4.50	0.011	8.00	9.30	3.50	4.80	85	
			C1674	8225NE-182	8225NE-183	CON	36	3.00	0.011	CON	54	4.50	0.011	7.80	8.00	3.30	3.50	16	
		Williams St (Jefferson to Madison)	C1958	8225NE-40	8225NE-83	VIT	12	1.00	0.014	CON	15	1.25	0.011	10.00	7.50	8.75	6.25	298	Alternative 1 pipe length total = 2855 ft
			C1939	8225NE-314	8225NE-318	CON	12	1.00	0.011	CON	15	1.25	0.011	5.00	5.20	3.75	3.95	517	
		Utter St (Jefferson to Eldridge)	C1941	8225NE-318	8225NE-98	CON	8	0.67	0.011	CON	15	1.25	0.011	5.20	7.50	3.95	6.25	361	
Broadway	1 - Eldridge Ave Branch		C1959	8224SE-171	8224SE-194	CON	8	0.67	0.011	CON	12	1.00	0.011	5.05	5.50	4.05	4.50	81	
			C1910	8225NE-124	8225NE-126	CON	24	2.00	0.011	CON	36	3.00	0.011	6.66	7.00	3.66	4.00	18	
		Eldridge Ave (Walnut to Utter)	C1911	8225NE-115	8225NE-124	CON	24	2.00	0.011	CON	36	3.00	0.011	7.42	6.66	4.42	3.66	134	
			C1926	8225NE-106	8225NE-115	CON	24	2.00	0.011	CON	36	3.00	0.011	7.46	7.42	4.46	4.42	128	
			C1927	8225NE-101	8225NE-106	CON	24	2.00	0.011	CON	36	3.00	0.011	7.43	7.46	4.43	4.46	13	

Outfall	Alternative	Location	SWMM Pipe Name	Inlet Node	Outlet Node	Existing System				Proposed Change				Inlet Invert Depth (ft)	Outlet Invert Depth (ft)	Inlet Cover (ft)	Outlet Cover (ft)	Length (ft)	Notes
						Material	Dia (in)	Dia (ft)	Roughness	Material	Dia (in)	Dia (ft)	Roughness						
Broadway	1 - Eldridge Ave Branch (cont.)	Eldridge Ave (Utter to Williams)	C1923	8225NE-83	8225NE-85	CON	24	2.00	0.011	CON	30	2.50	0.011	7.50	7.62	5.00	5.12	27	
			C1942	8225NE-85	8225NE-326	CON	24	2.00	0.011	CON	36	3.00	0.011	7.62	7.73	4.62	4.73	127	
			C1943	8225NE-326	8225NE-98	CON	24	2.00	0.011	CON	36	3.00	0.011	7.73	7.50	4.73	4.50	151	
		Eldridge Ave (Williams to Victor)	C1749	8225NE-68	8225NE-83	CON	21	1.75	0.011	CON	30	2.50	0.011	6.72	7.50	4.22	5.00	277	
			C1951	8225NE-65	8225NE-68	CON	21	1.75	0.011	CON	30	2.50	0.011	6.20	6.72	3.70	4.22	41	
		Eldridge Ave (Henry to Jaeger)	C1521	8225NE-47A	8225NE-48	CON	12	1.00	0.011	CON	18	1.50	0.011	6.31	6.50	4.81	5.00	16	
			C1519	8225NW-57	8225NE-47A	CON	12	1.00	0.011	CON	18	1.50	0.011	6.50	6.31	5.00	4.81	267	
			C1998	8225NW-51	8225NW-57	CON	12	1.00	0.011	CON	15	1.25	0.011	5.00	6.50	3.75	5.25	39	
		Lynn St (Eldridge to Washington)	C2000	8225NW-16	8225NW-51	CON	12	1.00	0.011	CON	21	1.75	0.011	4.90	5.00	3.15	3.25	361	
	2 - Eldridge Ave Branch	Williams St (Jefferson to Madison)	C1958	8225NE-40	8225NE-83	VIT	12	1.00	0.014	CON	15	1.25	0.011	10.00	7.50	8.75	6.25	298	Alternative 2 pipe length total = 3181 ft
			C1947	8225NE-7	8225NE-40	VIT	12	1.00	0.014	CON	15	1.25	0.011	5.70	10.00	4.45	8.75	461	
		Utter St (Jefferson to Eldridge)	C1941	8225NE-318	8225NE-98	CON	8	0.67	0.011	CON	15	1.25	0.011	5.20	7.50	3.95	6.25	361	
			C1939	8225NE-314	8225NE-318	CON	12	1.00	0.011	CON	15	1.25	0.011	5.00	5.20	3.75	3.95	517	
			C1959	8224SE-171	8224SE-194	CON	8	0.67	0.011	CON	12	1.00	0.011	5.05	6.00	4.05	5.00	81	
		Eldridge Ave (Walnut to Broadway)	C1908	8225NE-128	8225NE-130	CON	36	3.00	0.011	CON	42	3.50	0.011	6.93	6.78	3.43	3.28	57	
		Eldridge Ave (Walnut to Utter)	C1910	8225NE-124	8225NE-126	CON	24	2.00	0.011	CON	30	2.50	0.011	6.66	7.00	4.16	4.50	18	
			C1911	8225NE-115	8225NE-124	CON	24	2.00	0.011	CON	30	2.50	0.011	7.42	6.66	4.92	4.16	134	
		Eldridge Ave (Victor to Henry)	C1710	8225NE-51	8225NE-65	CON	18	1.50	0.011	CON	24	2.00	0.011	7.31	6.20	5.31	4.20	262	
			C1627	8225NE-48	8225NE-51	CON	18	1.50	0.011	CON	24	2.00	0.011	6.50	7.31	4.50	5.31	23	
		Eldridge Ave (Henry to Jaeger)	C1521	8225NE-47A	8225NE-48	CON	12	1.00	0.011	CON	24	2.00	0.011	6.31	6.50	4.31	4.50	16	
			C1519	8225NW-57	8225NE-47A	CON	12	1.00	0.011	CON	24	2.00	0.011	6.50	6.31	4.50	4.31	267	
			C1998	8225NW-51	8225NW-57	CON	12	1.00	0.011	CON	24	2.00	0.011	5.00	6.50	3.00	4.50	39	
			C2001	8225NW-42	8225NW-51	CON	12	1.00	0.011	CON	24	2.00	0.011	4.71	5.00	2.71	3.00	257	
			C1981	8225NW-39	8225NW-42	CON	12	1.00	0.011	CON	24	2.00	0.011	4.00	4.71	2.00	2.71	29	
		Lynn St (Eldridge to Washington)	C2000	8225NW-16	8225NW-51	CON	12	1.00	0.011	CON	21	1.75	0.011	4.90	5.00	3.15	3.25	361	
C Street	1	Astor St (C to D St)	C1932	8330NW-384	V0058-M01	CON	15	1.25	0.011	CON	18	1.50	0.011	3.50	8.60	2.00	7.10	97	
			C1931	8330NW-355	8330NW-384	CON	15	1.25	0.011	DI	18	1.50	0.013	2.50	3.50	1.00**	2.00	142	Cover less than 1ft threshold, invert elevation needs to be minumum 20.215 ft at node 8330NW-355.

Outfall	Alternative	Location	SWMM Pipe Name	Inlet Node	Outlet Node	Existing System				Proposed Change				Inlet Invert Depth (ft)	Outlet Invert Depth (ft)	Inlet Cover (ft)	Outlet Cover (ft)	Length (ft)	Notes
						Material	Dia (in)	Dia (ft)	Roughness	Material	Dia (in)	Dia (ft)	Roughness						
C Street	1 (cont.)	Astor St (D to E St)	C1816	8330NW-316	8330NW-355	CON	15	1.25	0.011	DI	18	1.50	0.013	6.98	2.50	5.48	1.00**	253	Cover less than 1ft threshold, invert elevation needs to be minumum 20.215 ft at node 8330NW-355.
		Astor St (E to F St)	C1614	8225NE-239	8330NW-315	CON	12	1.00	0.011	CON	15	1.25	0.011	5.60	7.10	4.35	5.85	261	
		Astor St (F to G St)	C2005	8225NE-228	8225NE-239	CON	12	1.00	0.011	CON	15	1.25	0.011	11.90	5.60	10.65	4.35	222	
		Railroad Access (C to D St)	C1992	8330NW-467	8330NW-470	CON	18	1.50	0.011	CON	21	1.75	0.011	7.70	10.03	5.95	8.28	16	
			C1913	8330NW-459	8330NW-467	CON	18	1.50	0.011	CON	21	1.75	0.011	6.86	7.70	5.11	5.95	64	
			C1919	8330NW-435	8330NW-459	CON	15	1.25	0.011	CON	18	1.50	0.011	6.80	6.86	5.30	5.36	55	
			C1918	8330NW-413	8330NW-435	CON	15	1.25	0.011	CON	18	1.50	0.011	6.49	6.80	4.99	5.30	64	
		Railroad Access (F to G St)	C1912	8225NE-247	8225NE-248	CON	12	1.00	0.011	DI	18	1.50	0.013	3.00	3.50	1.50*	2.00	7	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
			C1934	8225NE-271	8225NE-274	CON	15	1.25	0.011	CON	18	1.50	0.011	3.74	4.50	2.24	3.00	59	
			C1933	8225NE-259	8225NE-271	CON	15	1.25	0.011	DI	18	1.50	0.013	3.40	3.74	1.90*	2.24	93	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
			C1963	8225NE-248	8225NE-259	CON	15	1.25	0.011	DI	18	1.50	0.013	3.50	3.40	2.00	1.90*	88	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
Ellsworth	1	Girard St (C to D St)	C1578	8330NW-114	8330NW-131	CON	15	1.25	0.011	CON	21	1.75	0.011	4.80	6.40	3.05	4.65	194	
		Girard St (F to G St)	C1579	8330NW-50	8330NW-69	CON	15	1.25	0.011	CON	18	1.50	0.011	5.50	6.00	4.00	4.50	258	
		Ellsworth St (D to F St)	C1581	8330NW-140	8330NW-179	CON	15	1.25	0.011	CON	18	1.50	0.011	6.90	4.50	5.40	3.00	248	
			C1638	8330NW-115	8330NW-140	CON	15	1.25	0.011	CON	18	1.50	0.011	6.90	6.90	5.40	5.40	231	
		Ellsworth St (F to G St)	C1817	8330NW-99	8330NW-115	CON	12	1.00	0.011	CON	15	1.25	0.011	7.13	6.90	5.88	5.65	147	
			C1616	8330NW-88A	8330NW-99	CON	12	1.00	0.011	CON	15	1.25	0.011	5.95	7.13	4.70	5.88	126	
			C1830	8330NW-89	8330NW-88A	CON	12	1.00	0.011	CON	15	1.25	0.011	5.50	5.95	4.25	4.70	30	
		Jenkins St	C1518	8319SW-259	8319SW-219	CON	18	1.50	0.011	CON	24	2.00	0.011	8.40	6.90	6.40	4.90	275	Pipe is in the Broadway system, but upsize is only required to fix overflow into Ellsworth system if Ellsworth work is performed first. If Broadway system is fixed first, upsizing in the lower Broadway system solves the flooding in the Ellsworth system without needing to upsize this pipe.
Laurel	1	Laurel St (State to Cornwall)	C1634	8330SW-426	8330SW-424	CON	30	2.50	0.011	CON	36	3.00	0.011	11.03	11.13	8.03	8.13	62	Alternative 1 - upsize all pipes necessary to eliminate flooding
			C1559	8330SW-431	8330SW-426	CON	30	2.50	0.011	CON	36	3.00	0.011	10.79	11.03	7.79	8.03	37	
			C1576	8330SW-521	8330SW-431	CMP	30	2.50	0.024	CON	36	3.00	0.011	5.50	10.79	2.50	7.79	108	
			C1898	8330SW-439	8330SW-521	CON	30	2.50	0.011	CON	36	3.00	0.011	5.10	5.50	2.10	2.50	25	
			C1575	8330SW-442	8330SW-439	CON	30	2.50	0.011	CON	36	3.00	0.011	10.35	5.10	7.35	2.10	58	

Outfall	Alternative	Location	SWMM Pipe Name	Inlet Node	Outlet Node	Existing System				Proposed Change				Inlet Invert Depth (ft)	Outlet Invert Depth (ft)	Inlet Cover (ft)	Outlet Cover (ft)	Length (ft)	Notes
						Material	Dia (in)	Dia (ft)	Roughness	Material	Dia (in)	Dia (ft)	Roughness						
Laurel	1 (cont.)	Laurel St (Forest to State)	C1859	8331NW-310	8331NW-38	CON	12	1.00	0.011	CON	18	1.50	0.011	12.00	7.50	10.50	6.00	139	
		Forest St (Maple to Laurel)	C1866	W0168-M02	W0168-M01	PVC	12	1.00	0.011	CON	15	1.25	0.011	8.20	9.40	6.95	8.15	55	
			C1867	8331NW-303	W0168-M02	PVC	12	1.00	0.011	CON	15	1.25	0.011	5.00	8.20	3.75	6.95	163	
		E Maple St to Laurel trunk line	C1850	8330SW-439A	8330SW-439	CMP	15	1.25	0.024	CON	15	1.25	0.011	5.00	5.10	3.75	3.85	202	Change in material/roughness is enough to eliminate flooding without upsizing.
			C1574	S0301-CB06	8330SW-439A	CMP	15	1.25	0.024	CON	15	1.25	0.011	5.00	5.00	3.75	3.75	211	
			C1841	8330SW-407	S0301-CB06	CMP	15	1.25	0.024	CON	15	1.25	0.011	6.60	5.00	5.35	3.75	102	
Laurel	2	Laurel St (State to Cornwall)		8330SW-521															Alternative 2: rather than upsizing pipes C1634, C1898, C1575 - add a pressure lid to node 8330SW-521.
			C1559	8330SW-431	8330SW-426	CON	30	2.50	0.011	CON	36	3.00	0.011	10.79	11.03	7.79	8.03	37	
			C1576	8330SW-521	8330SW-431	CMP	30	2.50	0.024	CON	36	3.00	0.011	5.50	10.79	2.50	7.79	108	
		Laurel St (Forest to State)	C1859	8331NW-310	8331NW-38	CON	12	1.00	0.011	CON	18	1.50	0.011	12.00	7.50	10.50	6.00	139	
		Forest St (Maple to Laurel)	C1866	W0168-M02	W0168-M01	PVC	12	1.00	0.011	CON	15	1.25	0.011	8.20	9.40	6.95	8.15	55	
			C1867	8331NW-303	W0168-M02	PVC	12	1.00	0.011	CON	15	1.25	0.011	5.00	8.20	3.75	6.95	163	
		E Maple St to Laurel trunk line	C1850	8330SW-439A	8330SW-439	CMP	15	1.25	0.024	CON	15	1.25	0.011	5.00	5.10	3.75	3.85	202	Change in material/roughness is enough to eliminate flooding without upsizing.
			C1574	S0301-CB06	8330SW-439A	CMP	15	1.25	0.024	CON	15	1.25	0.011	5.00	5.00	3.75	3.75	211	
			C1841	8330SW-407	S0301-CB06	CMP	15	1.25	0.024	CON	15	1.25	0.011	6.60	5.00	5.35	3.75	102	
Olive	1	NW of S State St	C1871	8236SW-25	8236SW-2	CMP	18	1.50	0.024	CON	24	2.00	0.011	7.00	7.60	5.00	5.60	46	Only flooded node is first node upstream of outfall. Ponding at this location may not be an issue for COB.
Willow	1	Bayside Rd	C1582	7211SE-11	7211SE-6	CMP	18	1.50	0.024	CON	18	1.50	0.011	4.70	4.00	3.20	2.50	220	Change in material/roughness is enough to eliminate flooding without upsizing.
			C1583	7211SE-17	7211SE-11	CMP	18	1.50	0.024	CON	18	1.50	0.011	5.30	4.70	3.80	3.20	331	
			C1679	7211SE-16	7211SE-17	CMP	18	1.50	0.024	CON	18	1.50	0.011	5.20	5.30	3.70	3.80	127	
			C1631	7211SE-20	7211SE-16	CMP	18	1.50	0.024	DI	21	1.75	0.013	3.00	5.20	1.25*	3.45	346	Cover less than 2 ft threshold; Ductile Iron pipe recommended.
	2	Bayside Rd	C1582	7211SE-11	7211SE-6	CMP	18	1.50	0.024	CON	24	2.00	0.011	4.70	4.00	2.70	2.00	220	Alternative 2 provided in case an increase in pipe size is preferred
			C1583	7211SE-17	7211SE-11	CMP	18	1.50	0.024	CON	24	2.00	0.011	5.30	4.70	3.30	2.70	331	
			C1679	7211SE-16	7211SE-17	CMP	18	1.50	0.024	CON	24	2.00	0.011	5.20	5.30	3.20	3.30	127	
			C1631	7211SE-20	7211SE-16	CMP	18	1.50	0.024	DI	21	1.75	0.013	3.00	5.20	1.25*	3.45	346	Cover less than 2 ft threshold; Ductile Iron pipe recommended.

SUMMARY AND CONCLUSIONS

Watershed Science and Engineering developed hydrologic and hydraulic models and conducted detailed analyses to characterize current and future conditions flooding in nine direct discharge marine outfall systems in the City of Bellingham. WWHM hydrologic models covering the nine drainage basins were developed and used to generate hydrologic inputs for existing and full build-out land-use conditions. A comprehensive SWMM hydraulic model of the nine systems was constructed and used to characterize current and full build-out conditions flooding for four design flood events. The hydraulic model was then used to develop and evaluate potential flood reduction alternatives with the goal of eliminating flooding during the 25-year full build-out conditions flood event. The recommended system improvements to achieve the desired level of flood reduction are presented in Table 7.

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APPENDIX A – SCHEMATIC FIGURES OF DRAINAGE NETWORK SYSTEMS

ARBUTUS SYSTEM

Figure A1. Schematic diagram showing the Arbutus drainage network (green), active overflow paths (blue), and inactive overflow paths (yellow) during the 25-year flood event under full build-out land-use conditions. Overflow path locations are intended to be schematic only and do not indicate actual flowpaths. Drainage boundary is shown in red. The Arbutus system outfall is shown as a red triangle.

Bennett System

Figure A2. Schematic diagram showing the Bennett drainage network (green) during the 25-year flood event under full build-out land-use conditions. No overflow paths were identified in the Bennett system. Drainage boundary is shown in red. The Bennett system outfall is shown as a red triangle.

BROADWAY SYSTEM

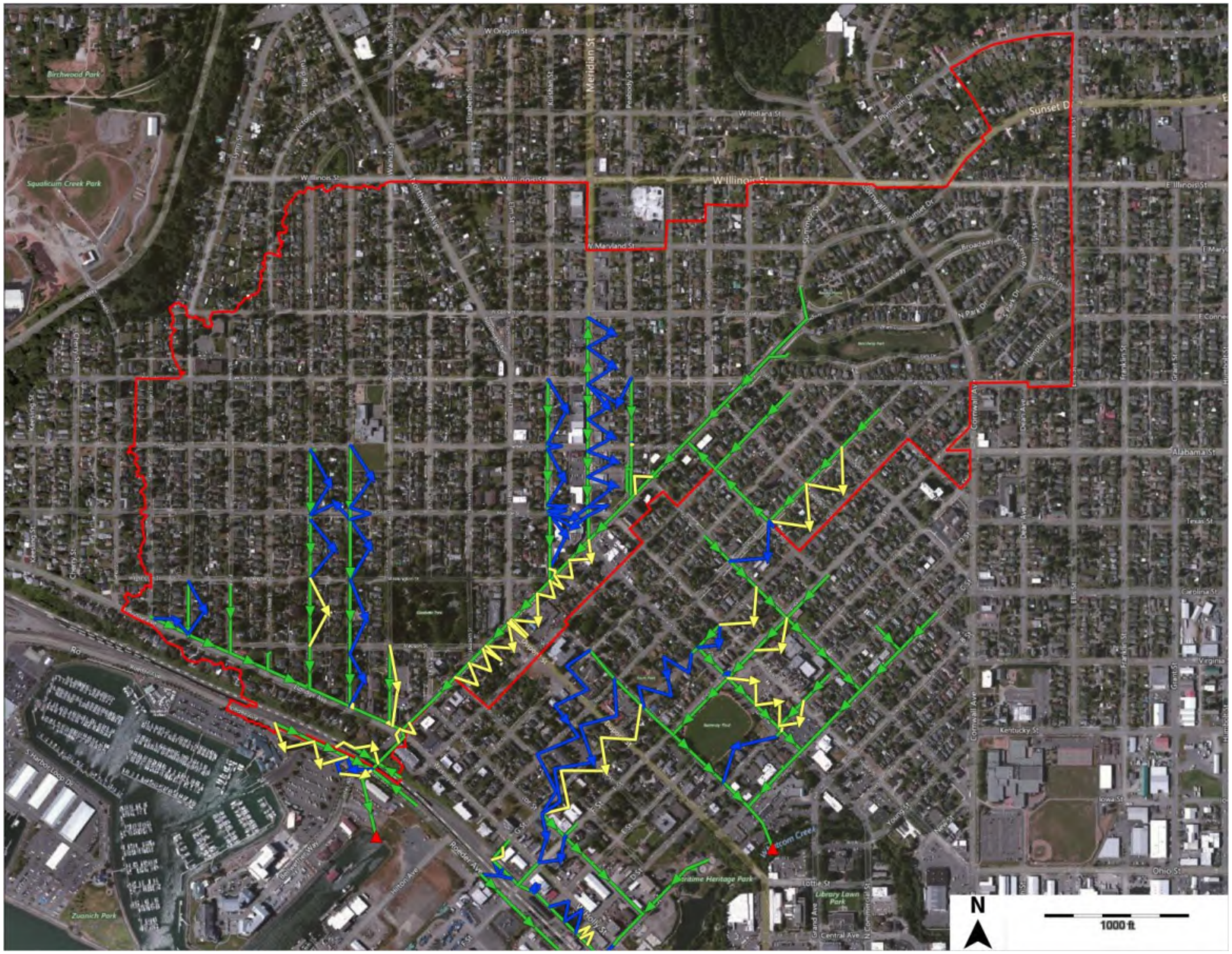

Figure A3. Schematic diagram showing the Broadway drainage network (green), active overflow paths (blue), and inactive overflow paths (yellow) during the 25-year flood event under full build-out land-use conditions. Overflow path locations are intended to be schematic only and do not indicate actual flowpaths. Drainage boundary is shown in red. The Broadway system outfall is shown as a red triangle. Note the active overflow path into the Ellsworth system.

CEDAR SYSTEM

Figure A4. Schematic diagram showing the Cedar drainage network (green), active overflow paths (blue), and inactive overflow paths (yellow) during the 25-year flood event under full build-out land-use conditions. Overflow path locations are intended to be schematic only and do not indicate actual flowpaths. Drainage boundary is shown in red. The Cedar system outfall is shown as a red triangle.

C Street System

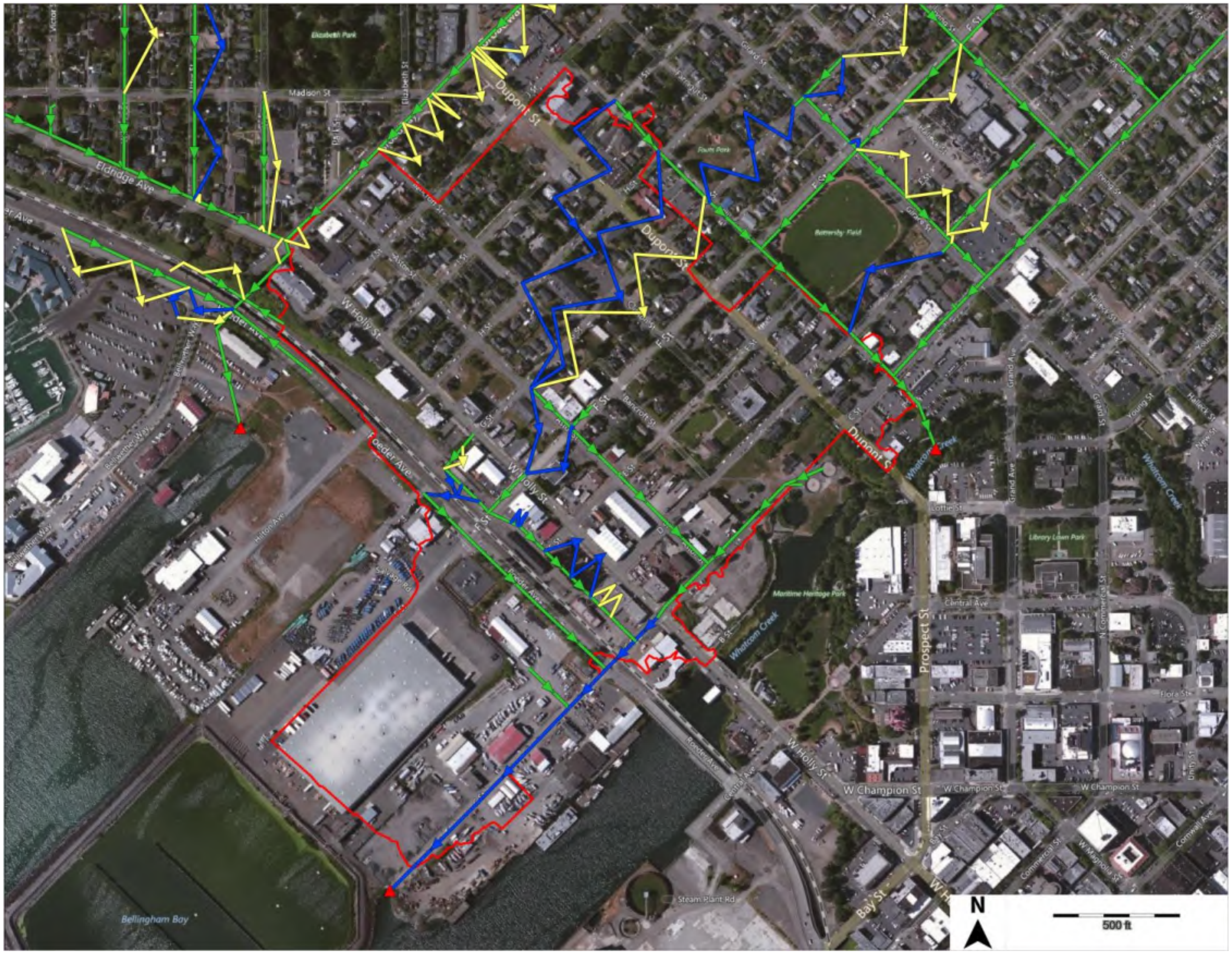

Figure A5. Schematic diagram showing the C Street drainage network (green), active overflow paths (blue), and inactive overflow paths (yellow) during the 25-year flood event under full build-out land-use conditions. Overflow path locations are intended to be schematic only and do not indicate actual flowpaths. Drainage boundary is shown in red. The C Street system outfall is shown as a red triangle. Note the active overflow path into the C Street system from the Ellsworth system.

Ellsworth System

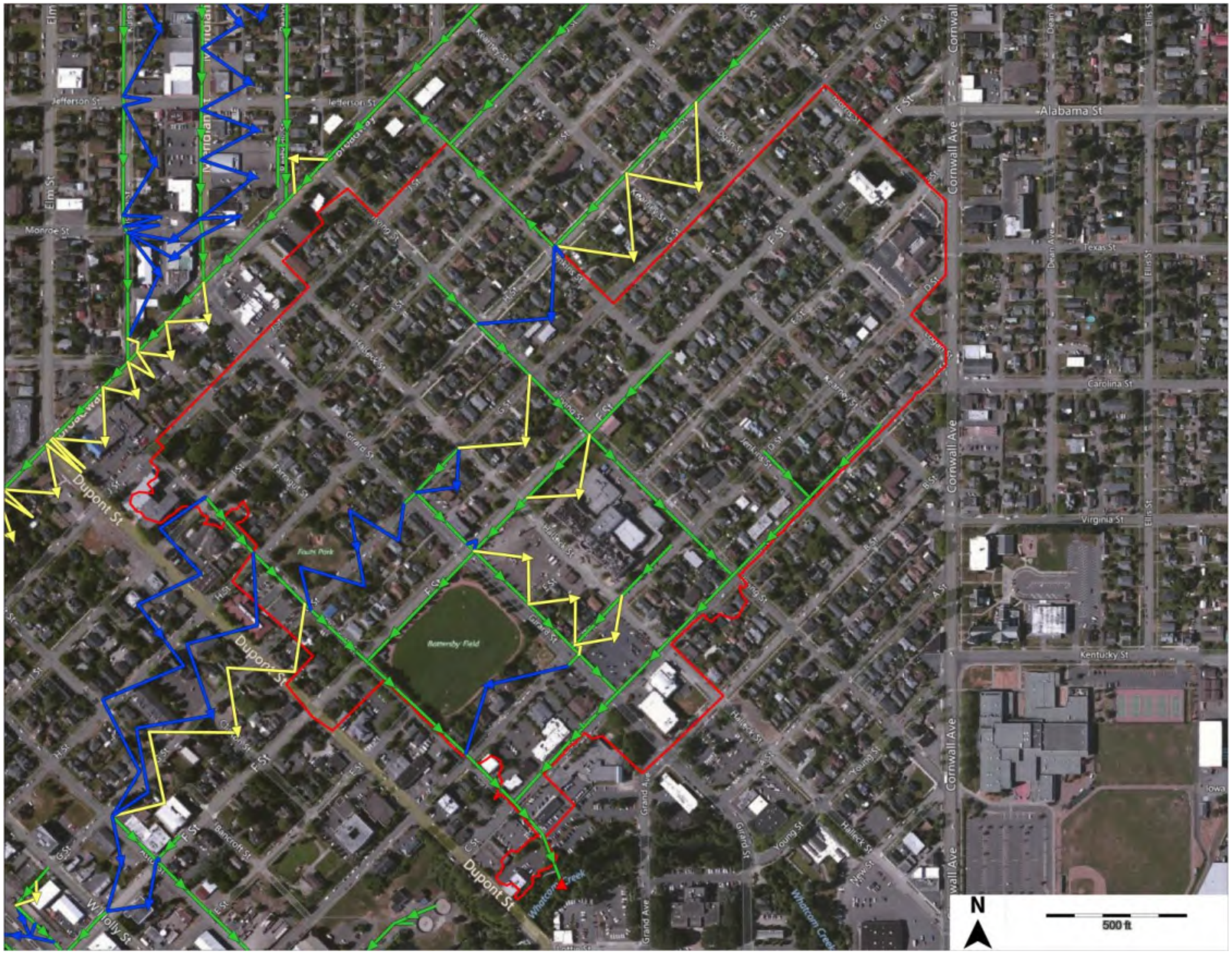

Figure A6. Schematic diagram showing the Ellsworth drainage network (green), active overflow paths (blue), and inactive overflow paths (yellow) during the 25-year flood event under full build-out land-use conditions. Overflow path locations are intended to be schematic only and do not indicate actual flowpaths. Drainage boundary is shown in red. The Ellsworth system outfall is shown as a red triangle. Note the active overflow path into the Ellsworth system from the Broadway system to the north, and the active overflow path from the Ellsworth system into the C Street system to the southwest.

LAUREL SYSTEM

Figure A7. Schematic diagram showing the Laurel drainage network (green), active overflow paths (blue), and inactive overflow paths (yellow) during the 25-year flood event under full build-out land-use conditions. Overflow path locations are intended to be schematic only and do not indicate actual flowpaths. Drainage boundary is shown in red. The two Laurel system outfalls are shown as red triangles.

OLIVE SYSTEM

Figure A8. Schematic diagram showing the Olive drainage network (green) during the 25-year flood event under full build-out land-use conditions. The only overflow path identified in the Olive system is not shown; it is immediately upstream of the outfall. Drainage boundary is shown in red. The Olive system outfall is shown as a red triangle.

WILLOW SYSTEM

Figure A9. Schematic diagram showing the Willow drainage network (green), active overflow paths (blue), and inactive overflow paths (yellow) during the 25-year flood event under full build-out land-use conditions. Overflow path locations are intended to be schematic only and do not indicate actual flowpaths. Drainage boundary is shown in red. The Willow system outfall is shown as a red triangle.

