City of Bonney Lake Watershed Protection Plan

Prepared for
City of Bonney Lake

BONNEY LAKE
Watershed
Plan

March 2018

Prepared by
Parametrix

City of Bonney Lake Watershed Protection Plan

Prepared for

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

APPENDICES

ACRONYMS AND ABBREVIATIONS

BIBI	Benthic Index of Biotic Integrity
BMP	best management practice
cfs	cubic feet per second
CIP	Capital Improvement Project
City	City of Bonney Lake
Commerce	Washington Department of Commerce
Ecology	Washington State Department of Ecology
FEMA	Federal Emergency Management Agency
GIS	geographic information system
GMA	Growth Management Act
HSPF	Hydrological Simulation Program—FORTRAN
LID	low impact development
LiDAR	Light Detection and Ranging
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
Plan	Watershed Protection Plan
R-B Index	Richards-Baker Flashiness Index
RM	River Mile
RSMP	regional stormwater monitoring program
SAM	Stormwater Action Monitoring
SR	State Route
TMDL	total maximum daily load
TSS	total suspended solids
USGS	U.S. Geological Survey
WQI	Water Quality Index
WSDOT	Washington State Department of Transportation
WWHM	Western Washington Hydrology Model

1. INTRODUCTION AND PURPOSE

1.1 Introduction

The City of Bonney Lake (City), located in a rapidly growing part of Pierce County in the Puyallup River watershed, is developing an integrated approach to watershed protection and land use planning. This approach will provide for land use choices that are iteratively shaped by watershed protection goals; encourage growth of the city in a thoughtful, sustainable manner; and address needs for the natural environment, built environment, and economic development of the city.

The objectives of this Watershed Protection Plan (Plan) include developing:

- Land use plans that are compatible with the Washington State Growth Management Act (GMA) and watershed goals established in this analysis
- Regional and sub-regional stormwater control plans, when appropriate
- Retrofitting and neighborhood redevelopment plans identified through the needs and prioritization process
- Site stormwater development standards, including low impact development measures, infill, redevelopment, new site development, and water quality retrofits

Traditional stormwater comprehensive planning and watershed planning often look at existing and proposed development as “given impacts” that are unchangeable, where these impacts can only be regionally reduced or mitigated during new development or redevelopment. By tackling these issues in an integrated and iterative fashion, factors related to watershed protection and land use can be proactively addressed and provide preferred technical and economic solutions across these multiple variables. This Plan will consider cumulative actions, positive and negative, on the receiving water resource and the drainage infrastructure. This integrated approach allows the City to consider multiple land development scenarios and intensities and their relative impact, including the effectiveness of stormwater mitigation measures.

The City recognizes its obligation to protect and improve the city’s valuable assets and natural resources while managing growth and potential impacts on surface water resources. To that end, the City will develop a strategy for preserving, protecting, and mitigating impacts to water resources in the City of Bonney Lake. Much of the city lies in the Fennel Creek watershed, a tributary to the Puyallup River (Figure 1), to which most of the city’s urban stormwater runoff drains. The City has nearly complete control over development, redevelopment, and land use decisions within the Fennel Creek basin. This provides several advantages to watershed planning for the city and Fennel Creek.

Basin-specific water resource protection standards can be applied. In this scenario, the decisions and restrictions on development would be consistent across the city and the watershed; development rights and impacts can be transferred across the city and still be in the same basin; adaptive management can be directly linked between land use and water resource protection measures; and the City can evaluate the entire suite of measures to minimize impacts and correct existing problems. This proposed scenario means that land use, stormwater controls, regional facilities, and basin-specific controls can be considered equally to make the best choices benefitting the resource and meeting growth management objectives.

The City identified funds for a stormwater comprehensive plan and a land use plan to be prepared in 2016 and 2017. Subsequently, the Washington State Department of Ecology (Ecology) and Washington Department of Commerce (Commerce) jointly solicited proposals from jurisdictions to study land use and stormwater and identify approaches and plans to address these intertwined issues. The City prepared a proposal and was successfully awarded a grant that supplemented its own resources to prepare this Plan. An early task in the Plan was preparing a needs assessment (Parametrix 2016) and existing conditions report (City of Bonney Lake and BERK 2017).

This Plan presents the work completed under the joint City resources for the stormwater comprehensive plan and grant funds. The Plan presents background information in establishing project goals and objectives, fact-finding and existing conditions summary, basin modeling and analysis, proposed land use guidance, recommended stormwater controls, and capital projects to solve existing stormwater problems. The City intends to use the Plan as the basis for an adopted stormwater basin plan under Ecology guidelines for use in the Ecology *Stormwater Management Manual for Western Washington* (Ecology 2014a).

1.2 