Technical Memorandum (FINAL)
Bellingham SW Comprehensive Plan

To:	Jason Porter
From:	Steven Thurin
Date:	July 8, 2019
Subject:	Padden Creek Flow Augmentation Analysis (Task 600)

1.0 Background

The City of Bellingham contracted with HDR to evaluate the possibility of augmenting low flows in Padden Creek by siphoning water from Lake Padden. This document describes the assumptions, methods, and results of HDR's evaluation of potential augmentation scenarios. A map of the area is shown in Figure 1.

2.0 Scope

The scope of analysis includes the following steps:

1. Determine minimum flows for Padden Creek
2. Estimate summer flows for Padden Creek
3. Develop stage-storage curve for Lake Padden
4. Develop spreadsheet water balance model for Lake Padden
5. Evaluate Lake Padden impacts
6. Size conveyance siphon

3.0 Analysis

Streamflow data were obtained from the City's 15-minute continuous streamflow gage on Padden Creek near Fairhaven Park. Gaps in the dataset were filled by extrapolating between adjoining data. Daily data were developed by averaging the 15-minute gage data. The resulting flows are shown in Figure 2. Figure 3 shows average daily flows.

Inflows to Lake Padden were developed from the Fairhaven gage data using the following assumptions:

1. Gains between Lake Padden and Fairhaven were assumed equal to 50 percent of the flow at Fairhaven when flow exceeded 1 cfs. This assumption is based upon review of SWMM modeling results, which show these ratios between inflow to Lake Padden and inflows at the confluence with Connelly Creek.
2. Losses in Lake Padden included 150 acre-feet of assumed evaporation distributed during June through September and 55 acre-feet of withdrawals by the Lake Padden Golf Course (LPGC), distributed based on water use data reported for 2016 and 2017.
3. Inflows to Lake Padden were calculated from the Fairhaven gage data using a water balance model using the assumptions above and the Padden Lake outflow stage versus discharge curve, shown in

Figure 4. The stage versus discharge curve closely follows the information provided in Ecology's 2018 Periodic Inspection Report on Padden Lake dam (DSO File WH01-0364).

A water balance model similar to the one used to estimate lake inflow was developed to estimate the potential to augment flows in Padden Creek. The model used the inflow data to the lake, plus assumptions about evaporation losses and data on LPGC withdrawals, and the stage versus discharge curve. The model is programmed to allow stream augmentation whenever summer (June through August) or fall (September through November) flows were less than a given amount. The function can also be used to set a minimum outflow rate for any month of the year.

4.0 Habitat Reach Hydraulic Analysis

An analysis was conducted to estimate the water depth in Padden Creek at the location where the Padden Creek Daylighting Project was built. The analysis calculated water depth as a function of proposed augmented flows that would be siphoned from Lake Padden during the summer months when flows within the habitat reach are known to completely dry-up. Flowmaster™ hydraulic software was used for the analysis by developing a typical channel cross-section using data from the 90 percent design plans for the Padden Creek Daylighting Project. The cross-section station-elevation data was taken at the widest point of the channel based on the schematic design. The schematic shows a fish passage channel with pools, however because there was no elevation data associated with the fish passage channel, a 2-foot wide by 1 foot deep fish passage channel was assumed for the analysis.

5.0 Augmentation Results

The water balance model was used to simulate the effect on Lake Padden and Padden Creek with various water withdrawal scenarios that augment flow to Padden Creek. Results are summarized in Table 1 and in Figures 5 through 10. Table 1 presents the Baseline (No Augmentation) results for simulated daily streamflow. The baseline lake level of 451 feet (MSL) was as a result of the water balance model using inflow and outflow rates, evapotranspiration losses and the resultant lake level when under existing conditions.

The percent exceedance results represent the values at which 90 percent of the daily results are larger. These are calculated by examining daily flow results for the entire 13.5 year period of record. For example, under Baseline conditions, Padden Creek flows are greater than 0.41 cfs on 80 percent of all days, and are greater than 0.16 cfs on 90 percent of all days, see Table 1. Conversely, this also means that the flow is less than these amounts on 20 percent and 10 percent of all days, respectively. The augmentation scenarios (for simplicity termed "Minimum", "Medium", and "Maximum") show how much these flow exceedance results are increased by the potential augmentation.

The augmentation scenarios examined show that summer and fall streamflow in Padden Creek can be maintained at between 1 and 2 cfs. This is a large increase over the baseline conditions, where summer and fall flows are frequently (20 percent of the time) less than 0.4 cfs, and 10 percent of the time are effectively zero, (see Figure 4). No evaluation was performed of habitat conditions associated with this level of flow augmentation.

Providing minimum flows in Padden Creek between 1 and 2 cfs can be done; however the impact on Lake Padden is that water levels decrease between one and three feet. Providing higher augmented flows results in greater drawdowns of Lake Padden.

To calculate siphon hydraulics, the standard orifice equation was used and determine that a flow of 2 cfs could be achieved using 6-inch diameter, 50-feet long siphon pipe with 5 feet of head differential from the lake to the creek.

Flow depths in the habitat channel (Figure 11) were calculated using the proposed siphoned flow rates of 2 and 3 cfs. At 2 cfs the flow depth in the habitat channel is estimated to be 0.59 feet and for a flow rate of 3 cfs the flow depth in the channel is estimated to be 0.79 feet (Figures 12 and 13).

Table 1. Summary of flow augmentation results.

Scenario	Minimum Summer Release (cfs)	Minimum Fall Release (cfs)	Average Lake Level (feet)	Minimum Lake Level (feet)	90% Exceedance Lake Level (feet)	Padden Creek Exceedance Flows (cfs)		
						70%	80%	90%
Baseline	0.00	0.00	451.5	451.0	451.2	.85	.41	.16
Minimum	1.00	1.00	451.3	450.0	450.9	1.08	1.00	0.96
Medium	2.00	1.00	450.9	448.9	450.3	2.01	1.88	1.00
Maximum	2.00	2.00	450.7	448.2	450.0	2.04	2.00	1.87

Notes:
Baseline: no flow augmentation. Existing conditions.
Minimum: minimal flow augmentation, 1 cfs in summer and fall seasons.
Medium: 2 cfs in summer, 1 cfs in fall.
Maximum: 2 cfs in summer and fall.

6.0 Conclusions

Flow gage data for Padden Creek shows that it consistently goes dry in the summer months. A water balance model for Lake Padden was developed to analyze the effects on lake levels due to potential water withdraws from the lake. Lake levels were simulated under three flow augmentation scenarios; minimum withdraws (1 cfs in summer and fall), medium withdraws (2 cfs in summer and 1 cfs in the fall) and a maximum withdraw (2 cfs in summer and fall). The analysis showed that augmenting summer flows in Padden Creek by siphoning water from Lake Padden could produce aquatic benefits by creating flow depths up to 0.7 feet in the habitat reach when 2 cfs are added.

In summary,

- Augmenting streamflow by two (2) cfs drops Lake Padden water levels by about 3 feet and produces channel depths of about 0.7 feet. Based on flow exceedance calculations, two cfs would be a significant flow augmentation rate.
- One (1) cfs drops Lake Padden by about 1 foot and produces channel depths of 0.6 feet. Similarly, 1 cfs would be a significant flow addition.

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Puget Sound
Bellingham
Project Location
Seattle
Tacoma
Spokane
Yakima
Vancouver
Happy Valley
South Bellingham
Edgemoor
Chuckanut Village
Mud Bay
Lake Padden
Fairhaven Park
Arroyo Park
Old Fairhaven Pkwy
Samish Way
Harris Ave
Donovan Ave
Wilson Ave
Cowgill Ave
Julia Ave
Lindsay Ave
Cody Ave
South Ave
Broad St
Victoria St
Church St
Old Samish Rd
Fairhaven Ave
California St
Chuckanut Dr N
Sea Pines Rd
Viewcrest Rd
Willow Rd
Fern Rd
Everglade Rd
Linden Rd
Middlefield Rd
Underhill Rd
Parkridge Rd
Hawthorne Rd
Bayside Rd
Kellogg St
Wilkin St
College St
Harrison St
Parkhurst Dr
Padden Hills Ct
Samish Crest Dr
Connelly Ave
Lake Padden Loop
N
0
0.25
0.5 Miles

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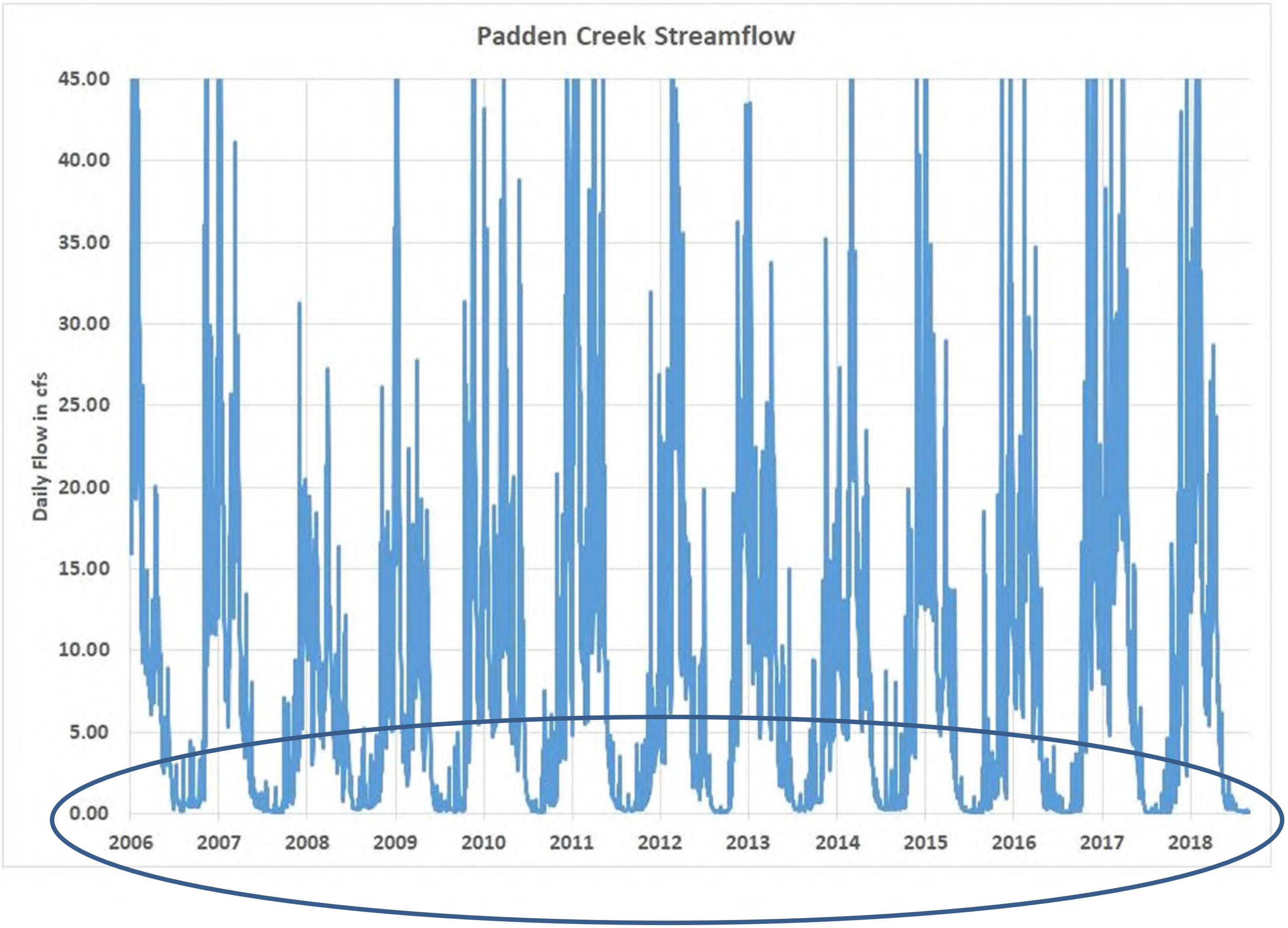

Figure 2. Padden Creek streamflow, Fairhaven gage.

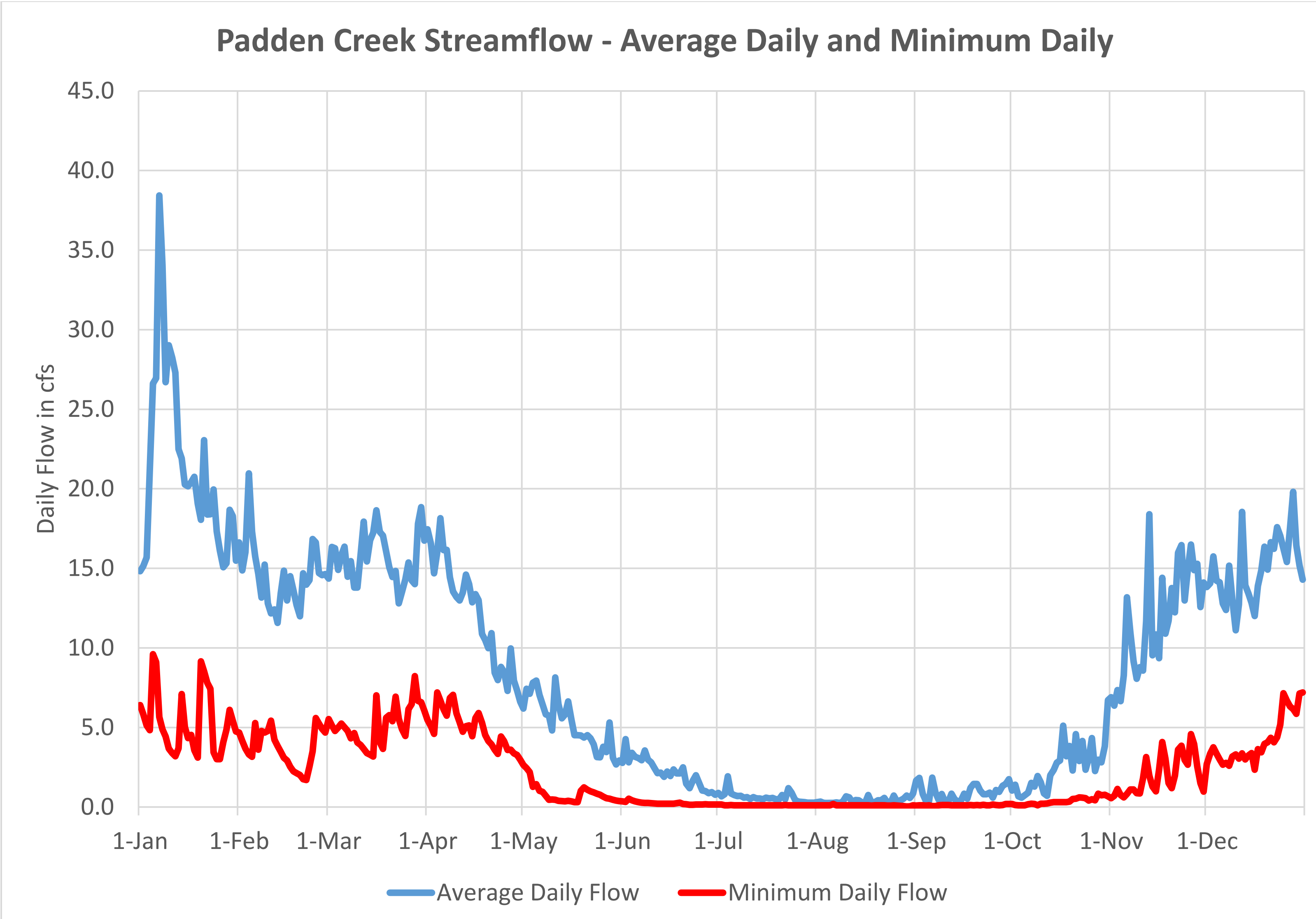

Figure 3. Padden Creek average daily flow at Fairhaven Park.

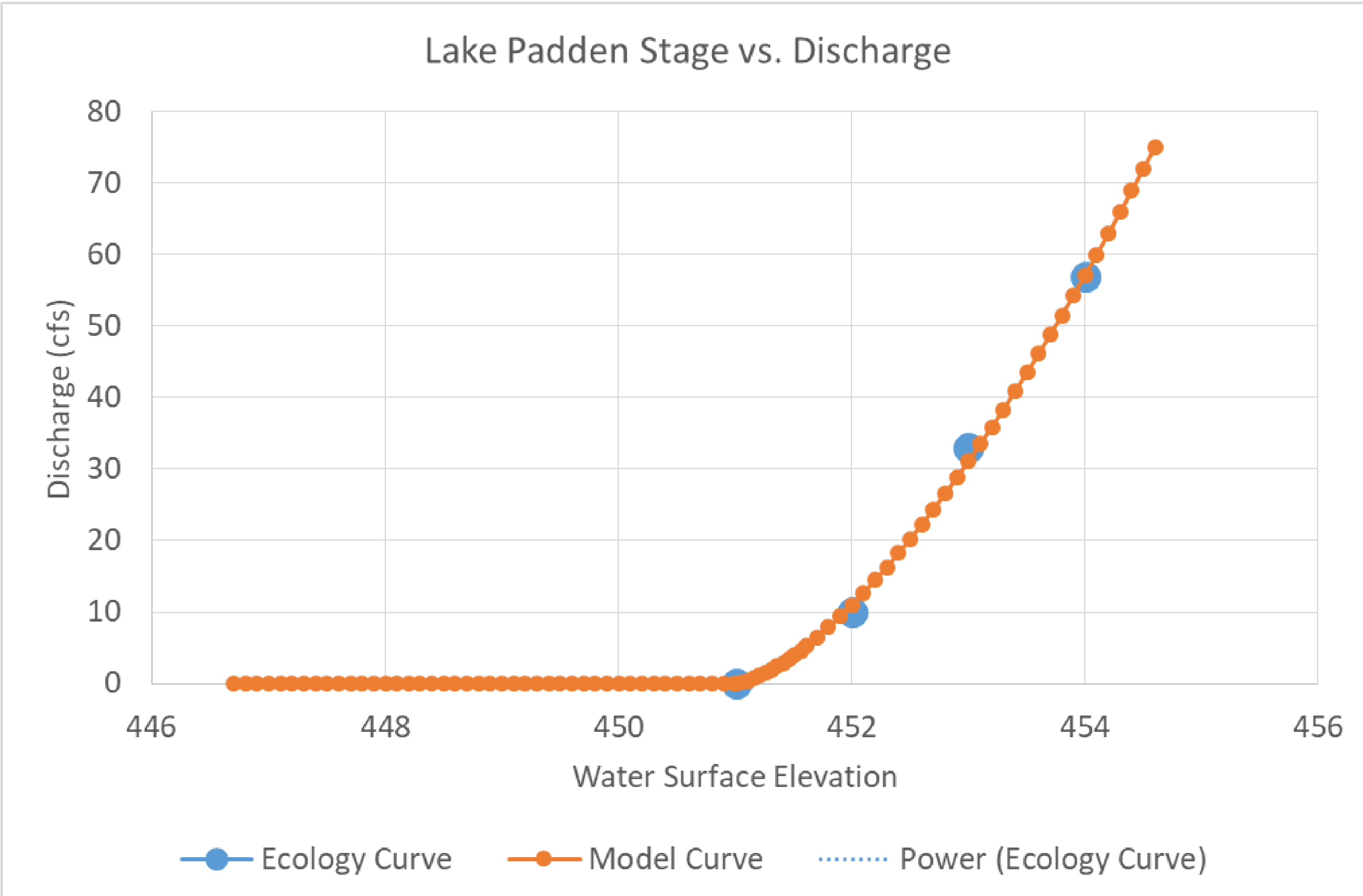

Figure 4. Simulated Lake Padden Water Surface Elevation versus Discharge

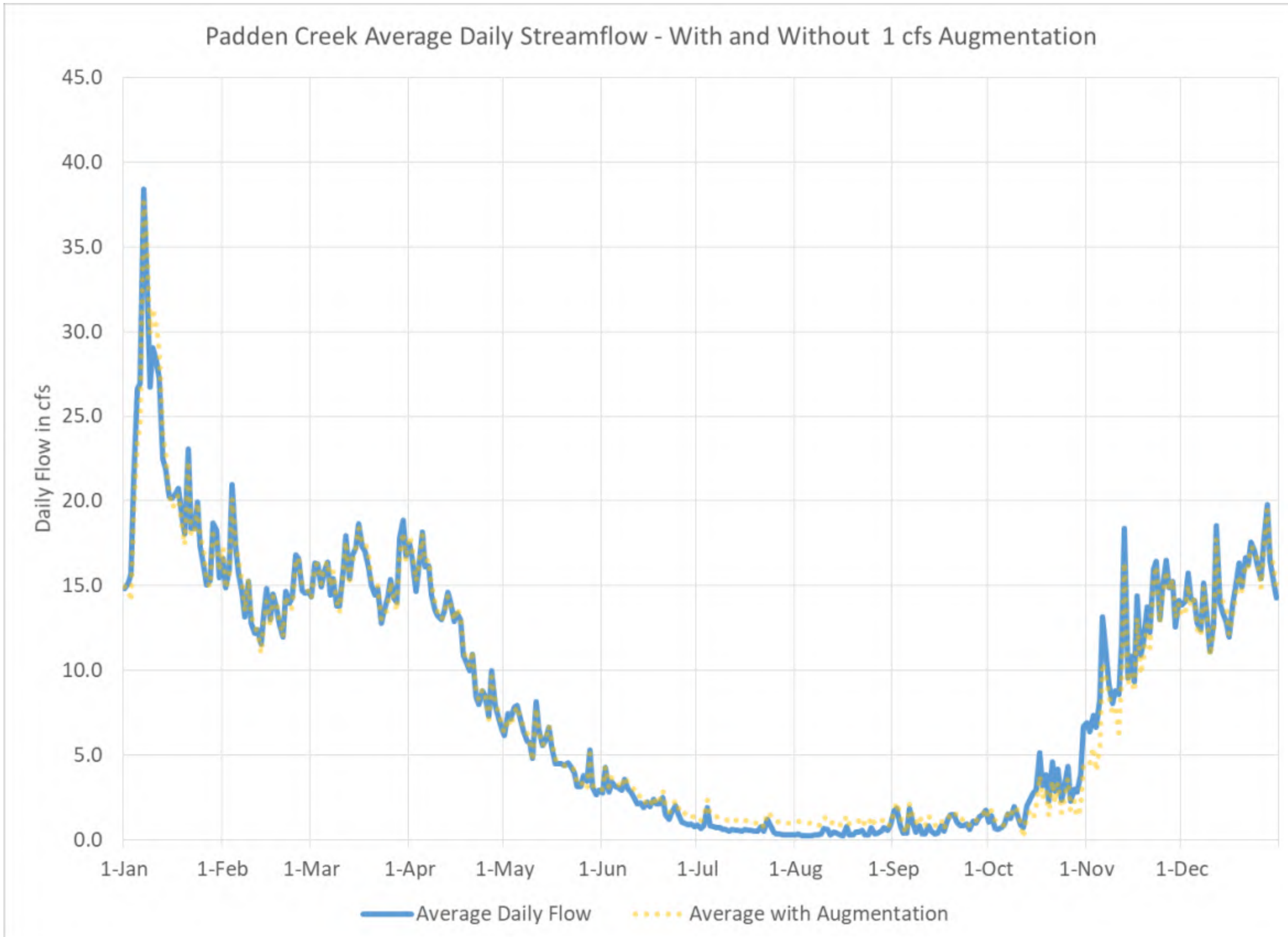

Figure 5. Simulated Padden Creek Flow– minimum augmentation.

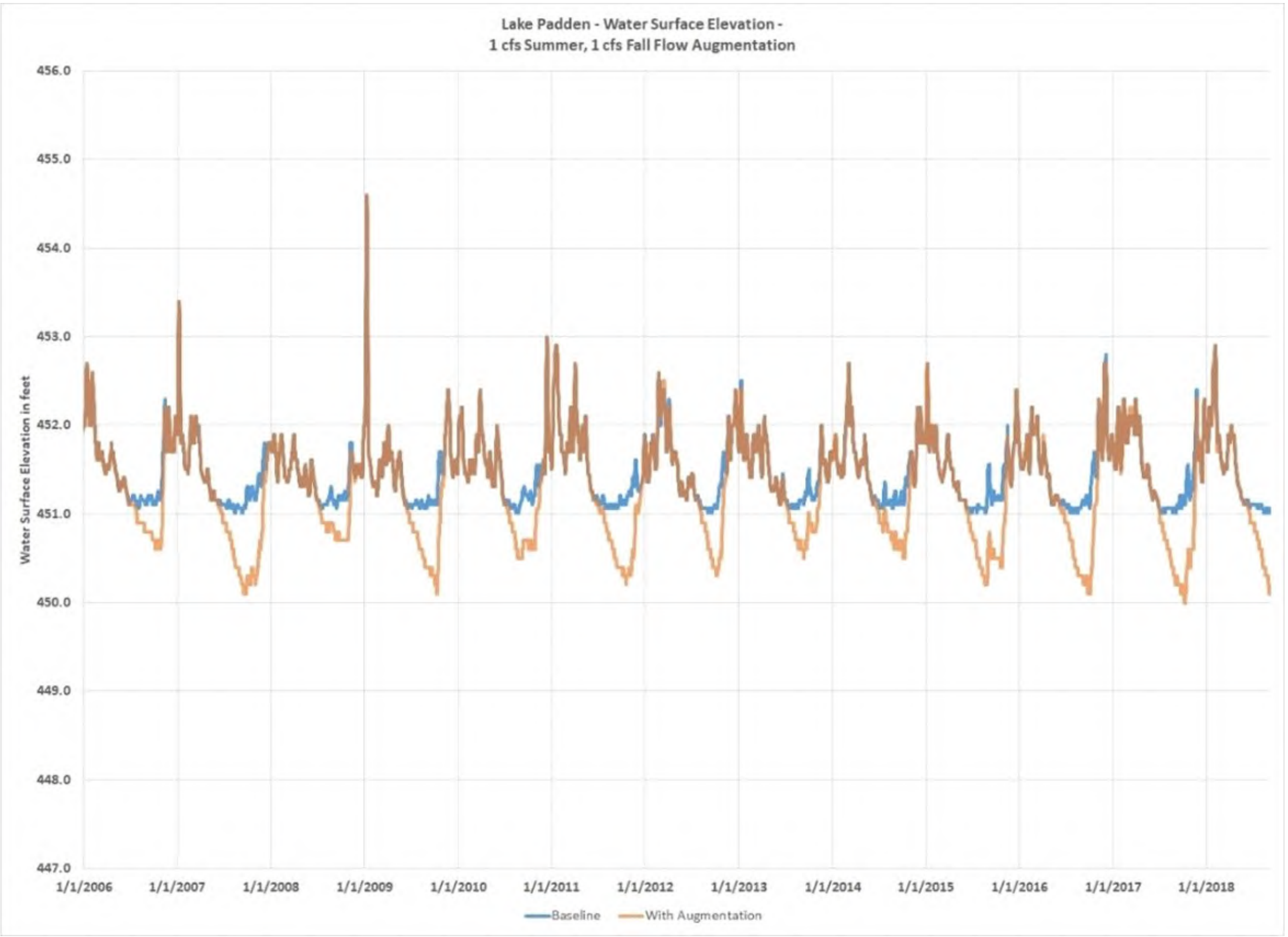

Figure 6. Simulated Lake Padden water levels– minimum augmentation.

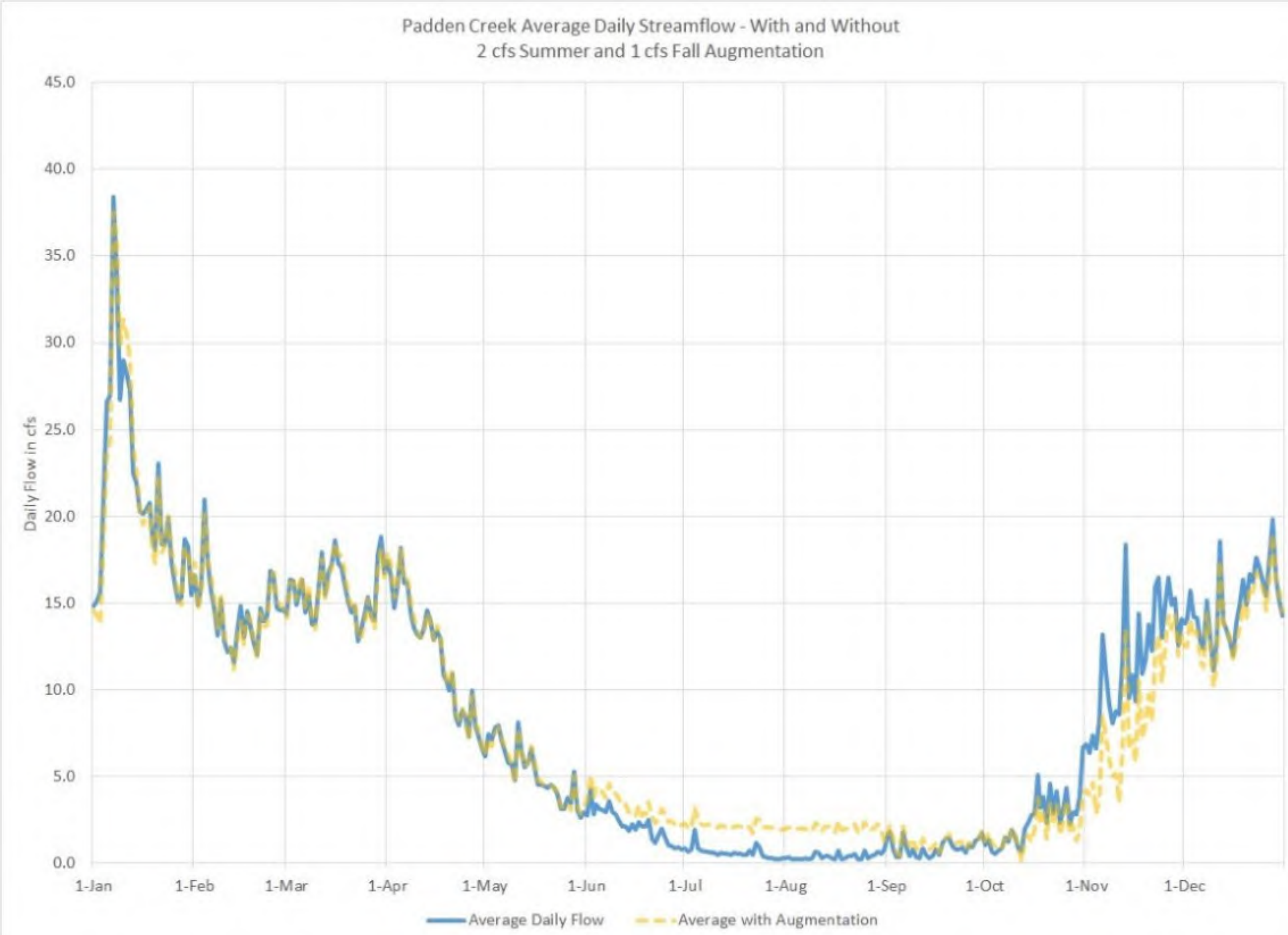

Figure 7. Simulated Padden Creek flow– medium augmentation.

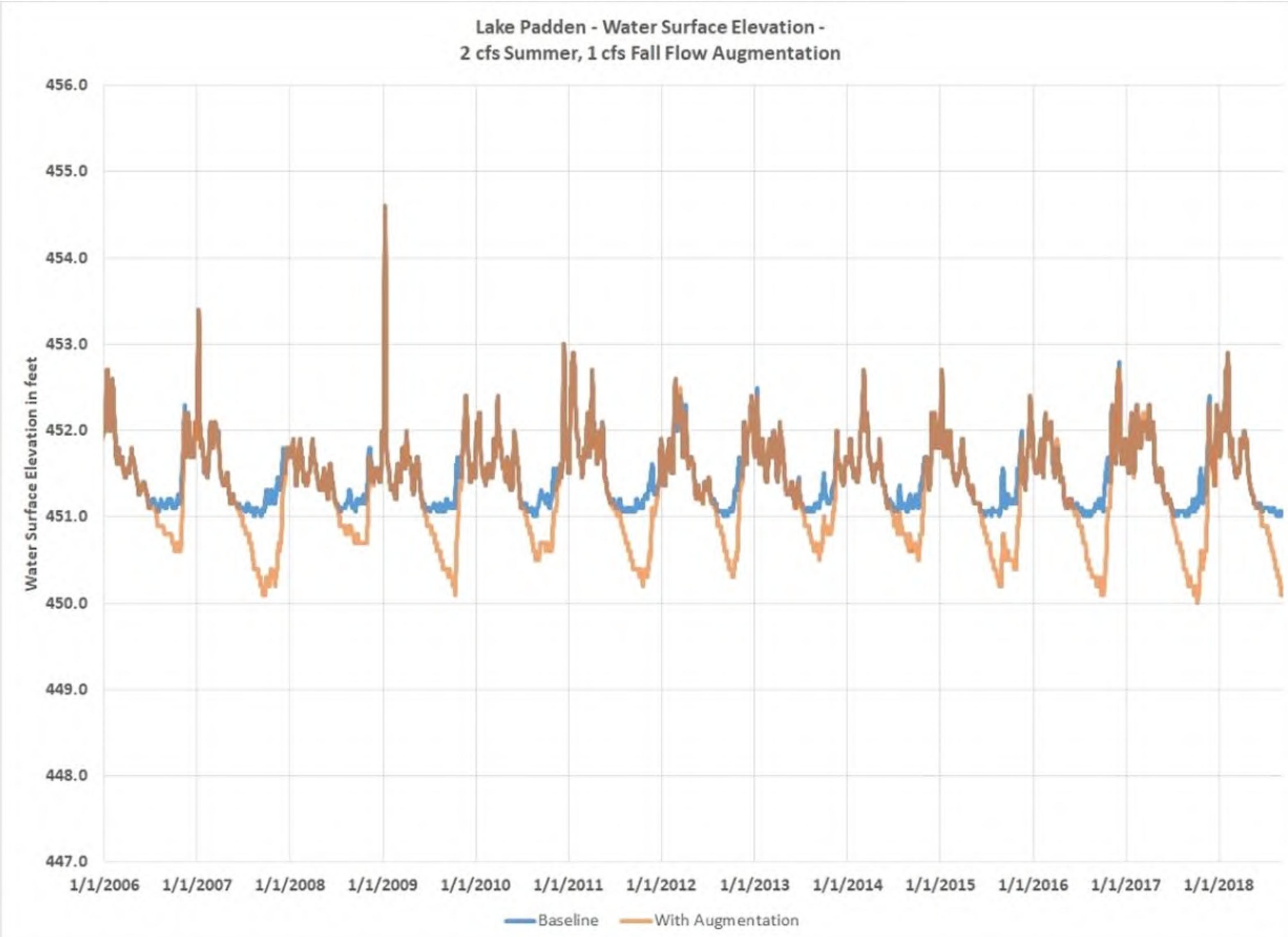

Figure 8. Simulated Lake Padden water level– medium augmentation.

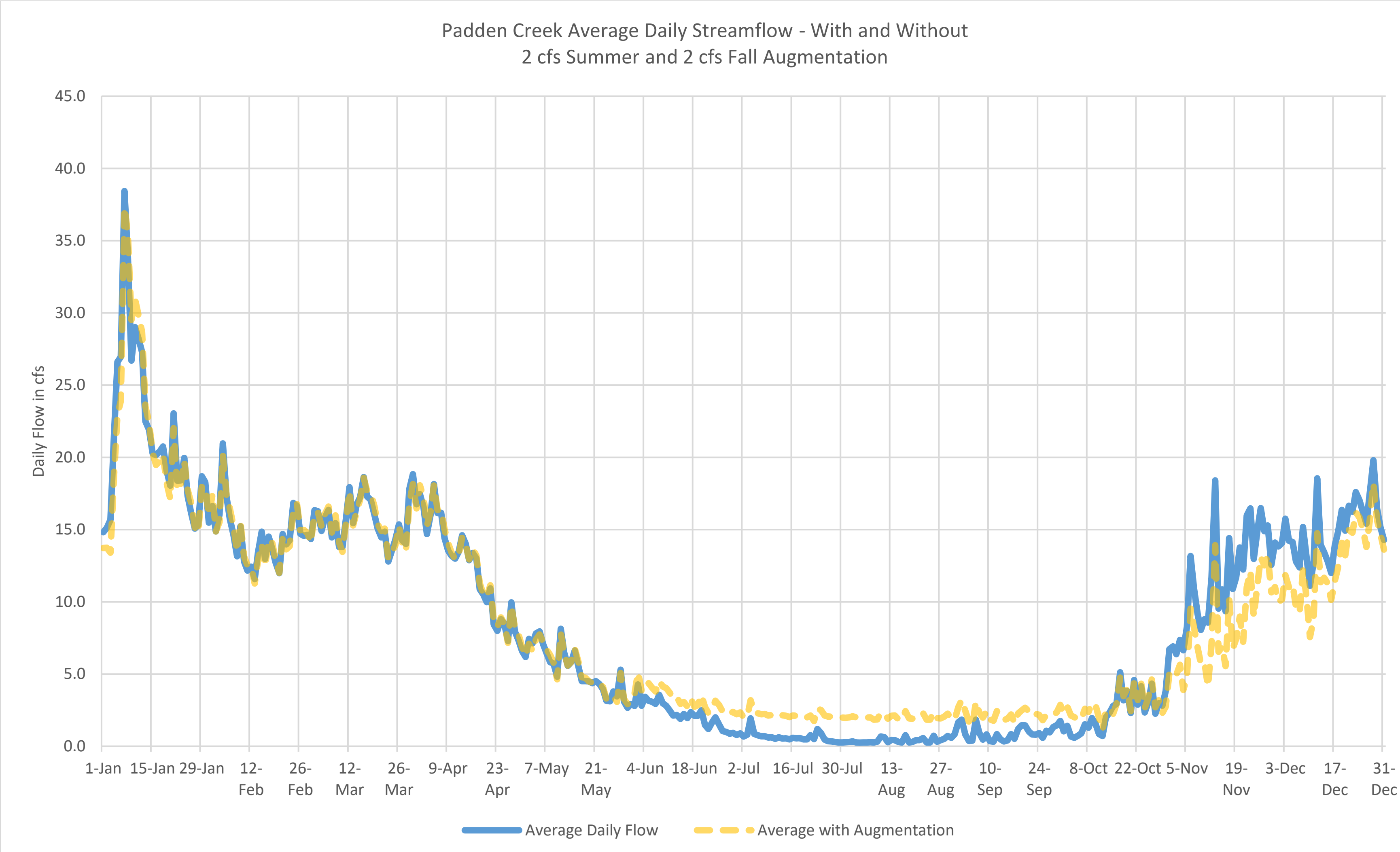

Figure 9. Simulated Padden Creek flow – maximum augmentation.

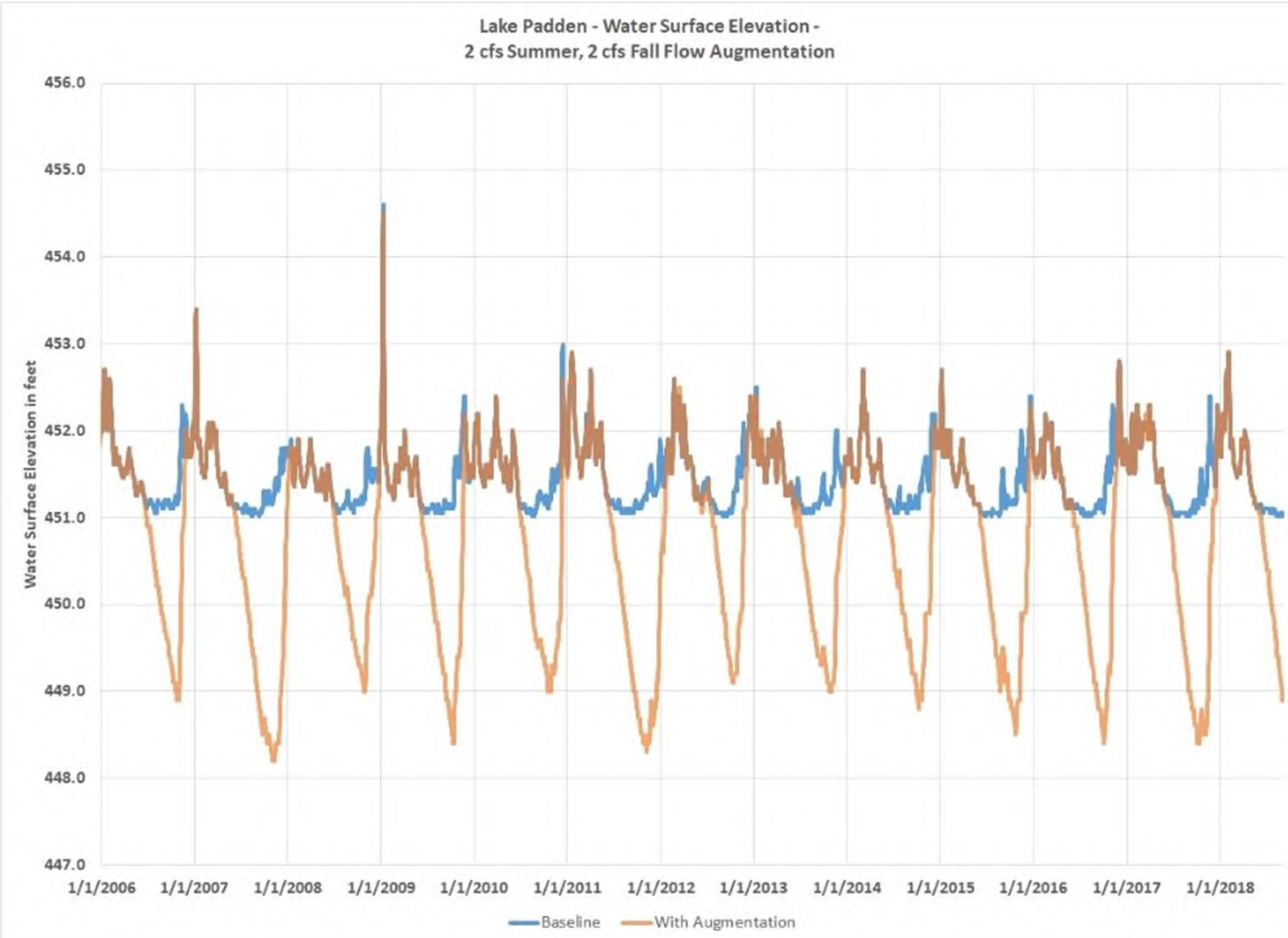

Figure 10. Simulated Lake Padden water level – maximum augmentation.

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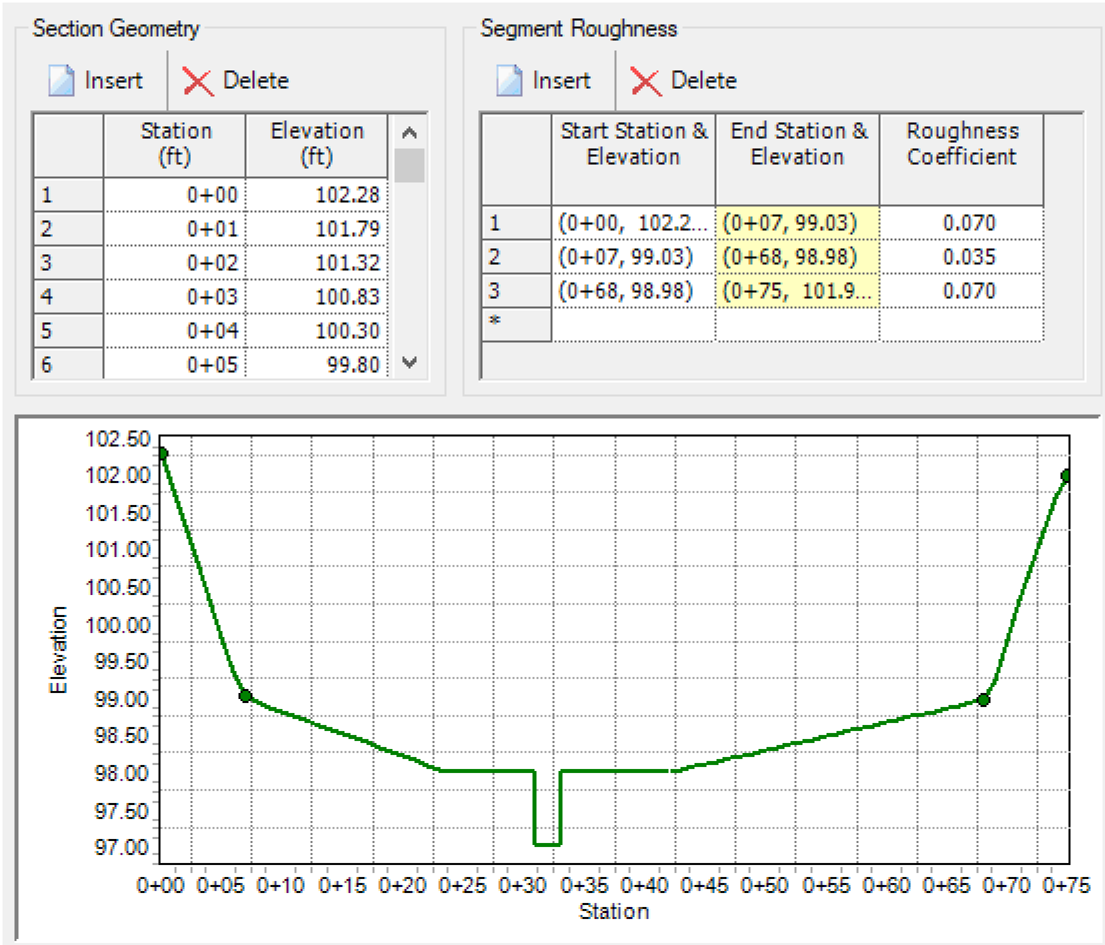

Figure 11. Habitat channel from 90 percent design plans.

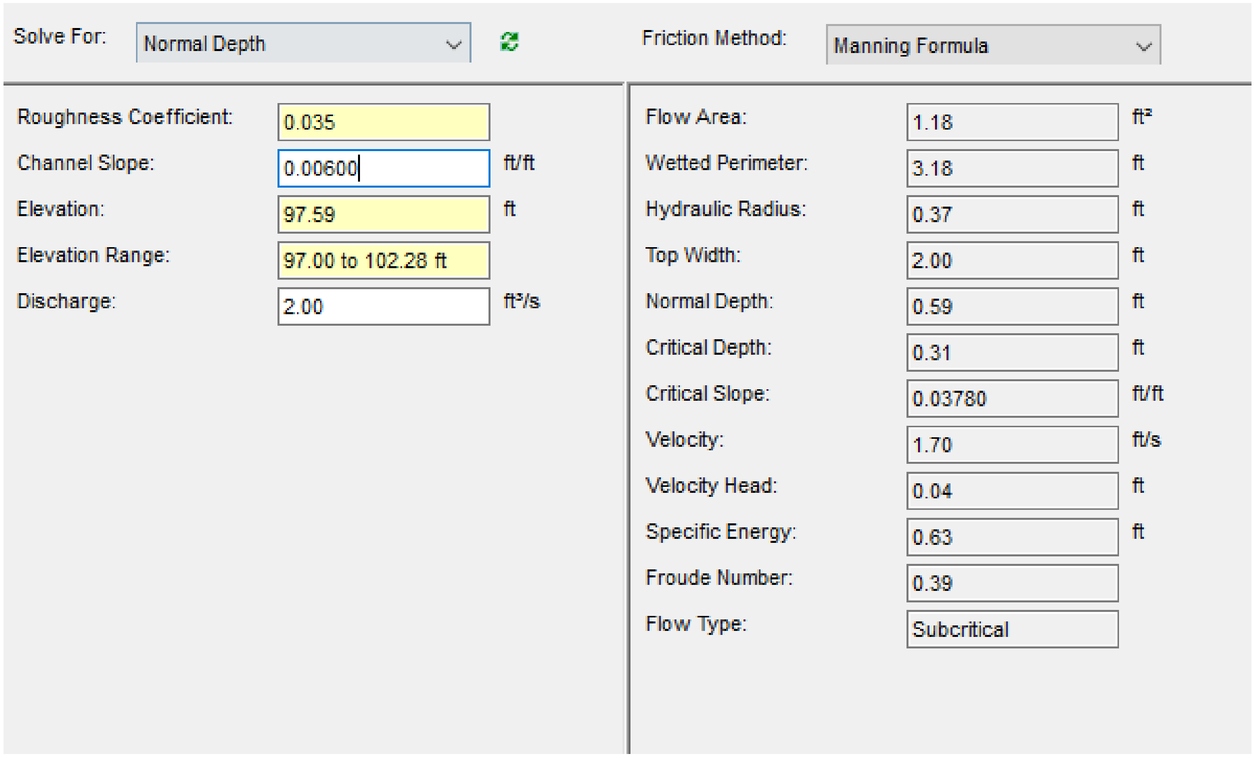

Figure 12. Channel depth with 1 cfs.

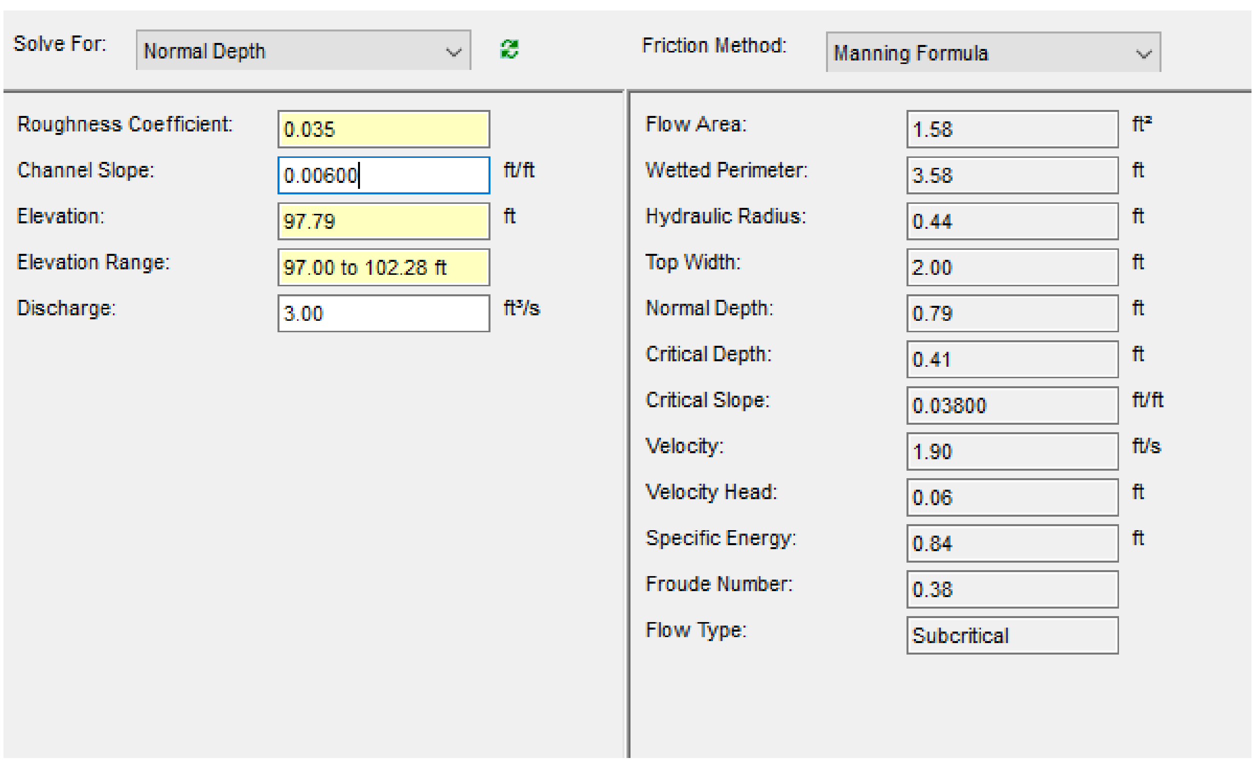

Figure 13. Channel depth, 3 cfs

Appendix D. CIP Exhibits

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Bellingham Stormwater Comprehensive Plan Update
Captial Improvement Plan

Large-CIP Scenario				
Category		Project Name	Project Cost	Category Total
Water Quality				**$ 5,737,000**
	1	D-04 Baker Creek WQ Facility	$ 3,700,000	
	2	D-01 Sqaulicum Way Filtration Vault	$ 288,000	
	3	D-02 Roeder Ave Filtration Vault	$ 249,000	
	4	D-03 Bill McDonald Pkwy Bioretention	$ 97,000	
	5	D-05 BR1 (W. Illinois St & Nome)	$ 287,000	
	6	D-06 BR2 (Cedarwood Ave & Pinewood Ave)	$ 143,000	
	7	D-07 BR3 (Cedarwood Ave & Firwood Ave)	$ 92,000	
	8	D-08 BR5 (Birchwood Ave & Firwood Ave)	$ 143,000	
	9	D-09 BR8 (Cheerywood, north of Cottonwood)	$ 111,000	
	10	D-10 BR9 (3230 to 3245 Lauralwood)	$ 340,000	
	11	D-11 BR10 (3126 Cedarwood)	$ 287,000	
Fish Passage				**$ 7,200,000**
	1	D-12 Squalicum Creek at Baker Creek Conflu	$ 200,000	
	2	D-13 SF Baker Creek at James St	$ 1,000,000	
	3	D-14 Baker Creek at James St	$ 1,000,000	
	4	D-15 Padden Creek at 16th St	$ 1,000,000	
	5	D-16 Squalicum Creek at Roeder Ave.	$ 4,000,000	
Infrastructure Renewal				**$ 9,470,500**
	1	D-17 Arbutus Alt. #2	$ 66,000	
	2	D-18 Willow Alt. #2	$ 565,000	
	3	D-19 Olive	$ 32,000	
	4	D-20 Laurel Alt. #1	$ 720,000	
	5	D-21 C Street	$ 695,000	
	6	D-22 Ellsworth	$ 792,500	
	7	D-23 Broadway Branch Outfall	$ 4,730,000	
	8	D-23 Broadway-Eldridge Alt#2	$ 1,870,000	
PURC				**$ 1,528,000**
	1	D-24 N. Graham Way	$ 300,000	
	2	D-25 Billy Frank Jr.	$ 200,000	
	3	D-26 Valencia St.	$ 1,028,000	
Conveyance Pipe Upgrades				**$ 20,041,500**
		Ellis Street #1	$ 2,787,000	
		Ellis Street #2	$ 1,764,000	
		King/Virginia/Lincoln	$ 3,048,000	
		Meador Avenue	$ 193,500	
		State Street	$ 597,000	
		Misc. Whatcom Outfalls	$ 264,000	
		Kentucky Street	$ 2,059,500	
		Orleans/Nevada	$ 1,387,500	
		Valencia/North/Verona	$ 4,995,000	
		Misc Improvements	$ 720,000	
		Lakeway Drive	$ 729,000	
		Raymond Street	$ 277,500	
		Lincoln Creek	$ 1,219,500	
CIP Total			**$ 43,977,000**	
Lake Whatcom Projects (funded from LWPAF)			**$ 1,000,000**	

Bellingham Stormwater Comprehensive Plan Update
Captial Improvement Plan

Medium-CIP Scenario			
Category	**Project Name**	**Project Cost**	**Category Total**
Water Quality			**$ 4,999,000**
	1 D-04 Baker Creek WQ Facility	$ 3,700,000	
	2 D-01 Sqaulicum Way Filtration Vault	$ 288,000	
	3 D-02 Roeder Ave Filtration Vault	$ 249,000	
	4 D-03 Bill McDonald Pkwy Bioretention	$ 97,000	
	5 D-05 BR1 (W. Illinois St & Nome)	$ 287,000	
	6 D-06 BR2 (Cedarwood Ave & Pinewood Ave)	$ 143,000	
	7 D-07 BR3 (Cedarwood Ave & Firwood Ave)	$ 92,000	
	8 D-08 BR5 (Birchwood Ave & Firwood Ave)	$ 143,000	
Fish Passage			**$ 2,200,000**
	1 D-12 Squalicum Creej at Baker Creek Conflu	$ 200,000	
	2 D-13 SF Baker Creek at James St	$ 1,000,000	
	3 D-14 Baker Creek at James St	$ 1,000,000	
Infrastructure Renewal			**$ 7,320,000**
	1 D-20 Laurel St Outfall	$ 720,000	
	2 D-23 Broadway Branch Outfall	$ 4,730,000	
	3 D-23 Eldridge Branch	$ 1,870,000	
PURC			**$ 1,528,000**
	1 D-24 N. Graham Way	$ 300,000	
	2 D-25 Billy Frank Jr.	$ 200,000	
	3 D-26 Valencia St.	$ 1,028,000	
Conveyance Pipe Upgrades			**$ 6,000,000**
	Annual Pipe Upgrades of $1 million for 6 years	$ 6,000,000	
CIP Total		**$ 22,047,000**	
Lake Whatcom Projects (funded from LWPAF)		**$ 1,000,000**	

Bellingham Stormwater Comprehensive Plan Update
Capital Improvement Plan

Small-CIP Scenario						
Category		**Project Name**		**Project Cost**		**Category Total**
Water Quality					**$**	**1,299,000**
	1	D-01 Sqaulicum Way Filtration Vault	$	288,000		
	2	D-02 Roeder Ave Filtration Vault	$	249,000		
	3	D-03 Bill McDonald Pkwy Bioretention	$	97,000		
	4	D-05 BR1 (W. Illinois St & Nome)	$	287,000		
	5	D-06 BR2 (Cedarwood Ave & Pinewood Ave)	$	143,000		
	6	D-07 BR3 (Cedarwood Ave & Firwood Ave)	$	92,000		
	7	D-08 BR5 (Birchwood Ave & Firwood Ave)	$	143,000		
Fish Passage					**$**	**1,200,000**
	1	D-12 Squalicum Creej at Baker Creek Conflu	$	200,000		
	2	D-13 SF Baker Creek at James St	$	1,000,000		
Infrastructure Renewal					**$**	**5,450,000**
	1	D-20 Laurel Alt. #1	$	720,000		
	2	D-23 Broadway Branch Outfall	$	4,730,000		
PURC					**$**	**1,528,000**
	1	D-24 N. Graham Way	$	300,000		
	2	D-25 Billy Frank Jr.	$	200,000		
	3	D-26 Valencia St.	$	1,028,000		
Conveyance Pipe Upgrades					**$**	**6,000,000**
		Annual Pipe Upgrades of $1 million for 6 years	$	6,000,000		
CIP Total			**$**	**15,477,000**		
Lake Whatcom Projects (funded from LWPAF)			**$**	**1,000,000**		

Appendix E. CIP Technical Information

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Whatcom County Area, Washington

82—Kickerville-Urban land complex, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2j64
Elevation: 60 to 100 feet
Mean annual precipitation: 35 to 55 inches
Mean annual air temperature: 50 degrees F
Frost-free period: 170 days
Farmland classification: Not prime farmland

Map Unit Composition

Kickerville and similar soils: 50 percent
Urban land: 30 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kickerville

Setting

Landform: Terraces
Parent material: Loess and volcanic ash over glacial outwash

Typical profile

H1 - 0 to 9 inches: ashy silt loam
H2 - 9 to 22 inches: ashy silt loam
H3 - 22 to 32 inches: very gravelly loam
H4 - 32 to 60 inches: very gravelly sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 20 to 40 inches to strongly contrasting textural stratification
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.7 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 1
Hydrologic Soil Group: B
Forage suitability group: Soils with Few Limitations (G002XN502WA)
Hydric soil rating: No

Description of Urban Land

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: No

Minor Components

Everett

Percent of map unit: 5 percent
Hydric soil rating: No

Clipper, undrained

Percent of map unit: 4 percent
Landform: Terraces
Hydric soil rating: Yes

Chuckanut

Percent of map unit: 3 percent
Hydric soil rating: No

Birchbay

Percent of map unit: 3 percent
Hydric soil rating: No

Nati

Percent of map unit: 3 percent
Hydric soil rating: No

Whatcom

Percent of map unit: 2 percent
Hydric soil rating: No

Data Source Information

Soil Survey Area: Whatcom County Area, Washington
Survey Area Data: Version 19, Sep 16, 2019

Whatcom County Area, Washington

159—Squalicum-Urban land complex, 5 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2j2p
Elevation: 200 to 600 feet
Mean annual precipitation: 45 inches
Mean annual air temperature: 48 degrees F
Frost-free period: 140 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Squalicum and similar soils: 50 percent
Urban land: 30 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Squalicum

Setting

Landform: Hillslopes
Parent material: Volcanic ash, loess, and slope alluvium over glacial drift

Typical profile

H1 - 0 to 7 inches: gravelly ashy loam
H2 - 7 to 30 inches: gravelly ashy loam
H3 - 30 to 44 inches: gravelly ashy loam
H4 - 44 to 60 inches: gravelly ashy loam

Properties and qualities

Slope: 5 to 20 percent
Depth to restrictive feature: 40 to 60 inches to densic material
Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 39 to 59 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Forage suitability group: Soils with Moderate Limitations (G002XF603WA)
Hydric soil rating: No

Description of Urban Land

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: No

Minor Components

Everett

Percent of map unit: 5 percent
Hydric soil rating: No

Whatcom

Percent of map unit: 5 percent
Hydric soil rating: No

Labounty, undrained

Percent of map unit: 4 percent
Landform: Depressions
Hydric soil rating: Yes

Sehome

Percent of map unit: 3 percent
Hydric soil rating: No

Squires

Percent of map unit: 2 percent
Hydric soil rating: No

Blethen

Percent of map unit: 1 percent
Hydric soil rating: No

Data Source Information

Soil Survey Area: Whatcom County Area, Washington
Survey Area Data: Version 19, Sep 16, 2019

AGENCY USE ONLY

Date received:

Agency reference #: ______

Tax Parcel #(s): ______

US Army Corps of Engineers
Seattle District

WASHINGTON STATE
Joint Aquatic Resources Permit Application (JARPA) Form[1,2]

USE BLACK OR BLUE INK TO ENTER ANSWERS IN THE WHITE SPACES BELOW.

Part 1–Project Identification

1. Project Name (A name for your project that you create. Examples: Smith's Dock or Seabrook Lane Development) [help]
Valencia Street Pipeline Repairs

Part 2–Applicant

The person and/or organization responsible for the project. [help]

2a. Name (Last, First, Middle)			
William M. Reilly			
2b. Organization (If applicable)			
City of Bellingham, Public Works Dept.			
2c. Mailing Address (Street or PO Box)			
2221 Pacific Street			
2d. City, State, Zip			
Bellingham, WA 98229			
2e. Phone (1)	**2f.** Phone (2)	**2g.** Fax	**2h.** E-mail
(360)778-7955	(360)820-4699	(360)778-7801	wreilly@cob.org

[1]Additional forms may be required for the following permits:

- If your project may qualify for Department of the Army authorization through a Regional General Permit (RGP), contact the U.S. Army Corps of Engineers for application information (206) 764-3495.
- If your project might affect species listed under the Endangered Species Act, you will need to fill out a Specific Project Information Form (SPIF) or prepare a Biological Evaluation. Forms can be found at http://www.nws.usace.army.mil/Missions/CivilWorks/Regulatory/PermitGuidebook/EndangeredSpecies.aspx.
- Not all cities and counties accept the JARPA for their local Shoreline permits. If you need a Shoreline permit, contact the appropriate city or county government to make sure they accept the JARPA.

[2]To access an online JARPA form with [help] screens, go to http://www.epermitting.wa.gov/site/alias__resourcecenter/jarpa_jarpa_form/9984/jarpa_form.aspx.

For other help, contact the Governor's Office of Regulatory Assistance at 1-800-917-0043 or help@ora.wa.gov.

Part 3–Authorized Agent or Contact

Person authorized to represent the applicant about the project. (Note: Authorized agent(s) must sign 11b of this application.) [help]

3a. Name (Last, First, Middle)			
Mike Olinger			
3b. Organization (If applicable)			
City of Bellingham, Public Works Dept.			
3c. Mailing Address (Street or PO Box)			
2221 Pacific Street			
3d. City, State, Zip			
Bellingham, WA 98229			
3e. Phone (1)	**3f.** Phone (2)	**3g.** Fax	**3h.** E-mail
(360)778-7725	(360)510-6349	(360)778-7701	malinger@cob.org

Part 4–Property Owner(s)

Contact information for people or organizations owning the property(ies) where the project will occur. Consider both **upland and aquatic** ownership because the upland owners may not own the adjacent aquatic land. [help]

☐ Same as applicant. (Skip to Part 5.)

☒ Repair or maintenance activities on existing rights-of-way or easements. (Skip to Part 5.)

☐ There are multiple upland property owners. Complete the section below and fill out JARPA Attachment A for each additional property owner.

☐ Your project is on Department of Natural Resources (DNR)-managed aquatic lands. If you don't know, contact the DNR at (360) 902-1100 to determine aquatic land ownership. If yes, complete JARPA Attachment E to apply for the Aquatic Use Authorization.

4a. Name (Last, First, Middle)			
4b. Organization (If applicable)			
4c. Mailing Address (Street or PO Box)			
4d. City, State, Zip			
4e. Phone (1)	**4f.** Phone (2)	**4g.** Fax	**4h.** E-mail
( )	( )	( )	

Part 5–Project Location(s)

Identifying information about the property or properties where the project will occur. [help]

☐ There are multiple project locations (e.g. linear projects). Complete the section below and use JARPA Attachment B for each additional project location.

5a. Indicate the type of ownership of the property. (Check all that apply.) [help]

☐ Private
☐ Federal
☒ Publicly owned (state, county, city, special districts like schools, ports, etc.)
☐ Tribal
☐ Department of Natural Resources (DNR) – managed aquatic lands (Complete JARPA Attachment E)

5b. Street Address (Cannot be a PO Box. If there is no address, provide other location information in 5p.) [help]

Valencia Street 1900 block to 2200 block

5c. City, State, Zip (If the project is not in a city or town, provide the name of the nearest city or town.) [help]

Bellingham, WA 98229

5d. County [help]

Whatcom

5e. Provide the section, township, and range for the project location. [help]

¼ Section	Section	Township	Range
Northeast	29	38	03

5f. Provide the latitude and longitude of the project location. [help]

- Example: 47.03922 N lat. / -122.89142 W long. (Use decimal degrees - NAD 83)

From 48.76 N lat./-122.447 W long. To 48.755 N lat./-122.447 W long.

5g. List the tax parcel number(s) for the project location. [help]

- The local county assessor's office can provide this information.

Not applicable, all in ROW

5h. Contact information for all adjoining property owners. (If you need more space, use JARPA Attachment C.) [help]

Name	Mailing Address	Tax Parcel # (if known)
See Jarpa Attachment C		

5i. List all wetlands on or adjacent to the project location. [help]	
None known	
5j. List all waterbodies (other than wetlands) on or adjacent to the project location. [help]	
Fever Creek, Whatcom Creek	
5k. Is any part of the project area within a 100-year floodplain? [help]	
☐ Yes ☒ No ☐ Don't know	
5l. Briefly describe the vegetation and habitat conditions on the property. [help]	
Some adjacent lawns, mainly commercial developed property adjacent to ROW	
5m. Describe how the property is currently used. [help]	
City ROW containing street, sidewalks, utilities, parking, gravel shoulders	
5n. Describe how the adjacent properties are currently used. [help]	
Mostly commercial or industrial with a few residential structures.	
5o. Describe the structures (above and below ground) on the property, including their purpose(s) and current condition. [help]	
See above. Water, sewer, storm underground. Telephone, power, cable partially underground partially overhead. Storm line piping from 42 inches to 54 inches in diameter. Transmits urban runoff and remnant portion of Fever Creek.	
5p. Provide driving directions from the closest highway to the project location, and attach a map. [help]	
From South, Interstate Five to Iowa Street Exit 254. Turn east on Iowa Street proceed ¾ miles to Valencia Street. Turn right and drive 500 feet to Valencia Bridge. Outlet from pipe is on north bank of Whatcom Creek west of bridge. Map attached showing location of piping to be repaired.	

Part 6–Project Description

6a. Briefly summarize the overall project. You can provide more detail in 6b. [help]

Project to temporarily bypass Upper Fever Creek into Lower Fever creek to allow the repair of a portion of a pipe system that carries water from a developed area of the City, along with a remnant portion of Fever Creek, a tributary to Whatcom Creek.

6b. Describe the purpose of the project and why you want or need to perform it. [help]

The purpose of the project is to bypass Upper Fever Creek into Lower Fever Creek for a period up to two weeks from the pipe system that now carries a mixture of creek and urban runoff to Whatcom Creek. This will allow for the repair of the invert of this pipe system (5 manholes, 5 sections of piping). Rocks running through the system have scratched the invert resulting in corrosion. The pipe is in good condition except for the invert corrosion. This repair is necessary to prevent failure of the piping prior to its design life. It is presently 29 years old. The design life for a fully coated pipe should be over 50 years. Failure to repair would result in a collapsed pipe, roadway failure, adjacent property damage and sediment delivered to Whatcom Creek.

HISTORY

The pipe system was constructed in 1984 as part of an improvement project to alleviate flooding and improve roadways in the Iowa Street business area. At that time, the flow in Fever Creek was split. The pipe system discussed here conveys the upper reaches of Fever Creek along Valencia Street to a point in Whatcom Creek 3,000 feet upstream from the original discharge point. The lower remnant areas of Fever Creek are drained by underground piping to that traditional discharge point at Nevada Street.

Prior to the project in 1984 Fever Creek was conveyed by a mix of public and private pipe systems that were grossly undersized. Overflows through manufacturing areas and streets carried pollutants into Whatcom Creek. This project was constructed with a Hydraulic Projects Approval from the Department of Fisheries (attached). A map of the project area and maps of the larger Fever Creek system are also attached.

6c. Indicate the project category. (Check all that apply) [help]

☐ Commercial ☐ Residential ☐ Institutional ☐ Transportation ☐ Recreational
☒ Maintenance ☐ Environmental Enhancement

6d. Indicate the major elements of your project. (Check all that apply) [help]

☐ Aquaculture	☒ Culvert/System Piping	☐ Float	☐ Retaining Wall (upland)
☐ Bank Stabilization	☐ Dam / Weir	☐ Floating Home	☐ Road
☐ Boat House	☐ Dike / Levee / Jetty	☐ Geotechnical Survey	☐ Scientific Measurement Device
☐ Boat Launch	☐ Ditch	☐ Land Clearing	☐ Stairs
☐ Boat Lift	☐ Dock / Pier	☐ Marina / Moorage	☐ Stormwater facility
☐ Bridge	☐ Dredging	☐ Mining	☐ Swimming Pool
☐ Bulkhead	☐ Fence	☐ Outfall Structure	

☐ Buoy ☐ Channel Modification	☐ Ferry Terminal ☐ Fishway	☐ Piling/Dolphin ☐ Raft	☒ Utility Line
☒ Other: Pipe Maintenance			

6e. Describe how you plan to construct each project element checked in 6d. Include specific construction methods and equipment to be used. [help]

- Identify where each element will occur in relation to the nearest waterbody.
- Indicate which activities are within the 100-year floodplain.

FISH EXCLUSION

The existing pipes have an average slope of 1% with the slope at the outlet being 1.4% with a drop to Whatcom Creek at normal depth (see photo). Three manholes have a 0.3 foot drop across them and one manhole has a 1.2 foot drop. Attached to this application is a velocity/depth chart indicating that velocity varies from 3.8 fps to over 9 fps for flows varying from 1 to 24 cfs with 24 cfs being roughly equivalent to the 2 year flow rate. For the same flows, the depth varies from 0.21 feet to 0.98 feet. This information is provided to describe the impassability of this pipe system. While there may be some resident fish above this pipe system it is unlikely that we have fish residing within the pipe system itself.

With the above being said, it is proposed that Fever Creek will be screened above the existing pipe system to prevent any upstream fish (if any are present) from entering the system during the maintenance activity. Any resident fish will be held at an appropriate holding pool. A screened pump or gravity line will continue to pump creek water through the pipe system and the system will be walked to assure no juveniles are present. Once it is verified that no fish are present the creek will be bypassed by pump or gravity into the remnant lower section of Fever Creek that outlets through separate piping to Whatcom Creek at Nevada Street. A fish exclusion screen will be set at the outlet end of the pipe system being rehabilitated along with internal dam/s to prevent any process water from getting to Whatcom Creek.

Invert Repair

Once the water from Fever Creek is cut off and the maintenance dams are in place the pipes will be cleaned using high pressure water. The water from this operation will pumped or vactored from the system and disposed of in the sanitary sewer.

The pipes are then ready for application of 12,000 psi concrete grout (specs and testing attached) to the invert of the pipe to both fill in existing pinholes and to create a new invert for the pipes. The grout will be mixed on site and pumped into the pipes for application. The grout will be allowed to cure for a minimum of 3 days. Prior to putting the pipe system back into service the City will flow water back into the system and evacuate that flow to sanitary sewer for a minimum of 2 hours to wash any residual concrete from the invert area. Upon completion, the pipe system will be put back into operation.

6f. What are the anticipated start and end dates for project construction? (Month/Year) [help]

- If the project will be constructed in phases or stages, use JARPA Attachment D to list the start and end dates of each phase or stage.

Start date: _August 2013_____ End date: ___September 2013_____ ☐ See JARPA Attachment D

6g. Fair market value of the project, including materials, labor, machine rentals, etc. [help]

$ 300,000

6h. Will any portion of the project receive federal funding? [help]

- **If yes**, list each agency providing funds.

☐ Yes ☒ No ☐ Don't know

Part 7–Wetlands: Impacts and Mitigation

☐ Check here if there are wetlands or wetland buffers on or adjacent to the project area. (If there are none, skip to Part 8.) [help]

7a. Describe how the project has been designed to avoid and minimize adverse impacts to wetlands. [help]

☐ Not applicable

7b. Will the project impact wetlands? [help]

☐ Yes ☐ No ☐ Don't know

7c. Will the project impact wetland buffers? [help]

☐ Yes ☐ No ☐ Don't know

7d. Has a wetland delineation report been prepared? [help]

- **If Yes**, submit the report, including data sheets, with the JARPA package.

☐ Yes ☐ No

7e. Have the wetlands been rated using the Western Washington or Eastern Washington Wetland Rating System? [help]

- **If Yes**, submit the wetland rating forms and figures with the JARPA package.

☐ Yes ☐ No ☐ Don't know

7f. Have you prepared a mitigation plan to compensate for any adverse impacts to wetlands? [help]

- **If Yes**, submit the plan with the JARPA package and answer 7g.
- **If No, or Not applicable**, explain below why a mitigation plan should not be required.

☐ Yes ☐ No ☐ Not applicable

7g. Summarize what the mitigation plan is meant to accomplish, and describe how a watershed approach was used to design the plan. [help]

7h. Use the table below to list the type and rating of each wetland impacted, the extent and duration of the impact, and the type and amount of mitigation proposed. Or if you are submitting a mitigation plan with a similar table, you can state (below) where we can find this information in the plan. [help]

Activity (fill, drain, excavate, flood, etc.)	Wetland Name[1]	Wetland type and rating category[2]	Impact area (sq. ft. or Acres)	Duration of impact[3]	Proposed mitigation type[4]	Wetland mitigation area (sq. ft. or acres)

[1] If no official name for the wetland exists, create a unique name (such as "Wetland 1"). The name should be consistent with other project documents, such as a wetland delineation report.
[2] Ecology wetland category based on current Western Washington or Eastern Washington Wetland Rating System. Provide the wetland rating forms with the JARPA package.
[3] Indicate the days, months or years the wetland will be measurably impacted by the activity. Enter "permanent" if applicable.
[4] Creation (C), Re-establishment/Rehabilitation (R), Enhancement (E), Preservation (P), Mitigation Bank/In-lieu fee (B)

Page number(s) for similar information in the mitigation plan, if available: ____________________

7i. For all filling activities identified in 7h, describe the source and nature of the fill material, the amount in cubic yards that will be used, and how and where it will be placed into the wetland. [help]

7j. For all excavating activities identified in 7h, describe the excavation method, type and amount of material in cubic yards you will remove, and where the material will be disposed. [help]

Part 8–Waterbodies (other than wetlands): Impacts and Mitigation

In Part 8, "waterbodies" refers to non-wetland waterbodies. (See Part 7 for information related to wetlands.) [help]

☒ Check here if there are waterbodies on or adjacent to the project area. (If there are none, skip to Part 9.)

8a. Describe how the project is designed to avoid and minimize adverse impacts to the aquatic environment. [help]

☐ Not applicable

See explanation in part 6E for prevention of impacts.

8b. Will your project impact a waterbody or the area around a waterbody? [help]

☒ Yes ☐ No

Only from diverting flow from the present outfall to the historic outfall.

8c. Have you prepared a mitigation plan to compensate for the project's adverse impacts to non-wetland waterbodies? [help]

- **If Yes,** submit the plan with the JARPA package and answer 8d.
- **If No, or Not applicable,** explain below why a mitigation plan should not be required.

☐ Yes ☐ No ☒ Not applicable

This is a maintenance activity associated with a previously approved pipe system. Impacts are temporary in nature with no impact to existing fish (if any are present) or habitat. The impact proposed is rerouting water from, this outfall to Whatcom Creek, to the Nevada Street outfall..

8d. Summarize what the mitigation plan is meant to accomplish. Describe how a watershed approach was used to design the plan.

- If you already completed 7g you do not need to restate your answer here. [help]

Maintenance activity. N/A

8e. Summarize impact(s) to each waterbody in the table below. [help]

Activity (clear, dredge, fill, pile drive, etc.)	Waterbody name[1]	Impact location[2]	Duration of impact[3]	Amount of material (cubic yards) to be placed in or removed from waterbody	Area (sq. ft. or linear ft.) of waterbody directly affected
Bypass Flow to Lower Fever Creek	Upper Fever Creek	Within water body	2 weeks	0	1800 lineal feet of pipe system will be vacated for maintenance

Pipe Maintenance	Valencia Pipe System Upper Fever Creek	Within Pipe System	2 weeks	Approximately 20 cy of grout will be placed within pipe to repair the invert	1800 lineal feet of pipe system

[1] If no official name for the waterbody exists, create a unique name (such as "Stream 1") The name should be consistent with other documents provided.
[2] Indicate whether the impact will occur in or adjacent to the waterbody. If adjacent, provide the distance between the impact and the waterbody and indicate whether the impact will occur within the 100-year flood plain.
[3] Indicate the days, months or years the waterbody will be measurably impacted by the work. Enter "permanent" if applicable.

8f. For all activities identified in 8e, describe the source and nature of the fill material, amount (in cubic yards) you will use, and how and where it will be placed into the waterbody. [help]

See 6E above as well. The grout is specifically formulated for use in pipe systems. It is a high strength grout designed for impact resistance.

8g. For all excavating or dredging activities identified in 8e, describe the method for excavating or dredging, type and amount of material you will remove, and where the material will be disposed. [help]

N/A

Part 9–Additional Information

Any additional information you can provide helps the reviewer(s) understand your project. Complete as much of this section as you can. It is ok if you cannot answer a question.

9a. If you have already worked with any government agencies on this project, list them below. [help]

Agency Name	Contact Name	Phone	Most Recent Date of Contact
		( )	
		( )	
		( )	

9b. Are any of the wetlands or waterbodies identified in Part 7 or Part 8 of this JARPA on the Washington

Department of Ecology's 303(d) List? [help]

- **If Yes,** list the parameter(s) below.
- If you don't know, use Washington Department of Ecology's Water Quality Assessment tools at: http://www.ecy.wa.gov/programs/wq/303d/.

☒ Yes ☐ No

Fever Creek appears to be listed for bacteria, DO, zinc and temperature. TMDL's for bacteria and temperature are in progress for the Whatcom Creek watershed. Fever Creek is a tributary to Whatcom and is included in those TMDL's.

9c. What U.S. Geological Survey Hydrological Unit Code (HUC) is the project in? [help]

- Go to http://cfpub.epa.gov/surf/locate/index.cfm to help identify the HUC.

17110002

9d. What Water Resource Inventory Area Number (WRIA #) is the project in? [help]

- Go to http://www.ecy.wa.gov/services/gis/maps/wria/wria.htm to find the WRIA #.

WRIA 1

9e. Will the in-water construction work comply with the State of Washington water quality standards for turbidity? [help]

- Go to http://www.ecy.wa.gov/programs/wq/swqs/criteria.html for the standards.

☒ Yes ☐ No ☐ Not applicable **In water work limited to set up of bypass and fish exclusion.**

9f. If the project is within the jurisdiction of the Shoreline Management Act, what is the local shoreline environment designation? [help]

- If you don't know, contact the local planning department.
- For more information, go to: http://www.ecy.wa.gov/programs/sea/sma/laws_rules/173-26/211_designations.html.

☐ Rural ☒ Urban ☐ Natural ☐ Aquatic ☐ Conservancy ☐ Other ______________

9g. What is the Washington Department of Natural Resources Water Type? [help]

- Go to http://www.dnr.wa.gov/BusinessPermits/Topics/ForestPracticesApplications/Pages/fp_watertyping.aspx for the Forest Practices Water Typing System.

☐ Shoreline ☒ Fish ☐ Non-Fish Perennial ☐ Non-Fish Seasonal

Note: The FPARS Mapping system erroneously shows Fever Creek as being an open system. It also does not indicate the flow diversion that occurred in 1984. The system has no data included for the system but calls it a Type F. A copy of the Fever Creek system is provided with areas of piping and open channel highlighted. Some resident fish may reside in some portions of the system but the pipe in question is not a part of the habitat.

9h. Will this project be designed to meet the Washington Department of Ecology's most current stormwater manual? [help]

- **If No**, provide the name of the manual your project is designed to meet.

☒ Yes ☐ No

Name of manual: 2012 version has been adopted by Bellingham. It's use for this project is not really germane.

9i. Does the project site have known contaminated sediment? [help]

- **If Yes**, please describe below.

☐ Yes ☒ No

No excavation will occur with this project. If there are contaminated soils in the area sealing the pipe from that contamination would improve water quality.

9j. If you know what the property was used for in the past, describe below. [help]

Since early 1900's this has been a City ROW and roadway.

9k. Has a cultural resource (archaeological) survey been performed on the project area? [help]

- **If Yes**, attach it to your JARPA package.

☐ Yes ☒ No

Since there is no excavation for this project it is assumed that cultural resources is not required.

9l. Name each species listed under the federal Endangered Species Act that occurs in the vicinity of the project area or might be affected by the proposed work. [help]

None known to inhabit Fever Creek. Salmonids are within the Whatcom Creek receiving water but are not a part of the ESU of concern in this area.

9m. Name each species or habitat on the Washington Department of Fish and Wildlife's Priority Habitats and Species List that might be affected by the proposed work. [help]

No species or habitat will be affected. Repair of the pipe will be done while dry.

Part 10–SEPA Compliance and Permits

Use the resources and checklist below to identify the permits you are applying for.

- Online Project Questionnaire at http://apps.ecy.wa.gov/opas/.
- Governor's Office of Regulatory Assistance at (800) 917-0043 or help@ora.wa.gov.
- For a list of addresses to send your JARPA to, click on agency addresses for completed JARPA.

10a. Compliance with the State Environmental Policy Act (SEPA). (Check all that apply.) [help]

- For more information about SEPA, go to www.ecy.wa.gov/programs/sea/sepa/e-review.html.

☐ A copy of the SEPA determination or letter of exemption is included with this application.

☐ A SEPA determination is pending with ______________ (lead agency). The expected decision date is ____________.

☐ I am applying for a Fish Habitat Enhancement Exemption. (Check the box below in 10b.) [help]

☒ This project is exempt (choose type of exemption below).

☒ Categorical Exemption. Under what section of the SEPA administrative code (WAC) is it exempt?

WAC 197–11–800 Categorical exemptions

(3) **Repair, remodeling and maintenance activities**. The following activities shall be categorically exempt: The repair, remodeling, maintenance, or minor alteration of existing private or public structures, facilities or equipment, including utilities, involving no material expansions or changes in use beyond that previously existing; except that, where undertaken wholly or in part on lands covered by water, only minor repair or replacement of structures may be exempt (examples include repair or replacement of piling, ramps, floats, or mooring buoys, or minor repair, alteration, or maintenance of docks).

City Note: This maintenance is considered by the City to be exempt once Fever Creek water is diverted to its historic outfall. When not containing waters of the State the pipe system is merely a portion of the City's stormwater piping network. By virtue of being piped, there are no lands covered with water and this pipe system was not located within any historic creek channel. Jarpa and requested HPA are for the temporary bypass of Fever Creek water to its historic outfall location.

☐ SEPA is pre-empted by federal law.

10b. Indicate the permits you are applying for. (Check all that apply.) [help]

LOCAL GOVERNMENT

Local Government Shoreline permits:

☐ Substantial Development ☐ Conditional Use ☐ Variance

☒ Shoreline Exemption Type (explain):

From Bellingham Municipal Code (BMC) Shoreline Development 22.05.020 Exemptions,B. Development,

b. Normal maintenance or repair of existing structures or developments, including damage by accident, fire or elements. "Normal maintenance" includes those usual acts to prevent a decline, lapse or cessation from a lawfully established condition. "Normal repair" means to restore a development to a state comparable to its original condition within a reasonable period after decay or partial destruction except where repair causes substantial adverse effects to the shoreline resource or environment. Replacement of a structure or development may be authorized as repair where such replacement is the common method of repair for the type of structure or development and the replacement structure or development is comparable to the original structure or development including but not limited to its size, shape, configuration, location and external appearance and the replacement does not cause substantial adverse effects to shoreline resources or environment;

Other city/county permits:

☐ Floodplain Development Permit ☒ Critical Areas Ordinance **Applicability to be determined.**

STATE GOVERNMENT

Washington Department of Fish and Wildlife:

☒ Hydraulic Project Approval (HPA) ☐ Fish Habitat Enhancement Exemption – Attach Exemption Form

Effective July 10, 2012, you must submit a check for $150 to Washington Department of Fish and Wildlife, unless your project qualifies for an exemption or alternative payment method below. **Do not send cash.**

Check the appropriate boxes:

☐ $150 check enclosed. (Check # 487227)
Attach check made payable to Washington Department of Fish and Wildlife.

☐ Charge to billing account under agreement with WDFW. (Agreement #)

☐ My project is exempt from the application fee. (Check appropriate exemption)
- ☐ HPA processing is conducted by applicant-funded WDFW staff. (Agreement #)
- ☐ Mineral prospecting and mining.
- ☐ Project occurs on farm and agricultural land.
(Attach a copy of current land use classification recorded with the county auditor, or other proof of current land use.)
- ☐ Project is a modification of an existing HPA originally applied for, prior to July 10, 2012. (HPA # 0019936-0)

Washington Department of Natural Resources:

☐ Aquatic Use Authorization

Complete JARPA Attachment E and submit a check for $25 payable to the Washington Department of Natural Resources. **Do not send cash.**

Washington Department of Ecology:

☐ Section 401 Water Quality Certification

FEDERAL GOVERNMENT

United States Department of the Army permits (U.S. Army Corps of Engineers):

☐ Section 404 (discharges into waters of the U.S.) ☐ Section 10 (work in navigable waters)

United States Coast Guard permits:

☐ Private Aids to Navigation (for non-bridge projects)

Part 11–Authorizing Signatures

Signatures are required before submitting the JARPA package. The JARPA package includes the JARPA form, project plans, photos, etc. [help]

11a. Applicant Signature (required) [help]

I certify that to the best of my knowledge and belief, the information provided in this application is true, complete, and accurate. I also certify that I have the authority to carry out the proposed activities, and I agree to start work only after I have received all necessary permits.

I hereby authorize the agent named in Part 3 of this application to act on my behalf in matters related to this application. WmR (initial)

By initialing here, I state that I have the authority to grant access to the property. I also give my consent to the permitting agencies entering the property where the project is located to inspect the project site or any work related to the project. WMR (initial)

WILLIAM M. REILLY	[signature]	8-6-13
Applicant Printed Name	Applicant Signature	Date

11b. Authorized Agent Signature [help]

I certify that to the best of my knowledge and belief, the information provided in this application is true, complete, and accurate. I also certify that I have the authority to carry out the proposed activities and I agree to start work only after all necessary permits have been issued.

Michael A. Olinger	[signature]	8/6/13
Authorized Agent Printed Name	Authorized Agent Signature	Date

11c. Property Owner Signature (if not applicant). [help]
Not required if project is on existing rights-of-way or easements.

I consent to the permitting agencies entering the property where the project is located to inspect the project site or any work. These inspections shall occur at reasonable times and, if practical, with prior notice to the landowner.

Property Owner Printed Name	Property Owner Signature	Date

18 U.S.C §1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of the United States knowingly falsifies, conceals, or covers up by any trick, scheme, or device a material fact or makes any false, fictitious, or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false, fictitious, or fraudulent statement or entry, shall be fined not more than $10,000 or imprisoned not more than 5 years or both.

If you require this document in another format, contact the Governor's Office of Regulatory Assistance (ORA) at (800) 917-0043. People with hearing loss can call 711 for Washington Relay Service. People with a speech disability can call (877) 833-6341.
ORA publication number: ENV-019-09 rev. 06-12

WASHINGTON STATE
Joint Aquatic Resources Permit Application (JARPA) [help]

US Army Corps of Engineers
Seattle District

AGENCY USE ONLY

Date received:

Agency reference #: ______

Tax Parcel #(s): ______

TO BE COMPLETED BY APPLICANT [help]

Project Name: Valencia St. Pipeline Maintenance

Location Name (if applicable): ______

Attachment C:
Contact information for adjoining property owners. [help]

Use this attachment only if you have more than four adjoining property owners.

Use black or blue ink to enter answers in white spaces below.

1. Contact information for all adjoining property owners. [help]

Name	Mailing Address	Tax Parcel # (if known)
LDV BELLINGHAM PROPERTIES LLC	2010 IOWA ST Bellingham WA 98229-4726	3803294393790000
JENSEN HOLDINGS	2207 VALENCIA ST Bellingham WA 98229-4775	3803294495160000
LORNA LEE LLC	P O BOX 28897 Bellingham WA 98228-0897	3803294495260000
YING-ER HUNG	304 KAHLO LOOP LAREDO TX 78045-6644	3803294495380000
ARTHUR C & CYNTHIA A BERRY	426 BOULEVARD ST Bellingham WA 98225-5303	3803294505050000
KENNETH M CONROY & CYNTHIA CRENNELL	620 HENRY COWELL DR SANTA CRUZ CA 95060-1480	3803294505380000
STRATEGIC PROPERTIES LLC	2000 KENTUCKY ST Bellingham WA 98229-4730	3803294534250000
HARVEY PARTNERSHIP PREMIER SCHOOL AGENDA	2000 KENTUCKY ST Bellingham WA 98229-4730	3803294534460000 3803294784320000
ENNEN BROTHERS PARTNERSHIP	1305 OLD FAIRHAVEN PKWY Bellingham WA 98225-7413	3803294544830000 3803294574700000 3803294574830000
JANNA L PALM	3451 BRIDLEWOOD CT Bellingham WA 98226-4140	3803294744470000

CITY OF BELLINGHAM FINANCE DEPT ASSET DIVISION	201 Lottie Street PO Box V Bellingham WA 98229-4730	3803294544980000
LARRY A & DIANNE M KEEN	2319 BIRCH ST Bellingham WA 98229-4527	3803294745130000
KARLA JEAN LLC	5570 KNIGHT RD BELLINGHAM WA 98226-9503	3803294745260000
KARL & DOROTHY FAST TRUST	P O BOX 29923 BELLINGHAM WA 98228-1923	3803294745360000
SHERMAN L & LORRAINE R GRANT	2108 BIRCH CIRCLE BELLINGHAM WA 98229-4515	3803294755200000
JEREMY ALBRIGHT	12408 WILLIAMS RD EVERETT WA 982O5-2544	3803294805380000
MADLYN M HOOPER TRUST 80% & MADLYN M HOOPER MARITAL TRUST 20%	798 SUMMERSET WAY SEDRO WOOLLEY WA 98284-9559	3803294814240000
CONAX PROPERTIES USA INC	8183 130 ST SURREY BC V3W 7X4 CAN	3803294814790000 3803294815040000
ROGER O & CYNTHIA M JOBS LLC	10918 VERNON RD LAKE STEVENS WA 98258-9411	3803294833770000

If you require this document in another format, contact the Governor's Office of Regulatory Assistance (ORA) at (800) 917-0043. People with hearing loss can call 711 for Washington Relay Service. People with a speech disability can call (877) 833-6341. ORA publication number: ENV-022-09 rev. 06-12

PROJECT AREA
1900 BLK VALENCIA

CityIQ

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Storm Utilities

- Catch Basin
- Manhole
- Clean Out
- Pipe End
- Fitting
- Storm Service Line
- Drain Line
- Culvert
- City Main
- City Main, Under Construction
- Private Main
- Private, Under Construction
- Ditch
- Detention Facility, City
- Detention Facility, Private

Transportation

- Interstate 5
- Primary City Roads
- Other City Roads
- Bridges
- Railroads

Trails

- Primary (>8ft wide; gravel)
- Secondary (6 - 8 ft wide; gravel
- Minor (dirt path)

Basemap

- City Limits
- Urban Growth Area
- Populated Area
- Indian Reservation
- Forest Service Lands
- National Park Service Lands
- Water Bodies
- Culverts
- Shorelines, Streams

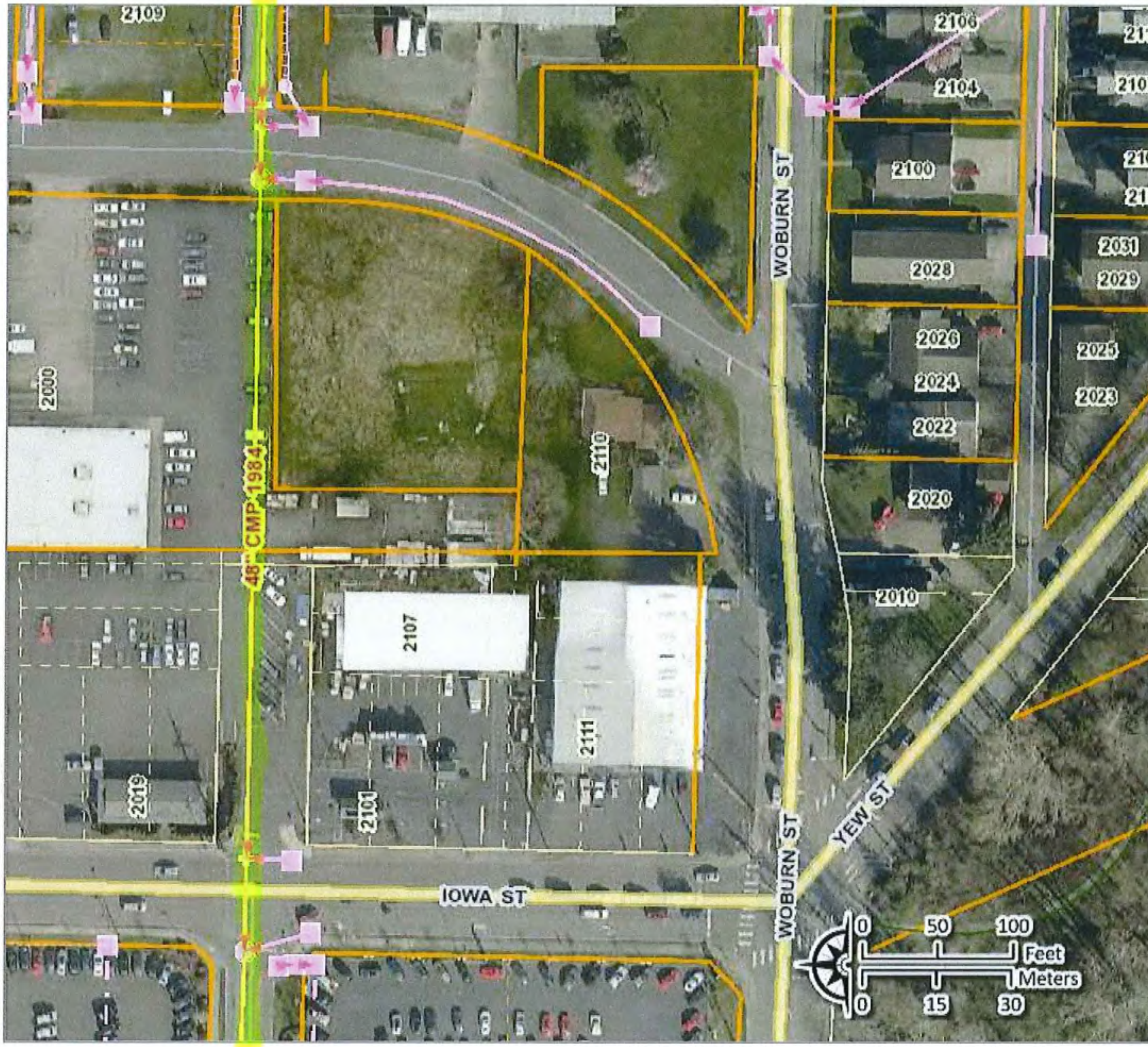
LineType, Accuracy

- Lot Line, High
- Lot Line, Low
- Property Line, High
- Property Line, Low
- ROW, High
- ROW, Low
- VROW, High
- VROW, Low

PROJECT AREA

2000 BLK VALENCIA

CityIQ



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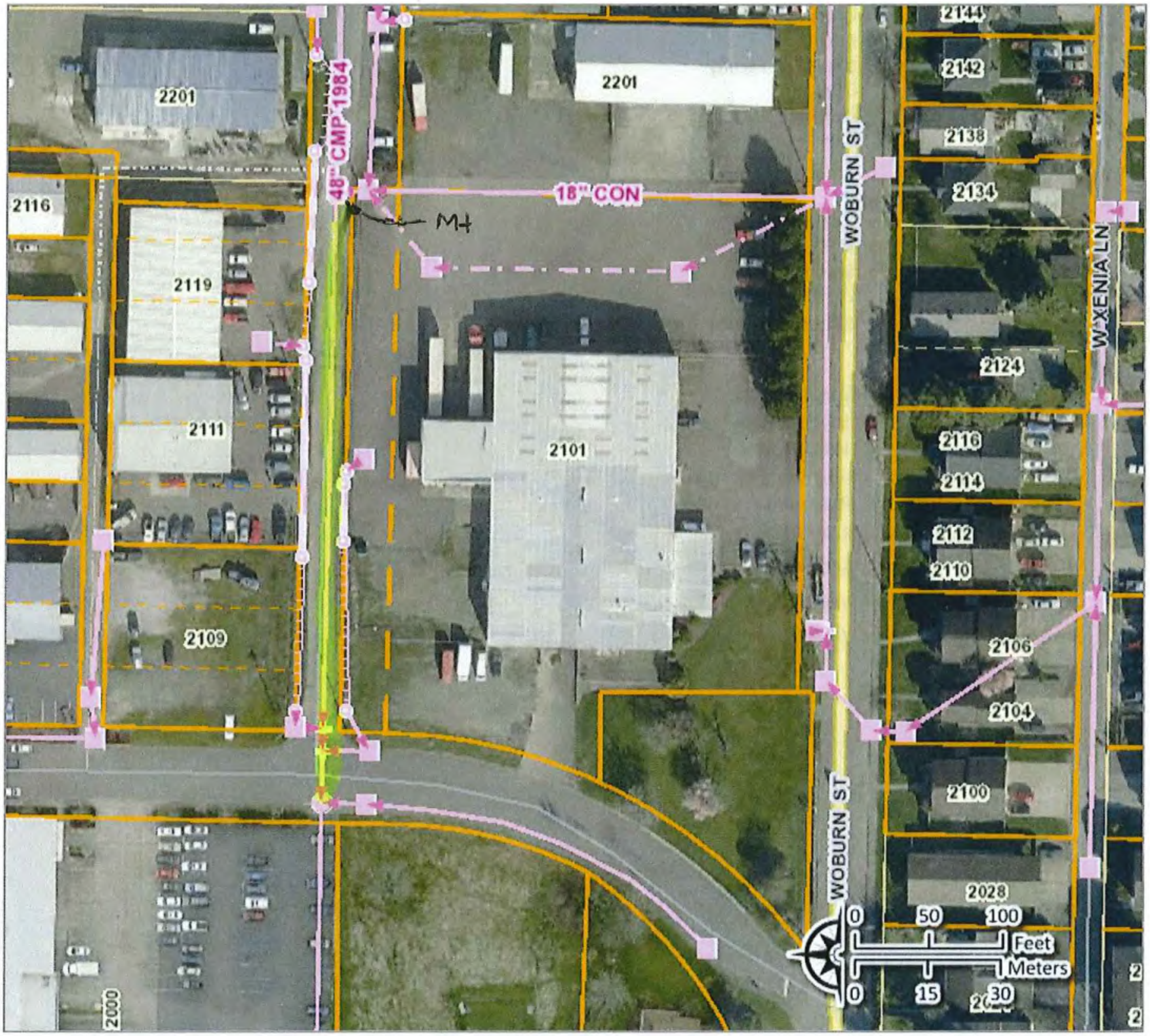
PROJECT AREA

2100 BK VALENCIA

CityIQ



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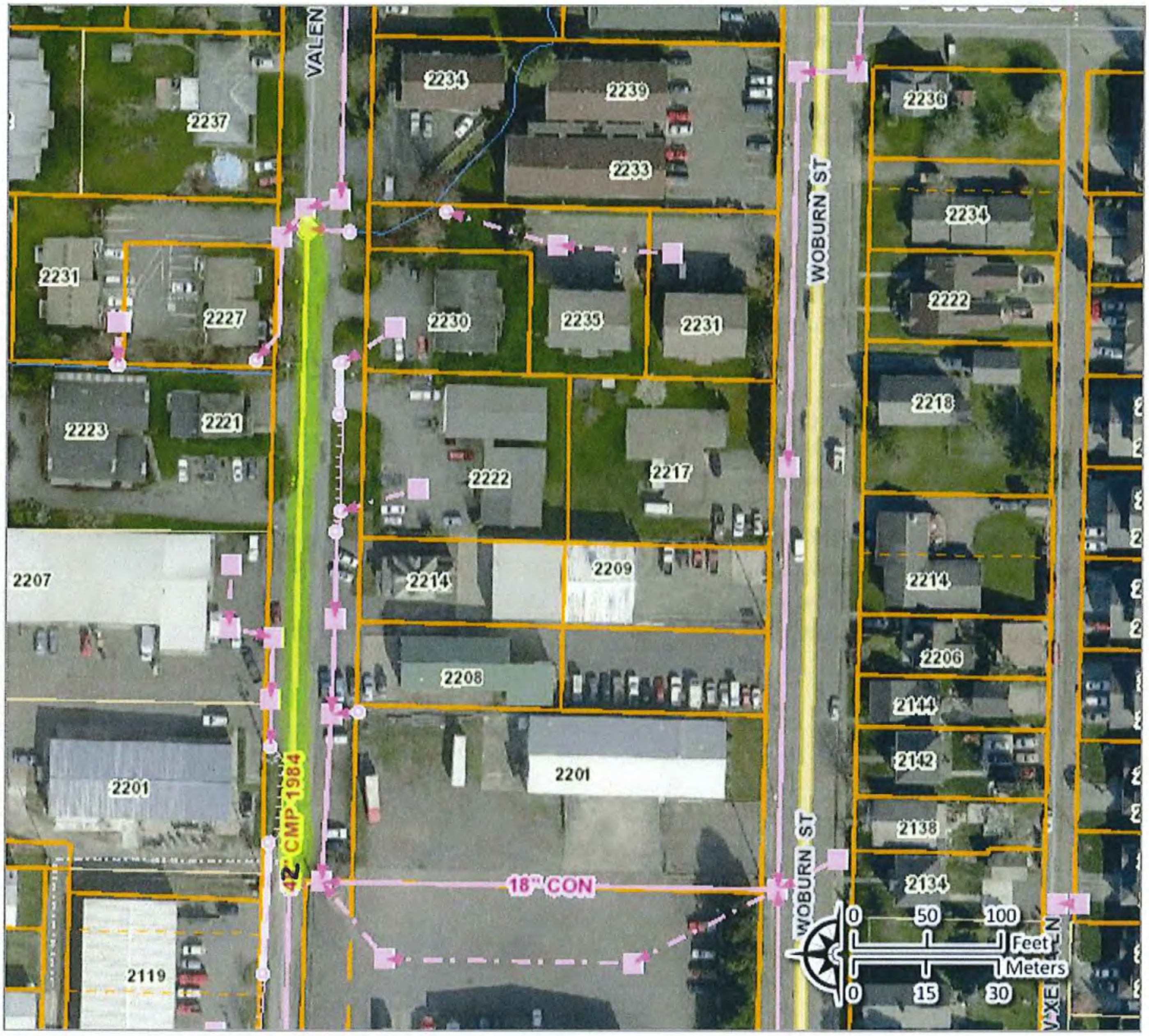
PROJECT AREA
2200 BLK VALENCIA

CityIQ



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PHOTO'S PIPE AREA

1900 BLK VALENCIA ST. OVER PIPE

OLD CHANNEL LOWER FEVER CK BYPASS

OUTFALL TO WHATCOM CREEK

2100 VALENCIA ST OVER PIPE

INLET TO VALENCIA PIPE SYSTEM

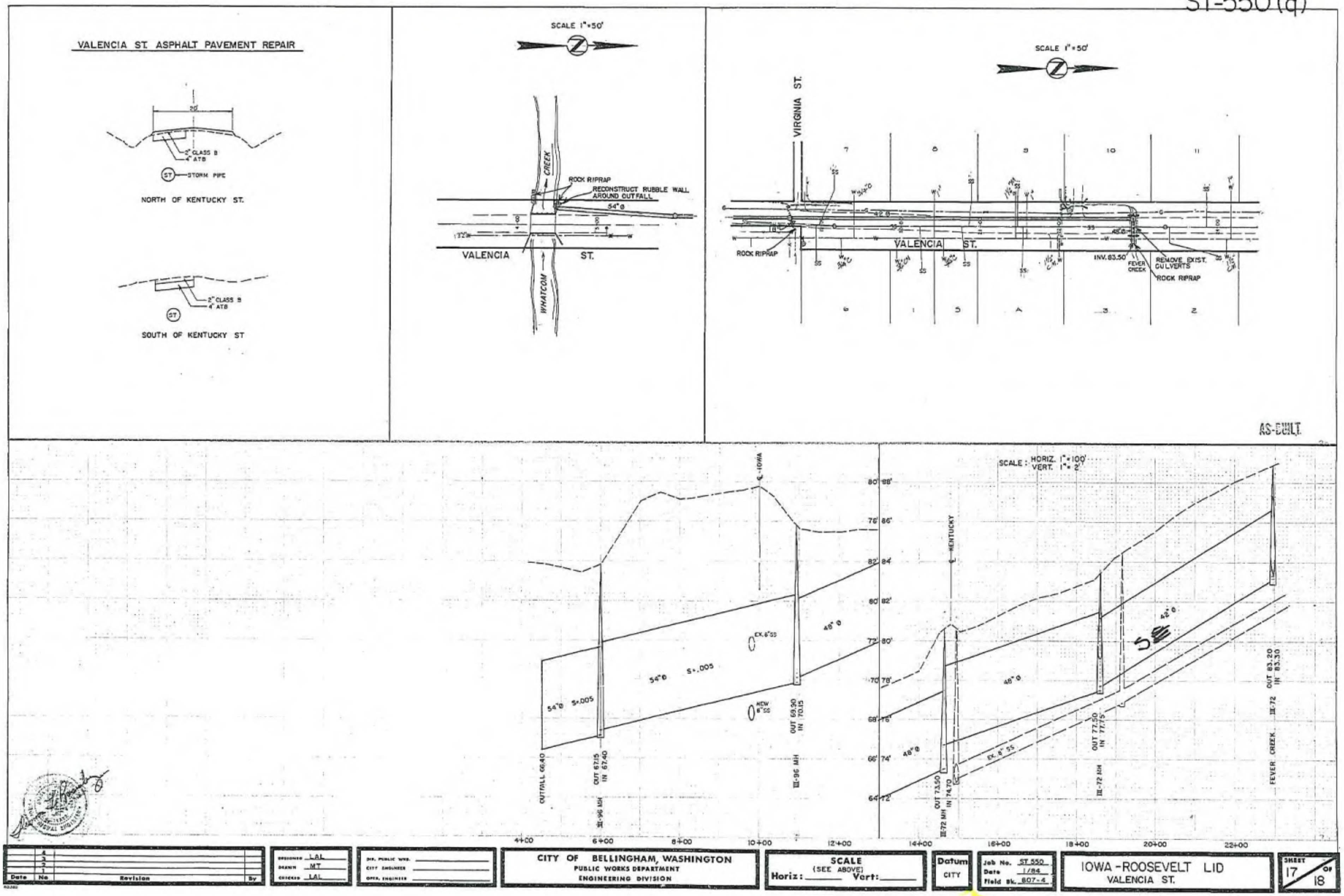
UPPER FEVER OUTLET FROM WOBURN

INLET TO VALENCIA PIPE SYSTEM

BURIED UPPER FEVER @ WOBURN

VALENCIA PIPE SYSTEM DESIGN (1984)

ST-550(q)



ORIGINAL HPA

DEPARTMENT OF FISHERIES

HYDRAULIC PROJECT APPROVAL

R.C.W. 75.20.100

[4] May 10, 1984

(Applicant should refer to this date in all correspondence)

DEPARTMENT OF FISHERIES
General Admin. Bldg.
Olympia, Washington 98504
(206) 753-6650

[10] LAST NAME: City of Bellingham; FIRST; [18] CONTACT PHONE(S): 676-6961	[1] [2] 1 2 3 4 [3] 00 19936-0
[19] STREET OR RURAL ROUTE: 210 Lottie Street	[7] [8] [9] WRIA
CITY: Bellingham; STATE: Washington; ZIP: 98225	A B C D A-01.0566
[12] WATER: Whatcom Creek; TRIBUTARY TO: Bellingham Bay	[14] [15] [16] F G [17] F
[13] QUARTER SECTION; SECTION: 29; TOWNSHIP: 38N; RANGE (E-W): 3E; COUNTY: Whatcom	[11] TYPE OF PROJECT: Storm Sewer Outfalls Installation

TIME LIMITATIONS:	[5] THIS PROJECT MAY BEGIN: Immediately	[6] AND BE COMPLETED BY: September 15, 1984

THIS APPROVAL IS TO BE AVAILABLE ON THE JOB SITE AT ALL TIMES AND ITS PROVISIONS FOLLOWED BY THE PERMITTEE AND OPERATOR PERFORMING THE WORK.

The person(s) to whom this approval is issued may be held liable for any loss or damage to fish life or habitat which results from failure to comply with the provisions of this approval.

Failure to comply with the provisions of this approval is a gross misdemeanor, possibly punishable by fine and/or imprisonment.

The Department reserves the right, subject to the holders opportunity to a hearing to contest agency actions as provided by the Administrative Procedure Act, chapter 34.04 RCW, to make additional restrictions or conditions or revoke the approval when new information shows such action is necessary by the department for the protection of fish life.

This department cannot be held liable for any property damage which might occur as a result of this project, except where damages are proximately caused by actions of the department.

This approval pertains only to the provisions of the Fisheries and Game Codes. Additional authorization from other public agencies may be necessary for this project.

Note: This L.I.D. project was proposed for the 1983 construction season but could not be approved by this department until a determination was made concerning the project's impact on the much larger Whatcom Creek flood control project (see copy of our response dated April 25, 1983). It was later determined by the Whatcom Creek flood control study team that the two outfall projects were separate and an approval should have been written by our department, except that our field representative, Mark Schuller, was not notified of this decision. In the meantime, the City of Bellingham has already installed the Valencia Street outfall and is currently working on the Nevada Street outfall (Fever Creek). The Valencia Street outfall appears to have no impact on fish life of Whatcom Creek. The current work on the Fever Creek outfall, however, is creating downstream silt problems on Whatcom Creek and was brought to the attention of your Public Works Department (via Emory Marco) on May 8, 1984 by Mr. Schuller. The following provisions pertain to the remaining work on the Fever Creek outfall.

1. The Fever Creek drainage (A-01.0568) will be enclosed in a 72 inch diameter pipe from Valencia Street, along Iowa Street, to its mouth at Whatcom Creek. This should keep most of the road and industrial pollutants out of Whatcom Creek.

2. The outfall installation from Iowa Street (at the Nevada Street intersection) to Whatcom Creek must be done in a manner that will not allow silt into Whatcom Creek. If silt fences and straw bales are not adequate, then this muddy Fever Creek water must be collected and pumped onto the adjacent vacant lot until the outfall is

DEPARTMENT OF FISHERIES DIRECTOR

ADDITIONAL PROVISIONS

May 10, 1984
Date

Approval given to: City of Bellingham

Stream or Lake: Whatcom Creek - Bellingham Bay

Type of Project: Storm Sewer Outfalls Installation

PROVISIONS:

completed.

SEPA: Final DNS by City of Bellingham, February 18, 1983.

Project Location: As described above.

Regional Habitat Manager: Mark Schuller, telephone 755-0421.

cc: Schuller
Carlîme-Patrol

dictate
5-9-84

DEPARTMENT OF GAME

600 Capitol Way North
Olympia, Washington 98504

HYDRAULIC PROJECT APPLICATION
(R.C.W. 75.20.100)

DEPARTMENT OF FISHERIES

General Admin. Bldg.
Olympia, Washington 98504

PLEASE PRINT OR TYPE
DO NOT WRITE IN SHADED AREA

[10] LAST NAME / FIRST: City of Bellingham
[19] CONTACT PHONE(S): 676-6961
[20] STREET OR RURAL ROUTE: 210 Lottie St.
CITY: Bellingham, STATE: Wa. ZIP: 98225
[12] STREAM OR LAKE: Whatcom Creek — TRIBUTARY TO: Bellingham Bay
[13] QUARTER SECTION: — SECTION: 29 — TOWNSHIP: 38N — RANGE (E-W): 3E
COUNTY: Whatcom

[1] [2] 1 2 3 4 [3] [7] [8] [9] WRIA A B C D 401.0566 [14] [15] [16] [17] F G

[11] TYPE OF PROJECT: 2 storm sewer outfalls

DESCRIPTION OF WORK, METHOD, AND EQUIPMENT

(IF NECESSARY USE BACK OF THIS SHEET OR ADDITIONAL SHEETS)

DISTANCE, DIRECTIONS TO PROJECT SITE FROM NEAREST TOWN

PROPOSED STARTING DATE — PROPOSED FINISHING DATE — PARTICIPATING ORGANIZATIONS (IF ANY)

[21] SEPA AGENCY/DATE: ☐ YES Final DNS by City on 2-18-83
[22] $ 25,000
[23] OTHER PERMITS: Shoreline

IT IS UNDERSTOOD THAT NO WORK WILL BE STARTED UNTIL A SIGNED APPROVAL IS RECEIVED. — SIGNATURE — DATE

TIME LIMITATIONS: Presently to Sept 15, 1984

L.I.D.

Note: This project was proposed for the 1983 construction season but ~~was held off~~ could not be approved by this department until a determination was made concerning the project's impact on the ~~what~~ much larger Whatcom Creek Flood Control project (see copy of our response to the W.C.F.C. feasibility team dated April 25, 1983). It was later determined that the 2 projects were separate, ~~and that~~ and an approval should have been written by our department, except that our field representative, Mark Schuller, was not notified of this decision. In the meantime the City of Bellingham has already installed the Valencia St. outfall and is currently working on the Nevada St. outfall (Fever Creek). ~~Since~~ The Valencia St outfall appears to have had no impact on the fish life of Whatcom Creek. The current work on the ~~tw~~ Fever Creek outfall, however, Sec.................., Township..................North, Range..................(E) or (W)

SKETCH MAP

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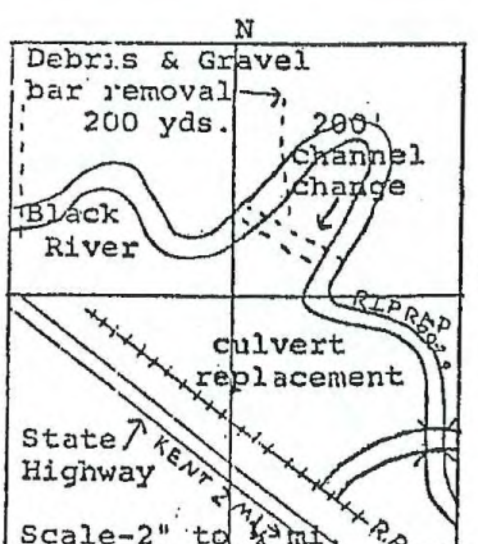
SEPA: Final DNS - City of Bellingham Feb 18, 1983
location: as described above
Asg Ht Mgr M. Schuller, 755-0421.
cc Corliss

N



SAMPLE MAP

The sample map to the left indicates the *type* of information which should be provided. Any scale may be used and the space does not necessarily have to represent a Section. Please indicate clearly all pertinent data on the space provided above for a sketch map—type of project, area of stream involved, landmarks, distance and direction to nearest town, etc.

JOHN SPELLMAN
Governor

COPY

WILLIAM R. WILKERSON
Director

STATE OF WASHINGTON
DEPARTMENT OF FISHERIES
115 General Administration Building • Olympia, Washington 98504 • (206) 753-6600 • (SCAN) 234-6600

April 25, 1983

City of Bellingham
210 Lottie Street
Bellingham, Washington 98225

Dear Mr. Rosenberg:

Hydraulic Project Application dated March 23, 1983
Storm Sewer Outfall, Whatcom Creek, Tributary to
Bellingham Bay, NE and NW 1/4, Section 29, Township
38 North, Range 3 East, in Whatcom County
WRIA A-01.0566

The Departments of Fisheries and Game have received the above-referenced application. The Department of Fisheries has taken lead status in processing your application but has been unable to complete this processing in the normal thirty-day time frame for the following reason(s):

> We have discussed your project with you and it has been mutually agreed that your application will be placed in abeyance and a final approval will be processed at a later date.

If you should have any questions regarding the status of your application, please contact Russ Orrell at 755-0421.

We appreciate your cooperation in our collective efforts to protect, perpetuate and manage the fishery resources of the State of Washington.

Sincerely,

Millard S. Deusen

William R. Wilkerson, for
Director

WRW:MS:sp

Fish
3/23

0010936 - 01 Mark

APPLICATION FORM TO THE DEPARTMENTS OF FISHERIES AND GAME ON PROPOSED HYDRAULIC PROJECTS

RECEIVED
MAR 10 1983
MANAGEMENT

A-01.0566

Department of Fisheries
and
Department of Game

Gentlemen:

The following is an application for approval in accordance with State laws. It is agreed that no work will be started on the project described below until a signed approval is received from the two departments.

NAME: City of Bellingham PHONE: (206) 676-6961

ADDRESS: 210 Lottie Street (Street Number or R.F.D.) Bellingham (CITY) WA 98225 (ZIP CODE)

LOCATION OF WORK: NE & NW (Quarter Section) 29 (Section) 38N (Township) 3E (Range [E or W])

Whatcom (County)

ROAD DISTANCE AND DIRECTION FROM NEAREST TOWN: Two outfalls, one 0.9 miles and other 1.5 miles east of City Hall

STREAM: Whatcom Creek (Name) (Tributary of)

TYPE OF WORK: Storm sewer outfall
(Culvert, Channel Change, Drainage, Gravel Operation, Flood or Erosion Control, Road or Bridge Construction, Dredging)

DESCRIPTION OF WORK AND EQUIPMENT TO BE USED: The City of Bellingham is planning to enclose an open-ditch drainage system as part of a major area improvement. Two outfalls into Whatcom Creek will be constructed. Back hoe will be used for excavation.

PROPOSED STARTING DATE: January 1984 FINISHING DATE: November 1984

PARTICIPATING ORGANIZATION (if any) none

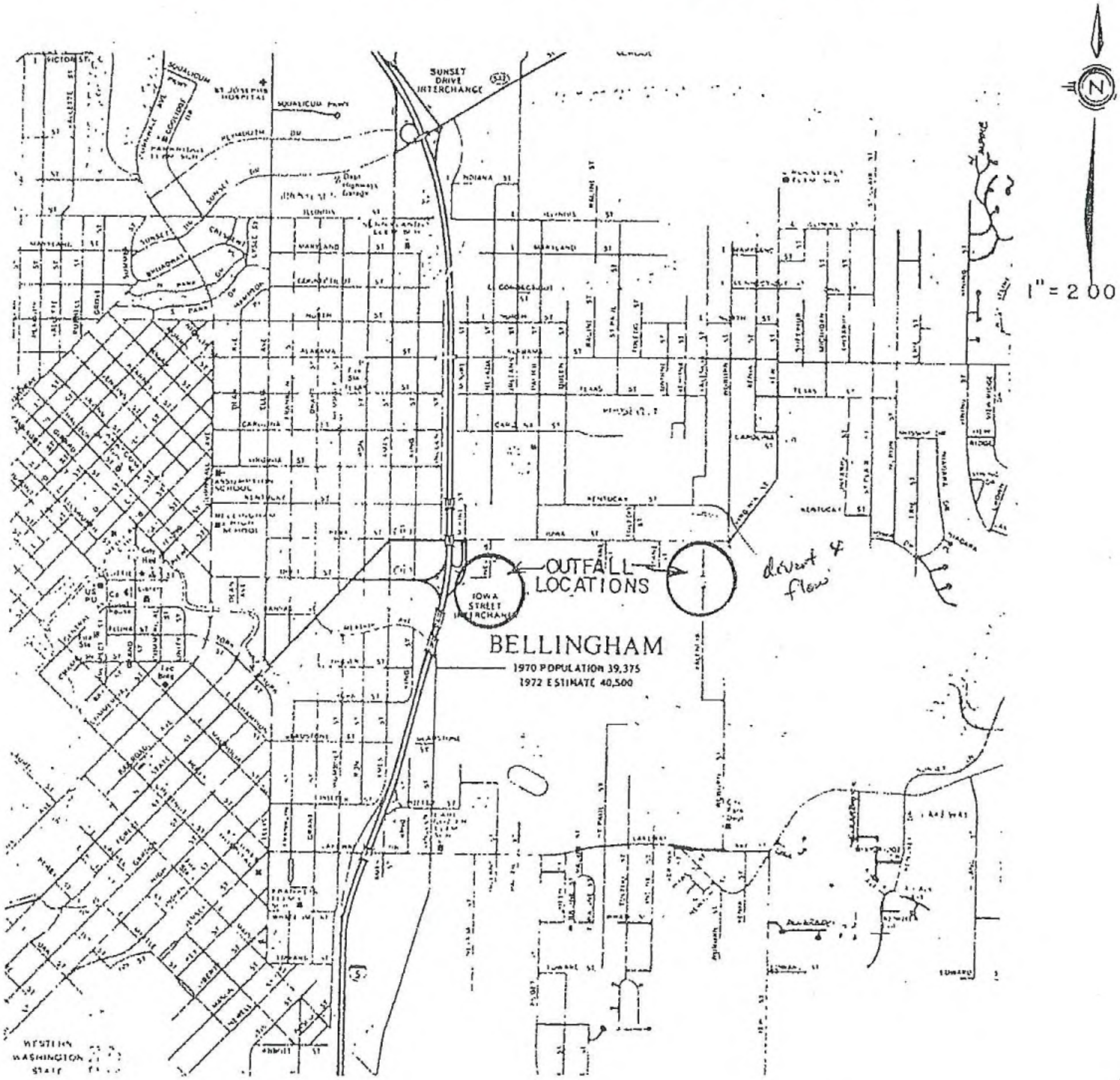
DATE: 3/14/83 SIGNATURE: [signature]

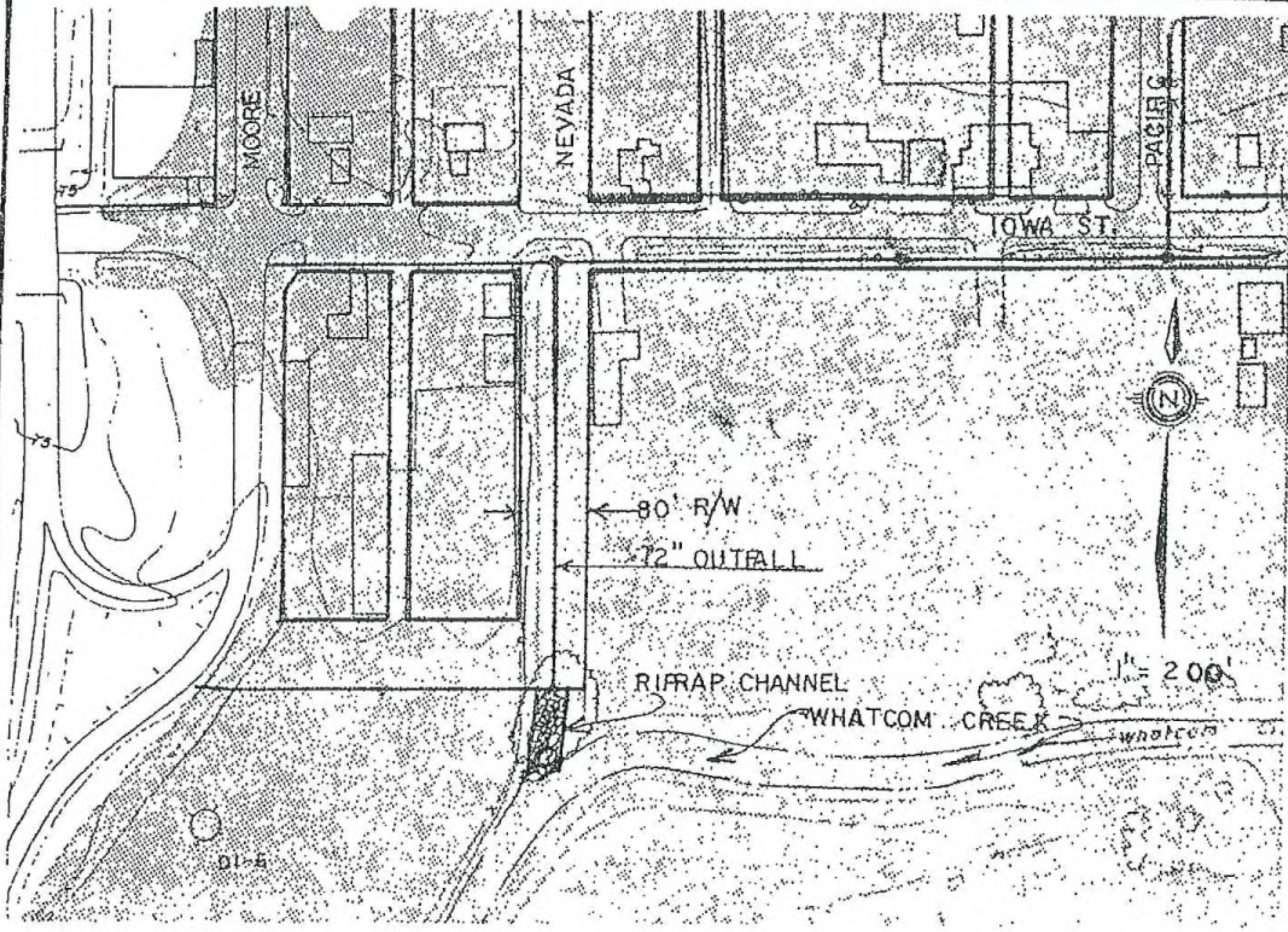
NOTE: Any additional information may be placed on the back of this sheet. If necessary more complete plans and specifications will be requested before granting final approval.

SEPA: Final DNS by City on 2-18-83

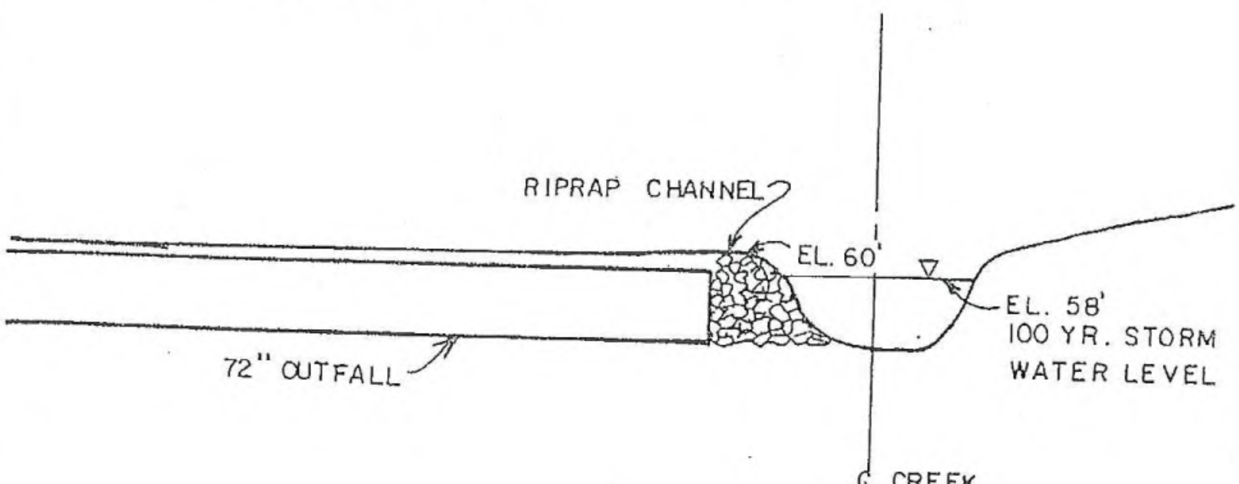
(PLEASE COMPLETE ATTACHED MAP)

WHATCOM CREEK - OUTFALL LOCATIONS



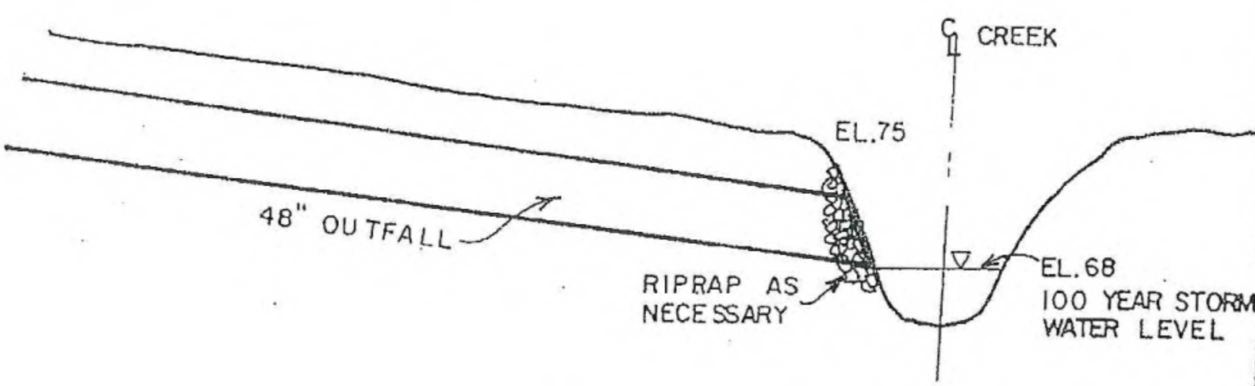


OUTFALL @ WHATCOM CREEK
(NEVADA ST.)



SCALE: 1" = 50' HORIZ.
1" = 10' VERT.

OUTFALL @ WHATCOM CREEK
(VALENCIA ST.)



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1"= 10' VERT.

Table

Rating Table for Circular Channel

VELOCITY/DEPTH SYSTEM OUTLET

Project Description	
Project File	c:\haestad\fmw\project1.fm2
Worksheet	Valencia Storm Main
Flow Element	Circular Channel
Method	Hazen-Williams Formula
Solve For	Channel Depth

Constant Data		
C Coefficient	100.0	
Channel Slope	0.014000	ft/ft
Diameter	54.00	in

Input Data	Minimum	Maximum	Increment
Discharge	1.00	24.00	1.00 cfs

Rating Table

Discharge (cfs)	Depth (ft)	Velocity (ft/s)
1.00	0.21	3.75
2.00	0.29	4.59
3.00	0.35	5.17
4.00	0.41	5.62
5.00	0.45	5.99
6.00	0.49	6.32
7.00	0.53	6.60
8.00	0.57	6.86
9.00	0.60	7.10
10.00	0.63	7.32
11.00	0.66	7.52
12.00	0.69	7.71
13.00	0.72	7.89
14.00	0.75	8.06
15.00	0.77	8.22
16.00	0.80	8.37
17.00	0.82	8.51
18.00	0.85	8.65
19.00	0.87	8.78
20.00	0.89	8.91
21.00	0.92	9.04
22.00	0.94	9.16
23.00	0.96	9.27
24.00	0.98	9.38

INVERT GROUT SPECS

CENTRIPIPE®

CENTRIFUGALLY CAST CONCRETE PIPE

PERMACAST® PL-8,000 PIPE LINER

PERMACAST® PL-8,000 is a high strength, high build, abrasion resistant and corrosion resistant mortar, based on advanced cements and additives. The special mortar is designed to be fluid, but very sticky to enhance adhesion and to allow for high build within the crown of the pipe.

PERMACAST® PL-8,000 is applied by a robotic SpinCaster™ operating at 5,000 rpm. The SpinCaster™ is placed in the center of the sewer pipe and retrieved as the cementitious liner is centrifugally cast evenly around the pipe interior. If operations are interrupted for any reason, retrieving the SpinCaster™ is temporarily stopped until operations can resume. The retrieval speed is easily varied to apply the proper thickness as conditions may dictate. Because of its even application around the circumference, thickness is easily verified at any point.

PERMACAST® PL-12,000 INVERT LINER

PERMACAST® PL-12,000 is an ultra high strength, high build, abrasion resistant and corrosion resistant flowable mortar, based on advanced cements and additives. PL-12,000 provides for the structural refurbishment and abrasion resistance of damaged inverts of buried concrete and corrugated steel storm or culvert pipe by the safe, quick and economical application of a high-strength, rapid setting, factory-blended, construction grout that easily flows into voids, under and around damaged or missing inverts and sets rapidly in place to form a new invert.

PERMACAST® PL-12,000 is placed by positioning the material hose at the far end of the deteriorated pipe. As the mortar fills the invert void, the hose is retrieved to the entry end. The mortar is shaped to conform generally to the radius of the original invert or it may be flat without significantly impacting the flow characteristics of the original pipe.

Physical Properties	**PL-8,000**	**PL-12,000**
ASTM C-403 Set Time @ 70^0F		
Initial Set	Approximate 150 minutes	Approximate 150 minutes
Final Set	240 minutes	240 minutes
ASTM C-293 Flexural Strength		
24 hours	600 psi	800 psi
28 days	1,080 psi	1,200 psi
ASTM C-109 Compressive Strength		
24 hours	3,000 psi	5,000 psi
28 days	8,000 psi	11,500 psi
ASTM C-496 Split Tensile Strength	650 psi	700 psi
ASTM C-882 Shear Bond	2,100 psi	1,700 psi
ASTM C-469 Modulus of Elasticity		
28 days	3.56×10^6	3.48×10^6
ASTM C-666 Freeze Thaw-300 Cyles	Pass	Pass
ASTM C-1202 Chloride Permeability	<550 Coulombs	<550 Coulombs

PERMAFORM the hole solution PERMACAST™

800.662.6465
AP/M PERMAFORM
Box 555 Johnston, IA 50131
515.276.9610
515.276.1274 Fax
www.centripipe.com

CENTRIFUGALLY CAST CONCRETE PIPE

CENTRIPIPE®

Corrugated metal pipe (CMP) commonly suffers structural damage from soil erosion, abrasion, corrosion and buckling. Washouts and collapse are disastrous and costly.

Centrifugally Cast Concrete Pipe is a cost effective, NO DIG solution for structural lining of culverts. A new, structural concrete pipe is spuncast throughout the entire length of the culvert using the CCCP method. The PL-8000 concrete liner is designed for H-20 wheel loading. It contains rust inhibitors to prevent corrosion of the old metal culvert and it is highly resistant to abrasion for extended wear.

Benefits:

- **fully structural pipe within the old pipe**
- **full flow capacities maintained**
- **completely monolithic – no joints**
- **sealed against ground water erosion**
- **high abrasion resistance**
- **internal rust inhibitors**
- **least expensive alternative**
- **quick return to service**
- **no excavation required**
- **impermeable – cannot leak**
- **certified applicator network**

INVERT ONLY

Another Trenchless Solution from AP/M PERMAFORM

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AP/M PERMAFORM
Box 555 Johnston, IA 50131
515.276.9610
515.276.1274 Fax
www.centripipe.com

NELSON TESTING LABORATORIES
Construction Materials
1210 REMINGTON ROAD
SCHAUMBURG, ILLINOIS 60173 USA
Phone (847) 882-1146 Fax (847) 882-1148
----
www.nelsontesting.com

GROUT ABRASION RESISTANCE VS STANDARD CONCRETE

June 18, 2012

AP/M Permaform
P.O. Box 555
Johnston, Iowa 50131-0555

Attn: Mr. Keith R. Walker

REPORT OF TESTS

SUBJECT:	**Comparative Concrete Abrasion Study**
PROJECT:	**AP/M Permaform – Centripipe PL-12,000**
TEST METHOD:	ASTM C 1138, "Standard Test Method for Abrasion Resistance of Concrete (Underwater Method)"
MATERIAL:	Delivered by AP/M Permaform to NTL in April, 2012
NTL PROJECT #:	1067-12
PAGE:	1 of 5

TEST RESULTS

ASTM C 1138 – Abrasion Resistance of Concrete

Mix 1 – CONTROL

Cast Dates:	April 30, 2012 and May 1, 2012
Test Dates:	May 3, 2012 and May 29, 2012
Age at Test:	3 and 28 days
Mix Design:	
Cement:	674.2 lbs/ft³ (Lafarge Type I/II)
Water:	258.2 lbs/ft³
½" Granite:	1527.1 lbs/ft³ (Ozark Granite)
Sand:	1741.0 lbs/ft³ (Elmhurst Chicago Stone – Washed Concrete Sand)
Comp. Strength:	5870 PSI @ 28 days (average of three 4" x 8" cylinders)
Specimen Size:	11.8" diameter 4.0" thick
Mass of Balls:	4.2 lbs.
Cycle:	12 hours
Test Duration:	72 hours

NELSON TESTING LABORATORIES
Construction Materials
1210 REMINGTON ROAD
SCHAUMBURG, ILLINOIS 60173 USA
Phone (847) 882-1146 Fax (847) 882-1148
----
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TEST RESULTS (continued)

ASTM C 1138 – Abrasion Resistance of Concrete

Mix 1 – CONTROL (continued)

Results: 3 Day Cure

Cycle	Specimen Volume (m3)	Cumulative Volume Loss (m3)	Cumulative Volume Loss (%)
0	0.00624	-----	-----
1	0.00604	0.00020	3.22%
2	0.00588	0.00036	5.74%
3	0.00583	0.00041	6.49%
4	0.00581	0.00043	6.80%
5	0.00580	0.00044	6.86%
6	0.00579	0.00045	7.17%

Cumulative Volume Loss After 6 Cycles **7.17%**

Results: 28 Day Cure

Cycle	Specimen Volume (m3)	Cumulative Volume Loss (m3)	Cumulative Volume Loss (%)
0	0.00617	-----	-----
1	0.00608	0.00009	1.41%
2	0.00602	0.00015	2.43%
3	0.00600	0.00017	2.72%
4	0.00597	0.00020	3.18%
5	0.00594	0.00023	3.65%
6	0.00587	0.00030	4.85%

Cumulative Volume Loss After 6 Cycles **4.85%**

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TEST RESULTS (continued)

ASTM C 1138 – Abrasion Resistance of Concrete

Mix 2 – CENTRIPIPE PL-12,000

Cast Dates: May 4, 2012 and May 3, 2012
Test Dates: May 7, 2012 and May 31, 2012
Age at Test: 3 and 28 days

Water Addition: 13.0%
Specimen Size: 11.8" diameter x 4.0" thick
Mass of Balls: 4.2 lbs.

Cycle: 12 hours
Test Duration: 72 hours

Results: 3 Day Cure

Cycle	Specimen Volume (m3)	Cumulative Volume Loss (m3)	Cumulative Volume Loss (%)
0	0.00684	-----	-----
1	0.00674	0.00010	1.43%
2	0.00665	0.00019	2.78%
3	0.00661	0.00023	3.39%
4	0.00653	0.00031	4.45%
5	0.00641	0.00043	6.23%
6	0.00631	0.00053	7.75%

Cumulative Volume Loss After 6 Cycles **7.75%**

Results: 28 Day Cure

Cycle	Specimen Volume (m3)	Cumulative Volume Loss (m3)	Cumulative Volume Loss (%)
0	0.00684	-----	-----
1	0.00682	0.00002	0.20%
2	0.00681	0.00003	0.40%
3	0.00680	0.00004	0.58%
4	0.00676	0.00008	1.11%
5	0.00670	0.00014	1.95%
6	0.00665	0.00019	2.68%

Cumulative Volume Loss After 6 Cycles **2.68%**

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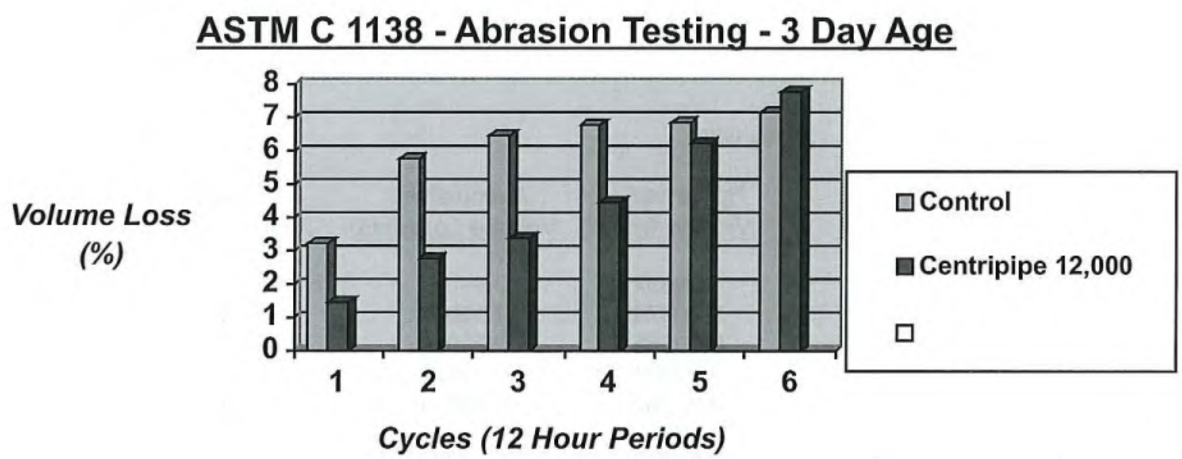
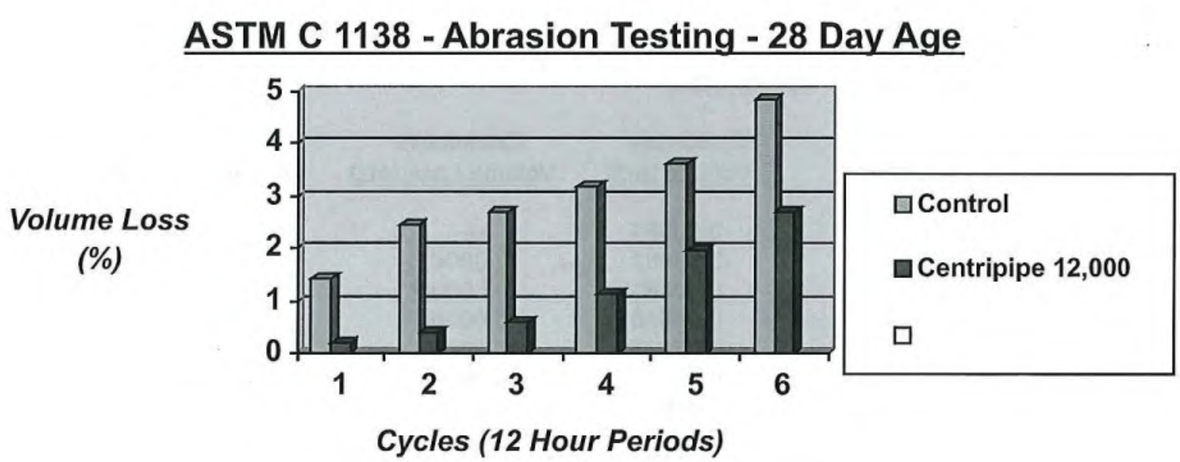
TEST SUMMARY

Cumulative Volume Loss After 6 Cycles (72 hours)

Specimen Age	Mix 1 – Control	Mix 2 – Centripipe 12,000
3 day	7.17%	7.75%
28 day	4.85%	2.68%





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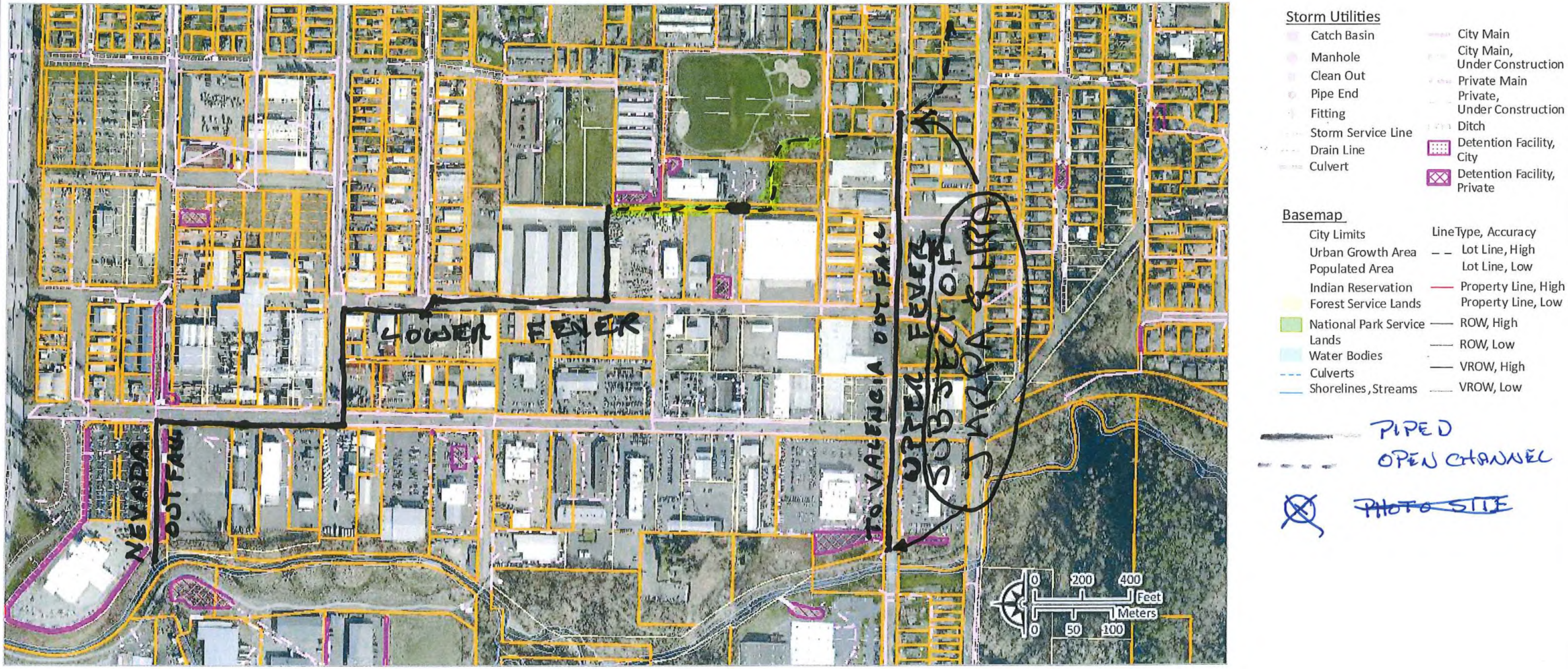
Respectfully submitted,

NELSON TESTING LABORATORIES

Mark R. Nelson
President

CityIQ SHEET 1 MATCH SHEET 2



CityIQ SHEET 2 MATCH SHEET 3

MATCH SHEET 1

TO WHATCOM CREEK

Storm Utilities

- Catch Basin
- Manhole
- Clean Out
- Pipe End
- Fitting
- Storm Service Line
- Drain Line
- Culvert
- City Main
- City Main, Under Construction
- Private Main
- Private, Under Construction
- Ditch
- Detention Facility, City
- Detention Facility, Private

Basemap

- City Limits
- Urban Growth Area
- Populated Area
- Indian Reservation
- Forest Service Lands
- National Park Service Lands
- Water Bodies
- Culverts
- Shorelines, Streams

LineType, Accuracy

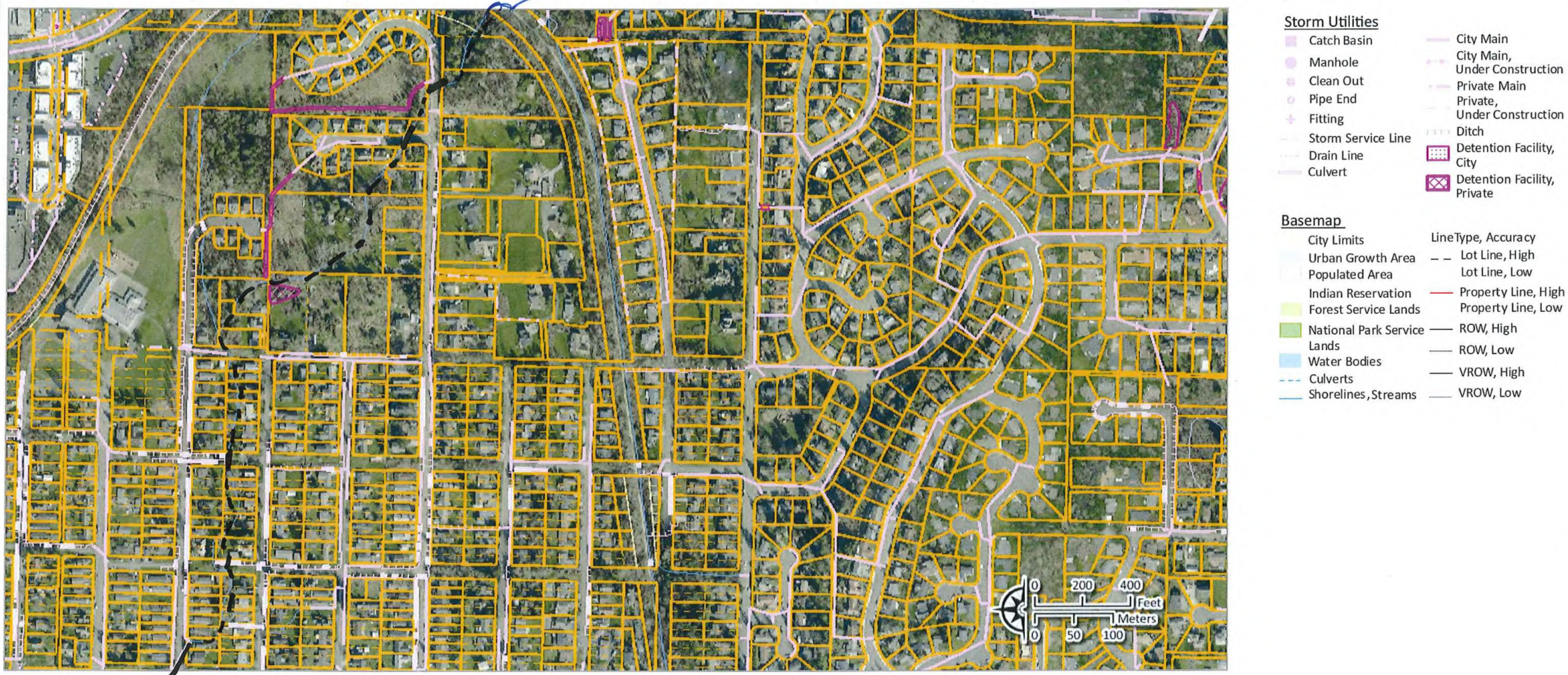
- Lot Line, High
- Lot Line, Low
- Property Line, High
- Property Line, Low
- ROW, High
- ROW, Low
- VROW, High
- VROW, Low

PIPED

OPEN CHANNEL

CityIQ SHEET 3

OUTLET ST. CLAIR FLOOD CONTROL DAM



MATCH SHEET 2

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Appendix F. CIP Detailed Cost Estimates

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Opinion of Probable Construction Cost
MWS or Similar Proprietary Treamtment Facility Improvements - Drainage System No. D01

Item	Quantity	Unit	Description	Unit Cost	Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$12,800	$12,800
2	1	LS	Surveying (2%)	$3,200	$3,200
3	1	LS	Utilities Locate and Protection (1%)	$1,600	$1,600
4	1	LS	Temp Traffic Control (6%)	$9,600	$9,600
5	1	LS	Force Account (3%)	$4,800	$4,800
Subtotal					**$32,000**
Division 2 - Earthwork					
6	1	LS	Removal of Structure and Obstruction (1%)	$2,000	$2,000
7	463	SF	Removal of Asphalt Concrete Pavement	$1.75	$810
8		SF	Removal of Cement Concrete Sidewalk	$1.50	$0
9		LF	Removal of Cement Concrete Curb and Gutter	$5	$0
Subtotal					**$2,810**
Division 3 - Aggregate Production and Acceptance					
10			No Payment Items		$0
Subtotal					**$0**
Division 4 - Bases					
11	85	TN	Crushed Surfacing Top Course (or Base Course)	$30	$2,550
Subtotal					**$2,550**
Division 5 - Surface Treatments and Pavements					
12	12	TN	HMA Cl. 1/2 PG 64-22	$140	$1,680
Subtotal					**$1,680**
Division 6 - Structures					
13		LF	Curb and Gutter Replacement	$30	$0
14		SF	Sidewalk Replacement	$10	$0
15	1	EA	Precast MWS Treatment 4ft. X 17ft. (Q = 0.206 cfs) (Without plants)	$110,000	$110,000
Subtotal					**$110,000**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
16	150	CY	Structure Excavation Class B Incl. Haul	$18	$2,700
17	1	EA	Shoring or Extra Excavation Class B	$12,000.00	$12,000
18	25	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Depth)	$60	$1,500
19	25	LF	Testing Storm Sewer Pipe	$5	$125
20	1	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$4,000
21	1	EA	Flow Splitter Catch Basin Type 2 60 In. Diam. (up to 8 ft. Depth)	$8,000	$8,000
22	5	EA	Connection to Drainage Structure	$500	$2,500
Subtotal					**$30,825**
Division 8 - Miscellaneous Construction					
23	1	LS	Temporary Erosion and Sediment Controls (4%)	$8,100	$8,100
24	1	LS	Care and Diversion Water (2%)	$4,100	$4,100
25		SF	MWS Cell Plantings, PSIPE	$6	$0
Subtotal					**$12,200**
			Subtotal Opinion of Probable Construction Cost		**$192,065**
			Contingency	30.0%	$57,620
			Design, Permitting, and Construction Management	20.0%	$38,413
			Parcel or Easement Acquisition		$0
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$288,098**

Notes:

(1) July 2019 dollars; 2) Does not include sales tax.

(3) Earthwork costs assume that excacated soils are suitable for re-use as embankment fill, and that no contaminated soils are encountered that would otherwise require special, higher cost off-site disposal.

(4) Assumes all improvements are within the ROW, and that no parcel or easement acquisition is required.

Opinion of Probable Construction Cost
MWS or Similar Proprietary Treamtment Facility Improvements - Drainage System No. D03

Item	Quantity	Unit	Description	Unit Cost	Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$11,000	$11,000
2	1	LS	Surveying (2%)	$2,800	$2,800
3	1	LS	Utilities Locate and Protection (1%)	$1,400	$1,400
4	1	LS	Temp Traffic Control (6%)	$8,300	$8,300
5	1	LS	Force Account (3%)	$4,100	$4,100
Subtotal					**$27,600**
Division 2 - Earthwork					
6	1	LS	Removal of Structure and Obstruction (1%)	$2,000	$2,000
7	168	SF	Removal of Asphalt Concrete Pavement	$1.75	$294
8		SF	Removal of Cement Concrete Sidewalk	$1.50	$0
9	25	LF	Removal of Cement Concrete Curb and Gutter	$5	$125
Subtotal					**$2,419**
Division 3 - Aggregate Production and Acceptance					
10			No Payment Items		$0
Subtotal					**$0**
Division 4 - Bases					
11	60	TN	Crushed Surfacing Top Course (or Base Course)	$30	$1,800
Subtotal					**$1,800**
Division 5 - Surface Treatments and Pavements					
12	13	TN	HMA Cl. 1/2 PG 64-22	$140	$1,820
Subtotal					**$1,820**
Division 6 - Structures					
13	25	LF	Curb and Gutter Replacement	$30	$750
14		SF	Sidewalk Replacement	$10	$0
15	1	EA	Precast MWS Treatment 4ft. X 13ft. (Q = 0.144 cfs)	$90,000	$90,000
Subtotal					**$90,750**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
16	90	CY	Structure Excavation Class B Incl. Haul	$18	$1,620
17	1	EA	Shoring or Extra Excavation Class B	$12,000.00	$12,000
18	25	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Depth)	$60	$1,500
19	25	LF	Testing Storm Sewer Pipe	$5	$125
20	1	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$4,000
21	1	EA	Flow Splitter Catch Basin Type 2 60 In. Diam. (up to 8 ft. Depth)	$8,000	$8,000
22	3	EA	Connection to Drainage Structure	$500	$1,500
Subtotal					**$28,745**
Division 8 - Miscellaneous Construction					
23	1	LS	Temporary Erosion and Sediment Controls (4%)	$8,100	$8,100
24	1	LS	Care and Diversion Water (2%)	$4,100	$4,100
25	60	SF	MWS Cell Plantings, PSIPE	$6	$360
Subtotal					**$12,560**
				Subtotal Opinion of Probable Construction Cost	**$165,694**
			Contingency	30.0%	$49,708
			Design, Permitting, and Construction Management	20.0%	$33,139
				Parcel or Easement Acquisition	$0
				Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost	**$248,541**

(1) July 2019 dollars; 2) Does not include sales tax.

(3) Earthwork costs assume that excacated soils are suitable for re-use as embankment fill, and that no contaminated soils are encountered that would otherwise require special, higher cost off-site disposal.

(4) Assumes all improvements are within the ROW, and that no parcel or easement acquisition is required.

									Avg Cost/SF Walls	$ 150
									Avg Cost/SF No Walls	$ 60
		Bioretention Sites (prioritized based on recommendations and treatment area)								
Prioirity	CIP #	Site ID	Intersection	Recommendations	Notes	Length (ft)	Width (ft)	Area (SF)	Walls?	Cost
1	D-10	9	3230 to 3245 Lauralwood Ave	Yes	ROW facility, west side of Lauralwood spanning across several lots.	355	16	5680	no	$ 341,000
2	D-05	1	W. Illinois St. & Nome St	Yes	Site facilities on both sides on W. Illinois, east of Nome. No sidewalks, no trees, OHP but can work around.	300	16	4800	no	$ 288,000
3	D-11	10	3126 Cedarwood Ave	Yes	ROW facility, north side of road, spans 2 lots.	300	16	4800	no	$ 288,000
4	D-09	8	Cheerywood Ave, north of Cottonwood Ave	Yes	Open lawn, no landscaping or diveway conflicts	116	16	1856	no	$ 111,000
5	D-08	5	Birchwood Ave & Firwood Ave	Yes	Conflicts: Mature trees, landscaping (SW), 1 mature tree in corner. Possible site could work around it and put facilities along Birchwood eastward and Firwood southward (SE), west of intersection on both sides of Birchwood, landscaping and shrubs are prohibitive.	150	12	1800	yes	$ 108,000
6	D-03		Bill McDonald Parkway	Yes	Add 20% to cost to cover abandoned SD line and traffic control	84	16	1344	no	$ 97,000
7	D-06	2	Cedarwood Avenue & Pinewood Ave	maybe	Mature trees along Cedarwood (SW corner), below grade lot (NW corner), sidewalk (SE). NE corner could work, but small .	150	16	2400	no	$ 144,000
8	D-07	3	Cedarwoood Ave. & Firwood	maybe	Landscaping improvements (NW), mature tree (NE), trees/shrubs (SE), one possible site (SW)	100	8	800	yes	$ 48,000

Bioretention Cost/Sqft Calc				
Facility	**Cost***	**Facility Area**	**Cost/Sq Ft**	**Walls/No Walls**
1	$238,885	2,218	$107.71	Walls
2	$92,690	2,769	$33.48	No Walls
3	$188,834	1,091	$173.08	Walls
4	$240,564	1,520	$158.27	Walls
5	$66,205	921	$71.88	No Walls
6	$254,476	1,522	$167.22	Walls
7	$74,352	1,204	$61.75	No Walls
Avg Cost/SF Walls		$150.00		
Avg Cost/SF No Walls		$60.00		

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Subareas PC 901, PC 902, PC 903 - Bioretention Facility No. 7 (no walls)

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$3,300	$3,300
2	1	LS	Surveying (2%)	$800	$800
3	1	LS	Utilities Locate and Protection (1%)	$400	$400
4	1	LS	Temp Traffic Control (6%)	$2,500	$2,500
5	1	LS	Force Account (3%)	$1,200	$1,200
Subtotal					**$8,200**
Division 2 - Earthwork					
1	0.09	AC	Clearing and Grubbing	$8,000	$700
2	1	LS	Removal/Replacement of Structure and Obstruction (1%)	$500	$500
2	85	CY	Excavation Incl. Haul	$14	$1,185
Subtotal					**$2,385**
Division 3 - Aggregate Production and Acceptance					
			No payment items		
Subtotal					**$0**
Division 4 - Bases					
			No payment items		
Subtotal					**$0**
Division 5 - Surface Treatments and Pavements					
			No payment items		
Subtotal					**$0**
Division 6 - Structures					
3	0	CY	CIP Conc. Class 4000	$800	$0
4	0	CY	Gravel Backfill for Wall	$45	$0
5	0	LS	Structural Carbon Steel	$2,500	$0
Subtotal					**$0**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
6	110	LF	Underdrain Pipe 8 In. Diam.	$24	$2,640
7	42	CY	Gravel Backfill for Drain	$45	$1,905
8	88	CY	Structure Excavation Class B Incl. Haul	$18	$1,578
9	789	SF	Shoring or Extra Excavation Class B (pipe)	$2.50	$1,972
10	1	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$4,000
11	1	EA	Overflow Grate Type 2	$1,500	$1,500
12	22	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Depth)	$60	$1,325
13	22	LF	Testing Storm Sewer Pipe	$5	$110
14	1	EA	Connection to Drainage Structure	$500	$500
Subtotal					**$15,530**
Division 8 - Miscellaneous Construction					
15	1	LS	Temporary Erosion and Sediment Controls (4%)	$2,000	$2,000
16	1	LS	Care and Diversion Water (2%)	$1,000	$1,000
17	71	CY	Topsoil Type A	$40	$2,822
18	19	CY	Compost	$40	$747
19	1,255	SF	Bioretention Cell Plantings, PSIPE	$6	$7,533
20	42	CY	Bioretention Cell Soil Mix	$150	$6,350
21	2	EA	Weirs/Level Spreaders	$1,500	$3,000
Subtotal					**$23,452**
			Subtotal Opinion of Probable Construction Cost		**$49,568**
			Contingency	30.0%	$14,870
			Design, Permitting, and Construction Management	20.0%	$9,914
			Parcel or Easement Acquisition		$0
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$74,352**

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Subareas PC 901, PC 902, PC 903 - Bioretention Facility No. 1 (walls)

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$10,600	$10,600
2	1	LS	Surveying (2%)	$2,700	$2,700
3	1	LS	Utilities Locate and Protection (1%)	$1,300	$1,300
4	1	LS	Temp Traffic Control (6%)	$8,000	$8,000
5	1	LS	Force Account (3%)	$4,000	$4,000
Subtotal					**$26,600**
Division 2 - Earthwork					
6	0.18	AC	Clearing and Grubbing	$8,000	$1,421
7	1	LS	Removal/Replacement of Structure and Obstruction (1%)	$1,600	$1,600
8	65	CY	Excavation Incl. Haul	$14	$904
Subtotal					**$3,925**
Division 3 - Aggregate Production and Acceptance					
9			No payment items		
Subtotal					**$0**
Division 4 - Bases					
10			No payment items		
Subtotal					**$0**
Division 5 - Surface Treatments and Pavements					
11			No payment items		
Subtotal					**$0**
Division 6 - Structures					
12	64	CY	CIP Conc. Class 4000	$800	$51,080
13	134	CY	Gravel Backfill for Wall	$45	$6,029
14	0	LS	Structural Carbon Steel	$2,500	$0
Subtotal					**$57,109**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
15	300	LF	Underdrain Pipe 8 In. Diam.	$24	$7,200
16	32	CY	Gravel Backfill for Drain	$45	$1,453
17	160	CY	Structure Excavation Class B Incl. Haul	$18	$2,880
18	1,260	SF	Shoring or Extra Excavation Class B (walls)	$15	$18,900
19	1,440	SF	Shoring or Extra Excavation Class B (pipe)	$2.50	$3,600
20	1	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$4,000
21	1	EA	Overflow Grate Type 2	$1,500	$1,500
22	10	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Dept	$60	$600
23	10	LF	Testing Storm Sewer Pipe	$5	$50
24	1	EA	Connection to Drainage Structure	$500	$500
Subtotal					**$40,683**
Division 8 - Miscellaneous Construction					
25	1	LS	Temporary Erosion and Sediment Controls (4%)	$6,400	$6,400
26	1	LS	Care and Diversion Water (2%)	$3,200	$3,200
27	143	CY	Topsoil Type A	$40	$5,733
28	19	CY	Compost	$40	$741
29	1,421	SF	Bioretention Cell Plantings, PSIPE	$6	$8,524
30	32	CY	Bioretention Cell Soil Mix	$150	$4,842
31	1	EA	Weirs/Level Spreaders	$1,500	$1,500
Subtotal					**$30,940**
			Subtotal Opinion of Probable Construction Cost		**$159,257**
			Contingency	30.0%	$47,777
			Design, Permitting, and Construction Management	20.0%	$31,851
			Parcel or Easement Acquisition		$0
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$238,885**

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Subareas PC 901, PC 902, PC 903 - Bioretention Facility No. 2 (no walls)

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$4,100	$4,100
2	1	LS	Surveying (2%)	$1,000	$1,000
3	1	LS	Utilities Locate and Protection (1%)	$500	$500
4	1	LS	Temp Traffic Control (6%)	$3,100	$3,100
5	1	LS	Force Account (3%)	$1,500	$1,500
Subtotal					**$10,200**
Division 2 - Earthwork					
6	0.12	AC	Clearing and Grubbing	$8,000	$970
7	1	LS	Removal/Replacement of Structure and Obstruction (1%)	$600	$600
8	60	CY	Excavation Incl. Haul	$14	$845
Subtotal					**$2,415**
Division 3 - Aggregate Production and Acceptance					
9			No payment items		
Subtotal					**$0**
Division 4 - Bases					
10			No payment items		
Subtotal					**$0**
Division 5 - Surface Treatments and Pavements					
11			No payment items		
Subtotal					**$0**
Division 6 - Structures					
12	0	CY	CIP Conc. Class 4000	$800	$0
13	0	CY	Gravel Backfill for Wall	$45	$0
14	0	LS	Structural Carbon Steel	$2,500	$0
Subtotal					**$0**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
15	126	LF	Underdrain Pipe 8 In. Diam.	$24	$3,019
16	30	CY	Gravel Backfill for Drain	$45	$1,358
17	108	CY	Structure Excavation Class B Incl. Haul	$18	$1,952
18	976	SF	Shoring or Extra Excavation Class B (pipe)	$2.50	$2,440
19	1	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$4,000
20	1	EA	Overflow Grate Type 2	$1,500	$22,710
21	15	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Depth)	$60	$908
22	15	LF	Testing Storm Sewer Pipe	$5	$76
23	15	EA	Connection to Drainage Structure	$500	$0
Subtotal					**$36,463**
Division 8 - Miscellaneous Construction					
24	1	LS	Temporary Erosion and Sediment Controls (4%)	$2,500	$2,500
25	1	LS	Care and Diversion Water (2%)	$1,200	$1,200
26	1	CY	Topsoil Type A	$40	$3,913
27	98	CY	Compost	$40	$503
28	13	SF	Bioretention Cell Plantings, PSIPE	$6	$75
29	815	CY	Bioretention Cell Soil Mix	$150	$4,525
30	30	EA	Weirs/Level Spreaders	$1,500	$0
Subtotal					**$12,716**
			Subtotal Opinion of Probable Construction Cost		**$61,794**
			Contingency	30.0%	$18,538
			Design, Permitting, and Construction Management	20.0%	$12,359
			Parcel or Easement Acquisition		$0
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$92,690**

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Subareas PC 901, PC 902, PC 903 - Bioretention Facility No. 3 (walls)

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$8,400	$8,400
2	1	LS	Surveying (2%)	$2,100	$2,100
3	1	LS	Utilities Locate and Protection (1%)	$1,000	$1,000
4	1	LS	Temp Traffic Control (6%)	$6,300	$6,300
5	1	LS	Force Account (3%)	$3,100	$3,100
Subtotal					**$20,900**
Division 2 - Earthwork					
6	0.08	AC	Clearing and Grubbing	$8,000	$600
7	1	LS	Removal/Replacement of Structure and Obstruction (1%)	$1,200	$1,200
8	54	CY	Excavation Incl. Haul	$14	$759
Subtotal					**$2,559**
Division 3 - Aggregate Production and Acceptance					
9			No payment items		
Subtotal					**$0**
Division 4 - Bases					
10			No payment items		
Subtotal					**$0**
Division 5 - Surface Treatments and Pavements					
11			No payment items		
Subtotal					**$0**
Division 6 - Structures					
12	51	CY	CIP Conc. Class 4000	$800	$40,835
13	110	CY	Gravel Backfill for Wall	$45	$4,930
14	0	LS	Structural Carbon Steel	$2,500	$0
Subtotal					**$45,765**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
15	160	LF	Underdrain Pipe 8 In. Diam.	$24	$3,840
16	27	CY	Gravel Backfill for Drain	$45	$1,220
17	127	CY	Structure Excavation Class B Incl. Haul	$18	$2,288
18	1,050	SF	Shoring or Extra Excavation Class B (walls)	$15	$15,750
19	1,144	SF	Shoring or Extra Excavation Class B (pipe)	$2.50	$2,860
20	1	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$4,000
21	1	EA	Overflow Grate Type 2	$1,500	$1,500
22	25	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Depth)	$60	$1,510
23	25	LF	Testing Storm Sewer Pipe	$5	$126
24	1	EA	Connection to Drainage Structure	$500	$500
Subtotal					**$33,594**
Division 8 - Miscellaneous Construction					
25	1	LS	Temporary Erosion and Sediment Controls (4%)	$5,000	$5,000
26	1	LS	Care and Diversion Water (2%)	$2,500	$2,500
27	61	CY	Topsoil Type A	$40	$2,421
28	15	CY	Compost	$40	$611
29	1,162	SF	Bioretention Cell Plantings, PSIPE	$6	$6,973
30	27	CY	Bioretention Cell Soil Mix	$150	$4,067
31	1	EA	Weirs/Level Spreaders	$1,500	$1,500
Subtotal					**$23,072**
			Subtotal Opinion of Probable Construction Cost		**$125,889**
			Contingency	30.0%	$37,767
			Design, Permitting, and Construction Management	20.0%	$25,178
			Parcel or Easement Acquisition		$0
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$188,834**

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Subareas PC 901, PC 902, PC 903 - Bioretention Facility No. 4 (walls)

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$10,700	$10,700
2	1	LS	Surveying (2%)	$2,700	$2,700
3	1	LS	Utilities Locate and Protection (1%)	$1,300	$1,300
4	1	LS	Temp Traffic Control (6%)	$8,000	$8,000
5	1	LS	Force Account (3%)	$4,000	$4,000
Subtotal					**$26,700**
Division 2 - Earthwork					
6	0.11	AC	Clearing and Grubbing	$8,000	$844
7	1	LS	Removal/Replacement of Structure and Obstruction (1%)	$1,600	$1,600
8	83	CY	Excavation Incl. Haul	$14	$1,164
Subtotal					**$3,608**
Division 3 - Aggregate Production and Acceptance					
9			No payment items		
Subtotal					**$0**
Division 4 - Bases					
10			No payment items		
Subtotal					**$0**
Division 5 - Surface Treatments and Pavements					
11			No payment items		
Subtotal					**$0**
Division 6 - Structures					
12	64	CY	CIP Conc. Class 4000	$800	$50,901
13	136	CY	Gravel Backfill for Wall	$45	$6,111
14	0	LS	Structural Carbon Steel	$2,500	$0
Subtotal					**$57,013**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
15	201	LF	Underdrain Pipe 8 In. Diam.	$24	$4,824
16	42	CY	Gravel Backfill for Drain	$45	$1,870
17	160	CY	Structure Excavation Class B Incl. Haul	$18	$2,880
18	1,281	SF	Shoring or Extra Excavation Class B (walls)	$15	$19,215
19	1,440	SF	Shoring or Extra Excavation Class B (pipe)	$2.50	$3,600
20	1	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$4,000
21	1	EA	Overflow Grate Type 2	$1,500	$1,500
22	32	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Depth)	$60	$1,896
23	32	LF	Testing Storm Sewer Pipe	$5	$158
24	1	EA	Connection to Drainage Structure	$500	$500
Subtotal					**$40,443**
Division 8 - Miscellaneous Construction					
25	1	LS	Temporary Erosion and Sediment Controls (4%)	$6,400	$6,400
26	1	LS	Care and Diversion Water (2%)	$3,200	$3,200
27	85	CY	Topsoil Type A	$40	$3,406
28	22	CY	Compost	$40	$864
29	1,585	SF	Bioretention Cell Plantings, PSIPE	$6	$9,509
30	42	CY	Bioretention Cell Soil Mix	$150	$6,233
31	2	EA	Weirs/Level Spreaders	$1,500	$3,000
Subtotal					**$32,612**
			Subtotal Opinion of Probable Construction Cost		**$160,376**
			Contingency	30.0%	$48,113
			Design, Permitting, and Construction Management	20.0%	$32,075
			Parcel or Easement Acquisition		$0
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$240,564**

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Subareas PC 901, PC 902, PC 903 - Bioretention Facility No. 5 (no walls)

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$2,900	$2,900
2	1	LS	Surveying (2%)	$700	$700
3	1	LS	Utilities Locate and Protection (1%)	$400	$400
4	1	LS	Temp Traffic Control (6%)	$2,200	$2,200
5	1	LS	Force Account (3%)	$1,100	$1,100
Subtotal					**$7,300**
Division 2 - Earthwork					
6	0.09	AC	Clearing and Grubbing	$8,000	$688
7	1	LS	Removal/Replacement of Structure and Obstruction (1%)	$400	$400
8	61	CY	Excavation Incl. Haul	$14	$856
Subtotal					**$1,943**
Division 3 - Aggregate Production and Acceptance					
9			No payment items		
Subtotal					**$0**
Division 4 - Bases					
10			No payment items		
Subtotal					**$0**
Division 5 - Surface Treatments and Pavements					
11			No payment items		
Subtotal					**$0**
Division 6 - Structures					
12	0	CY	CIP Conc. Class 4000	$800	$0
13	0	CY	Gravel Backfill for Wall	$45	$0
14	0	LS	Structural Carbon Steel	$2,500	$0
Subtotal					**$0**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
15	128	LF	Underdrain Pipe 8 In. Diam.	$24	$3,072
16	31	CY	Gravel Backfill for Drain	$45	$1,375
17	73	CY	Structure Excavation Class B Incl. Haul	$18	$1,312
18	656	SF	Shoring or Extra Excavation Class B (pipe)	$2.50	$1,640
19	1	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$4,000
20	1	EA	Overflow Grate Type 2	$1,500	$1,500
21	13	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Depth)	$60	$794
22	13	LF	Testing Storm Sewer Pipe	$5	$66
23	1	EA	Connection to Drainage Structure	$500	$500
Subtotal					**$14,259**
Division 8 - Miscellaneous Construction					
24	1	LS	Temporary Erosion and Sediment Controls (4%)	$1,800	$1,800
25	1	LS	Care and Diversion Water (2%)	$900	$900
26	69	CY	Topsoil Type A	$40	$2,773
27	16	CY	Compost	$40	$632
28	1,158	SF	Bioretention Cell Plantings, PSIPE	$6	$6,946
29	31	CY	Bioretention Cell Soil Mix	$150	$4,583
30	2	EA	Weirs/Level Spreaders	$1,500	$3,000
Subtotal					**$20,635**
			Subtotal Opinion of Probable Construction Cost		**$44,137**
			Contingency	30.0%	$13,241
			Design, Permitting, and Construction Management	20.0%	$8,827
			Parcel or Easement Acquisition		$0
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$66,205**

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Subareas PC 901, PC 902, PC 903 - Bioretention Facility No. 6 (walls)

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$11,300	$11,300
2	1	LS	Surveying (2%)	$2,800	$2,800
3	1	LS	Utilities Locate and Protection (1%)	$1,400	$1,400
4	1	LS	Temp Traffic Control (6%)	$8,500	$8,500
5	1	LS	Force Account (3%)	$4,200	$4,200
Subtotal					**$28,200**
Division 2 - Earthwork					
6	0.11	AC	Clearing and Grubbing	$8,000	$848
7	1	LS	Removal/Replacement of Structure and Obstruction (1%)	$1,700	$1,700
8	55	CY	Excavation Incl. Haul	$14	$768
Subtotal					**$3,317**
Division 3 - Aggregate Production and Acceptance					
9			No payment items		
Subtotal					**$0**
Division 4 - Bases					
10			No payment items		
Subtotal					**$0**
Division 5 - Surface Treatments and Pavements					
11			No payment items		
Subtotal					**$0**
Division 6 - Structures					
12	70	CY	CIP Conc. Class 4000	$800	$55,957
13	150	CY	Gravel Backfill for Wall	$45	$6,765
14	0	LS	Structural Carbon Steel	$2,500	$0
Subtotal					**$62,722**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
15	215	LF	Underdrain Pipe 8 In. Diam.	$24	$5,160
16	27	CY	Gravel Backfill for Drain	$45	$1,235
17	177	CY	Structure Excavation Class B Incl. Haul	$18	$3,182
18	1,421	SF	Shoring or Extra Excavation Class B (walls)	$15	$21,315
19	1,591	SF	Shoring or Extra Excavation Class B (pipe)	$2.50	$3,978
20	1	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$4,000
21	1	EA	Overflow Grate Type 2	$1,500	$1,500
22	25	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Depth)	$60	$1,500
23	25	LF	Testing Storm Sewer Pipe	$5	$125
24	1	EA	Connection to Drainage Structure	$500	$500
Subtotal					**$42,495**
Division 8 - Miscellaneous Construction					
25	1	LS	Temporary Erosion and Sediment Controls (4%)	$6,800	$6,800
26	1	LS	Care and Diversion Water (2%)	$3,400	$3,400
27	86	CY	Topsoil Type A	$40	$3,422
28	18	CY	Compost	$40	$706
29	1,412	SF	Bioretention Cell Plantings, PSIPE	$6	$8,471
30	27	CY	Bioretention Cell Soil Mix	$150	$4,117
31	4	EA	Weirs/Level Spreaders	$1,500	$6,000
Subtotal					**$32,916**
			Subtotal Opinion of Probable Construction Cost		**$169,650**
			Contingency	30.0%	$50,895
			Design, Permitting, and Construction Management	20.0%	$33,930
			Parcel or Easement Acquisition		$0
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$254,476**

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Subareas BC 154 - BC 156 - Regional Flow Control and Treatment Facilities Upstream of S Fork Baker Creek Outfall

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$144,100	$144,100
2	1	LS	Surveying (2%)	$36,000	$36,000
3	1	LS	Utilities Locate and Protection (1%)	$18,000	$18,000
4	1	LS	Temp Traffic Control (6%)	$108,100	$108,100
5	1	LS	Force Account (3%)	$54,000	$54,000
Subtotal					**$360,200**
Division 2 - Earthwork					
6	2.8	AC	Clearing and Grubbing	$6,000	$16,800
7	1	LS	Removal of Structure and Obstruction (1%)	$19,900	$19,900
8	7,600	CY	Excavation Incl. Haul	$12	$91,200
9	1,190	CY	Unsuitable Foundation Excavation Incl. Haul	$15	$17,850
10	1,670	CY	Select Borrow Incl. Haul from Stockpile	$8	$13,360
11	1,700	CY	Embankment Compaction	$5	$8,500
12	20	CY	Controlled Density Fill	$130	$2,600
13	1,780	SY	Construction Geogrid/Geotextile	$18	$32,040
Subtotal					**$202,250**
Division 3 - Aggregrate Production and Acceptance					
14	0	0	No Payment Items		$0
Subtotal					**$0**
Division 4 - Bases					
15	610	TN	Crushed Surfacing Top Course (or Base Course)	$30	$18,300
16	1,260	TN	Foundation Material	$25	$31,500
Subtotal					**$49,800**
Division 5 - Surface Treatments and Pavements					
17	140	TN	HMA Cl. 1/2 PG 64-22	$140	$19,600
Subtotal					**$19,600**
Division 6 - Structures					
18	25	CY	CIP Conc. Class 4000	$800	$20,000
19	61,800	CF	Pre-cast Concrete Vault	$14	$865,200
20	800	CY	Gravel Backfill for Wall	$45	$36,000
21	1	LS	Structural Carbon Steel	$15,000	$15,000
22	100	LF	Curb and Gutter Replacement	$30	$3,000
Subtotal					**$939,200**
Division 7 - Drainage Structures, Storm Sewers, Sanitary Sewers, Waster Mains, and Conduits					
23	500	LF	Underdrain Pipe 12 In. Diam.	$42	$21,000
24	180	CY	Gravel Backfill for Drain	$45	$8,100
25	3,600	CY	Structure Excavation Class B Incl. Haul	$18	$64,800
26	5,300	SF	Shoring or Extra Excavation Class B	$2.50	$13,250
27	0	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Depth)	$60	$0
28	50	LF	Polypropylene Storm Sewer Pipe 18 In. Diam. (up to 8 ft. Depth)	$90	$4,500
29	0	LF	Polypropylene Storm Sewer Pipe 24 In. Diam. (up to 8 ft. Depth)	$132	$0
30	0	LF	Polypropylene Storm Sewer Pipe 30 In. Diam. (up to 8 ft. Depth)	$165	$0
31	250	LF	Polypropylene Storm Sewer Pipe 36 In. Diam. (up to 8 ft. Depth)	$216	$54,000
32	1	EA	Tapered End Sect. with Safety Bars 36 In. Diam.	$3,000	$3,000
33	300	LF	Testing Storm Sewer Pipe	$4	$1,200
34	3	EA	Manhole 48 In. Diam. Type 1 (up to 8 ft. Depth)	$4,500	$13,500

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Subareas BC 154 - BC 156 - Regional Flow Control and Treatment Facilities Upstream of S Fork Baker Creek Outfall

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
35	2	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$8,000
36	3	EA	Catch Basin Type 2 60 In. Diam. (up to 8 ft. Depth)	$5,500	$16,500
37	1	EA	Catch Basin Type 2 72 In. Diam. (up to 8 ft. Depth)	$7,000	$7,000
38	1	EA	Flow Splitter Catch Basin Type 2 96 In. Diam. (up to 8 ft. Depth)	$15,000	$15,000
38	2	EA	Adjust Catch Basin or Manhole	$1,000	$2,000
39	14	EA	Connection to Drainage Structure or Manhole	$500	$7,000
40	1	EA	Riser/Primary Spillway Detention Pond Outlet Control	$5,000	$5,000
41	1	LS	Emergency Spillway Detention Pond Outlet Control	$20,000	$20,000
42	1	LS	OWS Coalescing Plate Pack	$80,000	$80,000
43	360	LF	Polypropylene Sewer Pipe 8 In. Diam. (up to 8 ft. Depth)	$48	$17,280
44	360	LF	Testing Sewer Pipe	$4	$1,440
Subtotal					**$362,570**
Division 8 - Miscellaneous Construction					
45	1	LS	Temporary Erosion and Sediment Controls (4%)	$79,700	$79,700
46	1	LS	Care and Diversion Water (2%)	$39,900	$39,900
47	500	CY	Topsoil Type A	$40	$20,000
48	30	CY	Compost	$40	$1,200
49	22,000.0	SF	Landscape Plantings PSIPE	$2	$44,000
50	570	LF	Handrail	$75	$42,750
Subtotal					**$227,550**
			Subtotal Opinion of Probable Construction Cost		**$2,161,170**
			Contingency	30.0%	$648,351
			Design, Permitting, and Constructon Management	20.0%	$432,234
			Parcel or Easement Acqisition		$460,000
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$3,701,755**

Notes:

(1) July 2019 dollars

(2) Does not include sales tax

(3) Earthwork costs assume that excacated soils are suitable for re-use as embankment fill, and that no contaminated soils are encountered that would otherwise require special, higher cost off-site disposal.

Appendix F

Bellingham Fish Passage Culvert Replacement Program				
				Projected 2019 Values [2]
Project #	Stream	Road Crossing	2010 Constuction Cost [1]	Construction
1	Squalicum Cr	Baker Creek Confluence	$ 200,000	$239,000
2	SF Baker Creek	James St.	$ 1,000,000	$1,195,000
3	Baker Creek	James St.	$ 1,000,000	$1,195,000
4	Padden Cr	Old Fairhaven Pkwy.	$ 1,000,000	$1,195,000
5	Squalicum Cr	Roeder Ave.	$ 4,000,000	$4,780,000
Totals:			$ 7,200,000	$8,604,000

Notes:

1: Rank and cost from 2010 Anchor Environmental Study

2: Values projected based on 2010 estimates with rate and period stated below.

Future Values

Rate:	2.0%
Period (yrs)	9

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Marine Outfalls Conveyance Storm Drain Improvements - Drainage System/Outfall: Arbutus, Alternative 2

Arbutus Alt. 2

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$2,900	$2,900
2	1	LS	Surveying (2%)	$700	$700
3	1	LS	Utilities Locate and Protection (1%)	$400	$400
4	1	LS	Temp Traffic Control (6%)	$2,200	$2,200
5	1	LS	Force Account (3%)	$1,100	$1,100
Subtotal					**$7,300**
Division 2 - Earthwork					
6	1	LS	Removal of Structure and Obstruction (1%)	$400	$400
7	135	SF	Removal of Asphalt Concrete Pavement	$1.75	$236
8	378	SF	Removal of Cement Concrete Sidewalk	$1.50	$567
9	84	LF	Removal of Cement Concrete Curb and Gutter	$5	$420
Subtotal					**$1,623**
Division 3 - Aggregate Production and Acceptance					
10			No Payment Items		$0
Subtotal					**$0**
Division 4 - Bases					
11	7	TN	Crushed Surfacing Top Course (or Base Course)	$30	$218
Subtotal					**$218**
Division 5 - Surface Treatments and Pavements					
12	5	TN	HMA Cl. 1/2 PG 64-22	$140	$711
Subtotal					**$711**
Division 6 - Structures					
13	84	LF	Curb and Gutter Replacement	$30	$2,520
14	378	SF	Sidewalk Replacement	$10	$3,780
Subtotal					**$6,300**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
15	119	CY	Structure Excavation Class B Incl. Haul	$18	$2,142
16	713	SF	Shoring or Extra Excavation Class B	$2.50	$1,783
17	0	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Depth)	$60	$0
18	114	LF	Polypropylene Storm Sewer Pipe 18 In. Diam. (up to 8 ft. Depth)	$90	$10,260
33	114	LF	Testing Storm Sewer Pipe	$5	$570
34	2	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$8,000
42	5	EA	Connection to Drainage Structure	$500	$2,500
Subtotal					**$25,255**
Division 8 - Miscellaneous Construction					
43	1	LS	Temporary Erosion and Sediment Controls (4%)	$1,700	$1,700
44	1	LS	Care and Diversion Water (2%)	$800	$800
Subtotal					**$2,500**
			Subtotal Opinion of Probable Construction Cost		**$43,906**
			Contingency	30.0%	$13,172
			Design, Permitting, and Construction Management	20.0%	$8,781
			Parcel or Easement Acquisition		$0
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$65,859**

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Marine Outfalls Conveyance Storm Drain Improvements - Drainage System/Outfall: Willow, Alternative 2
Willow Alt. 2

Item	Est. Quantity	Unit	Description	Unit Cost		Extended Amount
Division 1 - General Requirements						
1	1	LS	Mobilization/Demobilization (8%)	$25,100		$25,100
2	1	LS	Surveying (2%)	$6,300		$6,300
3	1	LS	Utilities Locate and Protection (1%)	$3,100		$3,100
4	1	LS	Temp Traffic Control (6%)	$18,800		$18,800
5	1	LS	Force Account (3%)	$9,400		$9,400
Subtotal						**$62,700**
Division 2 - Earthwork						
6	1	LS	Removal of Structure and Obstruction (1%)	$3,600		$3,600
7	500	SF	Removal of Asphalt Concrete Pavement	$1.75		$875
8	4,620	SF	Removal of Cement Concrete Sidewalk	$1.50		$6,930
9	924	LF	Removal of Cement Concrete Curb and Gutter	$5		$4,620
Subtotal						**$16,025**
Division 3 - Aggregate Production and Acceptance						
10			No Payment Items			$0
Subtotal						**$0**
Division 4 - Bases						
11	27	TN	Crushed Surfacing Top Course (or Base Course)	$30		$806
Subtotal						**$806**
Division 5 - Surface Treatments and Pavements						
12	19	TN	HMA Cl. 1/2 PG 64-22	$140		$2,631
Subtotal						**$2,631**
Division 6 - Structures						
13	924	LF	Curb and Gutter Replacement	$30		$27,720
14	4,620	SF	Sidewalk Replacement	$10		$46,200
Subtotal						**$73,920**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits						
15	1,058	CY	Structure Excavation Class B Incl. Haul	$18		$19,044
16	5,721	SF	Shoring or Extra Excavation Class B	$2.50		$14,303
17	0	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Depth)	$60		$0
18	0	LF	Polypropylene Storm Sewer Pipe 18 In. Diam. (up to 8 ft. Depth)	$90		$0
19	1,024	LF	Polypropylene Storm Sewer Pipe 24 In. Diam. (up to 8 ft. Depth)	$132		$135,168
33	1024	LF	Testing Storm Sewer Pipe	$5		$5,120
34	5	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000		$20,000
42	10	EA	Connection to Drainage Structure	$500		$5,000
Subtotal						**$198,635**
Division 8 - Miscellaneous Construction						
43	1	LS	Temporary Erosion and Sediment Controls (4%)	$14,500		$14,500
44	1	LS	Care and Diversion Water (2%)	$7,200		$7,200
Subtotal						**$21,700**
					Subtotal Opinion of Probable Construction Cost	**$376,417**
				Contingency	30.0%	$112,925
				Design, Permitting, and Construction Management	20.0%	$75,283
					Parcel or Easement Acquisition	$0
					Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost	**$564,625**

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Marine Outfalls Conveyance Storm Drain Improvements - Drainage System/Outfall: Olive
Olive

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$1,400	$1,400
2	1	LS	Surveying (2%)	$400	$400
3	1	LS	Utilities Locate and Protection (1%)	$200	$200
4	1	LS	Temp Traffic Control (6%)	$1,100	$1,100
5	1	LS	Force Account (3%)	$500	$500
Subtotal					**$3,600**
Division 2 - Earthwork					
6	1	LS	Removal of Structure and Obstruction (1%)	$200	$200
7	230	SF	Removal of Asphalt Concrete Pavement	$1.75	$403
8	0	SF	Removal of Cement Concrete Sidewalk	$1.50	$0
9	0	LF	Removal of Cement Concrete Curb and Gutter	$5	$0
Subtotal					**$603**
Division 3 - Aggregate Production and Acceptance					
10			No Payment Items		$0
Subtotal					**$0**
Division 4 - Bases					
11	12	TN	Crushed Surfacing Top Course (or Base Course)	$30	$371
Subtotal					**$371**
Division 5 - Surface Treatments and Pavements					
12	9	TN	HMA Cl. 1/2 PG 64-22	$140	$1,210
Subtotal					**$1,210**
Division 6 - Structures					
Subtotal					**$0**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
15	71	CY	Structure Excavation Class B Incl. Haul	$18	$1,278
16	382	SF	Shoring or Extra Excavation Class B	$2.50	$955
17	0	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Depth)	$60	$0
18	0	LF	Polypropylene Storm Sewer Pipe 18 In. Diam. (up to 8 ft. Depth)	$90	$0
19	46	LF	Polypropylene Storm Sewer Pipe 24 In. Diam. (up to 8 ft. Depth)	$132	$6,072
27	46	LF	Polypropylene Storm Sewer Pipe 24 In. Diam. Extra Depth Add (8-12 ft.)	$24	$1,104
33	46	LF	Testing Storm Sewer Pipe	$5	$230
34	1	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$4,000
42	2	EA	Connection to Drainage Structure	$500	$1,000
Subtotal					**$14,639**
Division 8 - Miscellaneous Construction					
43	1	LS	Temporary Erosion and Sediment Controls (4%)	$800	$800
44	1	LS	Care and Diversion Water (2%)	$400	$400
Subtotal					**$1,200**
			Subtotal Opinion of Probable Construction Cost		**$21,623**
			Contingency	30.0%	$6,487
			Design, Permitting, and Construction Management	20.0%	$4,325
			Parcel or Easement Acquisition		$0
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$32,434**

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Marine Outfalls Conveyance Storm Drain Improvements - Drainage System/Outfall: Laurel, Alternative 1

Laurel Alt 1

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$32,000	$32,000
2	1	LS	Surveying (2%)	$8,000	$8,000
3	1	LS	Utilities Locate and Protection (1%)	$4,000	$4,000
4	1	LS	Temp Traffic Control (6%)	$24,000	$24,000
5	1	LS	Force Account (3%)	$12,000	$12,000
Subtotal					**$80,000**
Division 2 - Earthwork					
6	1	LS	Removal of Structure and Obstruction (1%)	$4,400	$4,400
7	4,909	SF	Removal of Asphalt Concrete Pavement	$1.75	$8,590
8	1,134	SF	Removal of Cement Concrete Sidewalk	$1.50	$1,700
9	218	LF	Removal of Cement Concrete Curb and Gutter	$5	$1,090
Subtotal					**$15,781**
Division 3 - Aggregate Production and Acceptance					
10			No Payment Items		$0
Subtotal					**$0**
Division 4 - Bases					
11	264	TN	Crushed Surfacing Top Course (or Base Course)	$30	$7,909
Subtotal					**$7,909**
Division 5 - Surface Treatments and Pavements					
12	185	TN	HMA Cl. 1/2 PG 64-22	$140	$25,835
Subtotal					**$25,835**
Division 6 - Structures					
13	218	LF	Curb and Gutter Replacement	$30	$6,540
14	1,134	SF	Sidewalk Replacement	$10	$11,336
Subtotal					**$17,876**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
15	1,590	CY	Structure Excavation Class B Incl. Haul	$18	$28,620
16	8,601	SF	Shoring or Extra Excavation Class B	$2.50	$21,503
18	872	LF	Polypropylene Storm Sewer Pipe 18 In. Diam. (up to 8 ft. Depth)	$90	$78,480
21	290	LF	Polypropylene Storm Sewer Pipe 36 In. Diam. (up to 8 ft. Depth)	$216	$62,640
26	194	LF	Polypropylene Storm Sewer Pipe 18 In. Diam. Extra Depth Add (8-12 ft.)	$18	$3,492
29	265	LF	Polypropylene Storm Sewer Pipe 36 In. Diam. Extra Depth Add (8-12 ft.)	$36	$9,540
33	1162	LF	Testing Storm Sewer Pipe	$5	$5,810
34	9	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$36,000
35	3	EA	Catch Basin Type 2 60 In. Diam. (up to 8 ft. Depth)	$5,500	$16,500
36	3	EA	Catch Basin Type 2 72 In. Diam. (up to 8 ft. Depth)	$7,000	$21,000
38	4	EA	Catch Basin Type 2 48 In. Diam. Extra Depth Add (8-12 ft.)	$600	$2,400
39	3	EA	Catch Basin Type 2 60 In. Diam. Extra Depth Add (8-12 ft.)	$800	$2,400
40	2	EA	Catch Basin Type 2 72 In. Diam. Extra Depth Add (8-12 ft.)	$1,000	$2,000
42	31	EA	Connection to Drainage Structure	$500	$15,500
Subtotal					**$305,885**
Division 8 - Miscellaneous Construction					
43	1	LS	Temporary Erosion and Sediment Controls (4%)	$17,700	$17,700
44	1	LS	Care and Diversion Water (2%)	$8,900	$8,900
Subtotal					**$26,600**
			Subtotal Opinion of Probable Construction Cost		**$479,885**
			Contingency	30.0%	$143,965
			Design, Permitting, and Construction Management	20.0%	$95,977
			Parcel or Easement Acquisition		$0
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$719,827**

Notes:

(1) July 2019 dollars

(2) Does not include sales tax

(3) Earthwork costs assume that excacated soils are suitable for re-use as embankment fill, and that no contaminated soils are encountered that would otherwise require special, higher cost off-site disposal.

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Marine Outfalls Conveyance Storm Drain Improvements - Drainage System/Outfall: C Street

$0

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$30,900	$30,900
2	1	LS	Surveying (2%)	$7,700	$7,700
3	1	LS	Utilities Locate and Protection (1%)	$3,900	$3,900
4	1	LS	Temp Traffic Control (6%)	$23,200	$23,200
5	1	LS	Force Account (3%)	$11,600	$11,600
Subtotal					**$77,300**
Division 2 - Earthwork					
6	1	LS	Removal of Structure and Obstruction (1%)	$4,300	$4,300
7	5,396	SF	Removal of Asphalt Concrete Pavement	$1.75	$9,442
8	999	SF	Removal of Cement Concrete Sidewalk	$1.50	$1,499
9	222	LF	Removal of Cement Concrete Curb and Gutter	$5	$1,110
Subtotal					**$16,351**
Division 3 - Aggregate Production and Acceptance					
10			No Payment Items		$0
Subtotal					**$0**
Division 4 - Bases					
11	290	TN	Crushed Surfacing Top Course (or Base Course)	$30	$8,693
Subtotal					**$8,693**
Division 5 - Surface Treatments and Pavements					
12	203	TN	HMA Cl. 1/2 PG 64-22	$140	$28,396
Subtotal					**$28,396**
Division 6 - Structures					
13	222	LF	Curb and Gutter Replacement	$30	$6,660
14	999	SF	Sidewalk Replacement	$10	$9,990
Subtotal					**$16,650**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
15	1,602	CY	Structure Excavation Class B Incl. Haul	$18	$28,836
16	9,543	SF	Shoring or Extra Excavation Class B	$2.50	$23,858
17	0	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Depth)	$60	$0
18	1,341	LF	Polypropylene Storm Sewer Pipe 18 In. Diam. (up to 8 ft. Depth)	$90	$120,690
19	80	LF	Polypropylene Storm Sewer Pipe 24 In. Diam. (up to 8 ft. Depth)	$132	$10,560
26	222	LF	Polypropylene Storm Sewer Pipe 18 In. Diam. Extra Depth Add (8-12 ft.)	$18	$3,996
27	80	LF	Polypropylene Storm Sewer Pipe 24 In. Diam. Extra Depth Add (8-12 ft.)	$24	$1,920
33	1421	LF	Testing Storm Sewer Pipe	$5	$7,105
34	15	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$60,000
35	2	EA	Catch Basin Type 2 60 In. Diam. (up to 8 ft. Depth)	$5,500	$11,000
38	3	EA	Catch Basin Type 2 48 In. Diam. Extra Depth Add (8-12 ft.)	$600	$1,800
39	2	EA	Catch Basin Type 2 60 In. Diam. Extra Depth Add (8-12 ft.)	$800	$1,600
42	38	EA	Connection to Drainage Structure	$500	$19,000
Subtotal					**$290,365**
Division 8 - Miscellaneous Construction					
43	1	LS	Temporary Erosion and Sediment Controls (4%)	$17,100	$17,100
44	1	LS	Care and Diversion Water (2%)	$8,600	$8,600
Subtotal					**$25,700**
			Subtotal Opinion of Probable Construction Cost		**$463,454**
			Contingency	30.0%	$139,036
			Design, Permitting, and Construction Management	20.0%	$92,691
			Parcel or Easement Acquisition		$0
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$695,181**

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Marine Outfalls Conveyance Storm Drain Improvements - Drainage System/Outfall: Ellsworth

Ellsworth

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$35,200	$35,200
2	1	LS	Surveying (2%)	$8,800	$8,800
3	1	LS	Utilities Locate and Protection (1%)	$4,400	$4,400
4	1	LS	Temp Traffic Control (6%)	$26,400	$26,400
5	1	LS	Force Account (3%)	$13,200	$13,200
Subtotal					**$88,000**
Division 2 - Earthwork					
6	1	LS	Removal of Structure and Obstruction (1%)	$4,900	$4,900
7	2,659	SF	Removal of Asphalt Concrete Pavement	$1.75	$4,653
8	4,283	SF	Removal of Cement Concrete Sidewalk	$1.50	$6,424
9	931	LF	Removal of Cement Concrete Curb and Gutter	$5	$4,655
Subtotal					**$20,632**
Division 3 - Aggregate Production and Acceptance					
10			No Payment Items		$0
Subtotal					**$0**
Division 4 - Bases					
11	143	TN	Crushed Surfacing Top Course (or Base Course)	$30	$4,284
Subtotal					**$4,284**
Division 5 - Surface Treatments and Pavements					
12	100	TN	HMA Cl. 1/2 PG 64-22	$140	$13,993
Subtotal					**$13,993**
Division 6 - Structures					
13	931	LF	Curb and Gutter Replacement	$30	$27,930
14	4,283	SF	Sidewalk Replacement	$10	$42,826
Subtotal					**$70,756**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
15	1,935	CY	Structure Excavation Class B Incl. Haul	$18	$34,830
16	11,216	SF	Shoring or Extra Excavation Class B	$2.50	$28,040
17	0	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Depth)	$60	$0
18	1,040	LF	Polypropylene Storm Sewer Pipe 18 In. Diam. (up to 8 ft. Depth)	$90	$93,600
19	469	LF	Polypropylene Storm Sewer Pipe 24 In. Diam. (up to 8 ft. Depth)	$132	$61,908
26	147	LF	Polypropylene Storm Sewer Pipe 18 In. Diam. Extra Depth Add (8-12 ft.)	$18	$2,646
27	275	LF	Polypropylene Storm Sewer Pipe 24 In. Diam. Extra Depth Add (8-12 ft.)	$24	$6,600
33	1509	LF	Testing Storm Sewer Pipe	$5	$7,545
34	8	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$32,000
35	4	EA	Catch Basin Type 2 60 In. Diam. (up to 8 ft. Depth)	$5,500	$22,000
38	2	EA	Catch Basin Type 2 48 In. Diam. Extra Depth Add (8-12 ft.)	$600	$1,200
42	22	EA	Connection to Drainage Structure	$500	$11,000
Subtotal					**$301,369**
Division 8 - Miscellaneous Construction					
43	1	LS	Temporary Erosion and Sediment Controls (4%)	$19,500	$19,500
44	1	LS	Care and Diversion Water (2%)	$9,800	$9,800
Subtotal					**$29,300**
			Subtotal Opinion of Probable Construction Cost		**$528,334**
			Contingency	30.0%	$158,500
			Design, Permitting, and Construction Management	20.0%	$105,667
			Parcel or Easement Acquisition		$0
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$792,500**

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Marine Outfalls Conveyance Storm Drain Improvements - Drainage System/Outfall: Broadway-Main

Broadway Main

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$210,200	$210,200
2	1	LS	Surveying (2%)	$52,600	$52,600
3	1	LS	Utilities Locate and Protection (1%)	$26,300	$26,300
4	1	LS	Temp Traffic Control (6%)	$157,700	$157,700
5	1	LS	Force Account (3%)	$78,800	$78,800
Subtotal					**$525,600**
Division 2 - Earthwork					
6	1	LS	Removal of Structure and Obstruction (1%)	$30,100	$30,100
7	38,176	SF	Removal of Asphalt Concrete Pavement	$1.75	$66,807
8	0	SF	Removal of Cement Concrete Sidewalk	$1.50	$0
9	0	LF	Removal of Cement Concrete Curb and Gutter	$5	$0
Subtotal					**$96,907**
Division 3 - Aggregate Production and Acceptance					
10			No Payment Items		$0
Subtotal					**$0**
Division 4 - Bases					
11	2,050	TN	Crushed Surfacing Top Course (or Base Course)	$30	$61,505
Subtotal					**$61,505**
Division 5 - Surface Treatments and Pavements					
12	1,435	TN	HMA Cl. 1/2 PG 64-22	$140	$200,917
Subtotal					**$200,917**
Division 6 - Structures					
13	0	LF	Curb and Gutter Replacement	$30	$0
14	0	SF	Sidewalk Replacement	$10	$0
Subtotal					**$0**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
15	10,124	CY	Structure Excavation Class B Incl. Haul	$18	$182,227
16	46,884	SF	Shoring or Extra Excavation Class B	$2.50	$117,209
17	0	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Depth)	$60	$0
18	523	LF	Polypropylene Storm Sewer Pipe 18 In. Diam. (up to 8 ft. Depth)	$90	$47,070
19	2,668	LF	Polypropylene Storm Sewer Pipe 24 In. Diam. (up to 8 ft. Depth)	$132	$352,176
20	1,029	LF	Polypropylene Storm Sewer Pipe 30 In. Diam. (up to 8 ft. Depth)	$165	$169,785
21	198	LF	Polypropylene Storm Sewer Pipe 36 In. Diam. (up to 8 ft. Depth)	$216	$42,768
22	523	LF	Polypropylene Storm Sewer Pipe 42 In. Diam. (up to 8 ft. Depth)	$252	$131,796
23	1,540	LF	Polypropylene Storm Sewer Pipe 48 In. Diam. (up to 8 ft. Depth)	$312	$480,480
24	101	LF	Polypropylene Storm Sewer Pipe 54 In. Diam. (up to 8 ft. Depth)	$351	$35,451
25	0	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. Extra Depth Add (8-12 ft.)	$12	$0
26	0	LF	Polypropylene Storm Sewer Pipe 18 In. Diam. Extra Depth Add (8-12 ft.)	$18	$0
27	485	LF	Polypropylene Storm Sewer Pipe 24 In. Diam. Extra Depth Add (8-12 ft.)	$24	$11,640
28	248	LF	Polypropylene Storm Sewer Pipe 30 In. Diam. Extra Depth Add (8-12 ft.)	$30	$7,440
29	198	LF	Polypropylene Storm Sewer Pipe 36 In. Diam. Extra Depth Add (8-12 ft.)	$36	$7,128
30	53	LF	Polypropylene Storm Sewer Pipe 42 In. Diam. Extra Depth Add (8-12 ft.)	$42	$2,226
31	1,386	LF	Polypropylene Storm Sewer Pipe 48 In. Diam. Extra Depth Add (8-12 ft.)	$48	$66,528
32	101	LF	Polypropylene Storm Sewer Pipe 54 In. Diam. Extra Depth Add (8-12 ft.)	$54	$5,454
33	6,582	LF	Testing Storm Sewer Pipe	$5	$32,910
34	21	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$84,000

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Marine Outfalls Conveyance Storm Drain Improvements - Drainage System/Outfall: Broadway-Main

Broadway Main

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
35	10	EA	Catch Basin Type 2 60 In. Diam. (up to 8 ft. Depth)	$5,500	$55,000
36	16	EA	Catch Basin Type 2 72 In. Diam. (up to 8 ft. Depth)	$7,000	$112,000
37	8	EA	Catch Basin Type 2 84 In. Diam. (up to 8 ft. Depth)	$8,500	$68,000
38	2	EA	Catch Basin Type 2 48 In. Diam. Extra Depth Add (8-12 ft.)	$600	$1,200
39	4	EA	Catch Basin Type 2 60 In. Diam. Extra Depth Add (8-12 ft.)	$800	$3,200
40	6	EA	Catch Basin Type 2 72 In. Diam. Extra Depth Add (8-12 ft.)	$1,000	$6,000
41	8	EA	Catch Basin Type 2 84 In. Diam. Extra Depth Add (8-12 ft.)	$1,200	$9,600
42	113	EA	Connection to Drainage Structure	$500	$56,500
Subtotal					**$2,087,788**
Division 8 - Miscellaneous Construction					
43	1	LS	Temporary Erosion and Sediment Controls (4%)	$120,300	$120,300
44	1	LS	Care and Diversion Water (2%)	$60,100	$60,100
Subtotal					**$180,400**
			Subtotal Opinion of Probable Construction Cost		**$3,153,117**
			Contingency	30.0%	$945,935
			Design, Permitting, and Construction Management	20.0%	$630,623
			Parcel or Easement Acquisition		$0
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$4,729,676**

Notes:

(1) July 2019 dollars

(2) Does not include sales tax

(3) Earthwork costs assume that excacated soils are suitable for re-use as embankment fill, and that no contaminated soils are encountered that would otherwise require special, higher cost off-site disposal.

(4) Assumes all storm drain replacement is within the ROW, and that no parcel or easement acquisition is required.

(5) For preliminary estimate of quantities, see separate marine outfalls quanity calculations spreadsheet

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Marine Outfalls Conveyance Storm Drain Improvements - Drainage System/Outfall: Broadway-Eldridge, Alternative 2

Broadway-Eldridge Alt 2

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$83,300	$83,300
2	1	LS	Surveying (2%)	$20,800	$20,800
3	1	LS	Utilities Locate and Protection (1%)	$10,400	$10,400
4	1	LS	Temp Traffic Control (6%)	$62,500	$62,500
5	1	LS	Force Account (3%)	$31,200	$31,200
Subtotal					**$208,200**
Division 2 - Earthwork					
6	1	LS	Removal of Structure and Obstruction (1%)	$11,900	$11,900
7	3,000	SF	Removal of Asphalt Concrete Pavement	$1.75	$5,250
8	12,905	SF	Removal of Cement Concrete Sidewalk	$1.50	$19,358
9	2,581	LF	Removal of Cement Concrete Curb and Gutter	$5	$12,905
Subtotal					**$49,413**
Division 3 - Aggregate Production and Acceptance					
10			No Payment Items		$0
Subtotal					**$0**
Division 4 - Bases					
11	161	TN	Crushed Surfacing Top Course (or Base Course)	$30	$4,833
Subtotal					**$4,833**
Division 5 - Surface Treatments and Pavements					
12	113	TN	HMA Cl. 1/2 PG 64-22	$140	$15,789
Subtotal					**$15,789**
Division 6 - Structures					
13	2,581	LF	Curb and Gutter Replacement	$30	$77,430
14	12,905	SF	Sidewalk Replacement	$10	$129,050
Subtotal					**$206,480**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
15	4,114	CY	Structure Excavation Class B Incl. Haul	$18	$74,052
16	23,367	SF	Shoring or Extra Excavation Class B	$2.50	$58,418
17	81	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. (up to 8 ft. Depth)	$60	$4,860
18	1,637	LF	Polypropylene Storm Sewer Pipe 18 In. Diam. (up to 8 ft. Depth)	$90	$147,330
19	1,254	LF	Polypropylene Storm Sewer Pipe 24 In. Diam. (up to 8 ft. Depth)	$132	$165,528
20	152	LF	Polypropylene Storm Sewer Pipe 30 In. Diam. (up to 8 ft. Depth)	$165	$25,080
21	0	LF	Polypropylene Storm Sewer Pipe 36 In. Diam. (up to 8 ft. Depth)	$216	$0
22	57	LF	Polypropylene Storm Sewer Pipe 42 In. Diam. (up to 8 ft. Depth)	$252	$14,364
23	0	LF	Polypropylene Storm Sewer Pipe 48 In. Diam. (up to 8 ft. Depth)	$312	$0
24	0	LF	Polypropylene Storm Sewer Pipe 54 In. Diam. (up to 8 ft. Depth)	$351	$0
25	0	LF	Polypropylene Storm Sewer Pipe 12 In. Diam. Extra Depth Add (8-12 ft.)	$12	$0
26	759	LF	Polypropylene Storm Sewer Pipe 18 In. Diam. Extra Depth Add (8-12 ft.)	$18	$13,662
27	0	LF	Polypropylene Storm Sewer Pipe 24 In. Diam. Extra Depth Add (8-12 ft.)	$24	$0
28	134	LF	Polypropylene Storm Sewer Pipe 30 In. Diam. Extra Depth Add (8-12 ft.)	$30	$4,020
29	0	LF	Polypropylene Storm Sewer Pipe 36 In. Diam. Extra Depth Add (8-12 ft.)	$36	$0
30	0	LF	Polypropylene Storm Sewer Pipe 42 In. Diam. Extra Depth Add (8-12 ft.)	$42	$0
31	0	LF	Polypropylene Storm Sewer Pipe 48 In. Diam. Extra Depth Add (8-12 ft.)	$48	$0
32	0	LF	Polypropylene Storm Sewer Pipe 54 In. Diam. Extra Depth Add (8-12 ft.)	$54	$0
33	3181	LF	Testing Storm Sewer Pipe	$5	$15,905
34	13	EA	Catch Basin Type 2 48 In. Diam. (up to 8 ft. Depth)	$4,000	$52,000
35	10	EA	Catch Basin Type 2 60 In. Diam. (up to 8 ft. Depth)	$5,500	$55,000

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Marine Outfalls Conveyance Storm Drain Improvements - Drainage System/Outfall: Broadway-Eldridge, Alternative 2

Broadway-Eldridge Alt 2

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
36	4	EA	Catch Basin Type 2 72 In. Diam. (up to 8 ft. Depth)	$7,000	$28,000
37	0	EA	Catch Basin Type 2 84 In. Diam. (up to 8 ft. Depth)	$8,500	$0
38	2	EA	Catch Basin Type 2 48 In. Diam. Extra Depth Add (8-12 ft.)	$600	$1,200
39	6	EA	Catch Basin Type 2 60 In. Diam. Extra Depth Add (8-12 ft.)	$800	$4,800
40	3	EA	Catch Basin Type 2 72 In. Diam. Extra Depth Add (8-12 ft.)	$1,000	$3,000
41	0	EA	Catch Basin Type 2 84 In. Diam. Extra Depth Add (8-12 ft.)	$1,200	$0
42	52	EA	Connection to Drainage Structure	$500	$26,000
Subtotal					**$693,219**
Division 8 - Miscellaneous Construction					
43	1	LS	Temporary Erosion and Sediment Controls (4%)	$47,600	$47,600
44	1	LS	Care and Diversion Water (2%)	$23,800	$23,800
Subtotal					**$71,400**
			Subtotal Opinion of Probable Construction Cost		**$1,249,333**
			Contingency	30.0%	$374,800
			Design, Permitting, and Construction Management	20.0%	$249,867
			Parcel or Easement Acquisition		$0
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$1,874,000**

Notes:

(1) July 2019 dollars

(2) Does not include sales tax

(3) Earthwork costs assume that excacated soils are suitable for re-use as embankment fill, and that no contaminated soils are encountered that would otherwise require special, higher cost off-site disposal.

(4) Assumes all storm drain replacement is within the ROW, and that no parcel or easement acquisition is required.

(5) For preliminary estimate of quantities, see separate marine outfalls quanity calculations spreadsheet

Appendix F
Marine Outfall Pipe Cost Estimate

	Arbutus Alt. 1	Arbutus Alt. 2	Willow Alt. 1	Willow Alt. 2	Olive	Laurel Alt. 1	Laurel Alt. 2	C Street	Ellsworth	Broadway-Main	Broadway-Eldridge Alt. 1	Broadway-Eldridge Alt. 2
Division 1 - General Requirements	$ 6,200	$ 7,300	$ 55,100	$ 62,700	$ 3,600	$ 80,000	$ 61,800	$ 77,300	$ 88,000	$ 525,600	$ 201,800	$ 208,200
Division 2 - Earthwork	$ 1,434	$ 1,623	$ 14,801	$ 16,025	$ 603	$ 15,781	$ 13,044	$ 16,351	$ 20,632	$ 96,907	$ 47,317	$ 49,413
Division 3 - Aggregate Production and Acceptance	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Division 4 - Bases	$ 193	$ 218	$ 741	$ 806	$ 371	$ 7,909	$ 6,308	$ 8,693	$ 4,284	$ 61,505	$ 1,676	$ 4,833
Division 5 - Surface Treatments and Pavements	$ 632	$ 711	$ 2,421	$ 2,631	$ 1,210	$ 25,835	$ 20,605	$ 28,396	$ 13,993	$ 200,917	$ 5,473	$ 15,789
Division 6 - Structures	$ 5,880	$ 6,300	$ 73,920	$ 73,920	$ -	$ 17,876	$ 17,222	$ 16,650	$ 70,756	$ -	$ 217,792	$ 206,480
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits	$ 21,583	$ 25,255	$ 168,845	$ 198,635	$ 14,639	$ 305,885	$ 230,358	$ 290,365	$ 301,369	$ 2,087,788	$ 667,115	$ 693,219
Division 8 - Miscellaneous Construction	$ 1,900	$ 2,500	$ 18,200	$ 21,700	$ 1,200	$ 26,600	$ 21,100	$ 25,700	$ 29,300	$ 180,400	$ 69,300	$ 71,400
Total	$ 56,732	$ 65,859	$ 495,497	$ 564,625	$ 32,434	$ 719,827	$ 555,655	$ 695,181	$ 792,500	$ 4,729,676	$ 1,815,709	$ 1,874,000
Length (LF)	$ 114	$ 114	$ 678	$ 1,024	$ 46	$ 872	$ 872	$ 1,314	$ 1,040	$ 6,582	$ 1,498	$ 1,498
Diameter (in)	$ 12	$ 18	$ 18	$ 24	$ 24	$ 18	$ 18	$ 18	$ 18		$ 18	$ 18
$/Linear Foot (like diameter)	$ 498	$ 578	$ 731	$ 551	$ 705	$ 825	$ 637	$ 529	$ 762	$ 719	$ 1,212	$ 1,251
Length (LF)			346									
Diameter (in)			24									

Residential 12" diameter (average $/LF)	$ 497.65
Residential 18" diameter (average $/LF)	$ 649.90
Residential 24" diameter (average $/LF)	$ 628.24
Arterial 18" (average $/LF)	$ 731.35
Commercail 18" to 54" (average $/LF)	$ 1,060.56

City of Bellingham - Stormwater Comprehensive Plan Retrofit CIP Projects
Opinion of Probable Construction Cost
Valencia Street - Fever Creek Conveyance Storm Drain - Lining, Alternative 1

Item	Est. Quantity	Unit	Description	Unit Cost	Extended Amount
Division 1 - General Requirements					
1	1	LS	Mobilization/Demobilization (8%)	$45,700	$45,700
2	1	LS	Surveying (2%)	$11,400	$11,400
3	1	LS	Utilities Locate and Protection (1%)	$5,700	$5,700
4	1	LS	Temp Traffic Control (6%)	$34,300	$34,300
5	1	LS	Force Account (3%)	$17,100	$17,100
Subtotal					**$114,200**
Division 2 - Earthwork					
6		AC	Clearing and Grubbing	$8,000	$0
7	1	LS	Removal/Replacement of Structure and Obstruction (1%)	$500	$500
Subtotal					**$500**
Division 3 - Aggregate Production and Acceptance					
8			No Payment Items		$0
Subtotal					**$0**
Division 4 - Bases					
9		TN	Crushed Surfacing Top Course (or Base Course)	$30	$0
Subtotal					**$0**
Division 5 - Surface Treatments and Pavements					
10		TN	HMA Cl. 1/2 PG 64-22	$140	$0
Subtotal					**$0**
Division 6 - Structures					
11		LF	Curb and Gutter Replacement	$30	$0
12		SF	Sidewalk Replacement	$10	$0
Subtotal					**$0**
Division 7 - Drainage Structures, Storm Sewers, Water Mains, and Conduits					
13	1,600	LF	Pipe Liner 48 inch Diam. (cured-in-place, full installation)	$350	$560,000
14	1,600	LF	Testing Storm Sewer Pipe	$5	$8,000
Subtotal					**$568,000**
Division 8 - Miscellaneous Construction					
15	1	LS	Temporary Erosion and Sediment Controls (4%)	$1,900	$1,900
16	1	LS	Care and Diversion Water (2%)	$900	$900
Subtotal					**$2,800**
			Subtotal Opinion of Probable Construction Cost		**$685,500**
			Contingency	30.0%	$205,650
			Design & CM	20.0%	$137,100
			Parcel or Easement Acquisition		$0
			Total Stormwater CIP Retrofit Project Planning Level Opinion of Probable Construction Cost		**$1,028,250**

Notes:

(1) July 2019 dollars

(2) Does not include sales tax

(3) Earthwork costs assume that excacated soils are suitable for re-use as embankment fill, and that no contaminated soils are encountered that

(4) Assumes all storm drain replacement is within the ROW, and that no parcel or easement acquisition is required.

Subbasin	Improvement Project Group	Pipe Upgrade Quantity (LF)	2007 Cost Opinion*	Construction Index	2019/2020 Cost of Opinion	2020 Cost (x 1,000)
Whatcom Creek	Ellis Street #1	2250	$ 1,858,000	150%	$ 2,787,000.00	$ 2,787
	Ellis Street #2	2050	$ 1,176,000	150%	$ 1,764,000.00	$ 1,764
	King/Virginia/Lincoln	3400	$ 2,032,000	150%	$ 3,048,000.00	$ 3,048
	Meador Avenue	200	$ 129,000	150%	$ 193,500.00	$ 194
	State Street	900	$ 398,000	150%	$ 597,000.00	$ 597
	Misc. Whatcom Outfalls	250	$ 176,000	150%	$ 264,000.00	$ 264
Fever Creek	Kentucky Street	1050	$ 1,373,000	150%	$ 2,059,500.00	$ 2,060
	Orleans/Nevada	1600	$ 925,000	150%	$ 1,387,500.00	$ 1,388
	Valencia/North/Verona	3500	$ 3,330,000	150%	$ 4,995,000.00	$ 4,995
	Misc Improvements	700	$ 480,000	150%	$ 720,000.00	$ 720
Cemetery Creek	(Insufficient Conveyance system data)					$ -
Hannah Creek	Lakeway Drive	800	$ 486,000	150.00%	$ 729,000.00	$ 729
	Raymond Street	200	$ 185,000	150.00%	$ 277,500.00	$ 278
Lincoln Creek	Lincoln Creek	1050	$ 813,000	150.00%	$ 1,219,500.00	$ 1,220
*Cost from 2007 Stormwater Comprehensive Plan, Pg. 92. https://www.cob.org/documents/pw/storm/2007-stormwater-comp-plan.pdf						
Estimate Year	Construction Inflation Index Percent Change*					
2007	78	*				
2019/20	116.6	*	1.5	**		
	*CA NONRESIDENTIAL BLDGS					
	Mortenson avg 6 cities nonres bldg					
	** Construction Index Used					
	Average Annual Rate of Change =		3.14%			
	Average Rate of Change Formula =		((Ending Value/Beginning Value)^(1/number of years))-1			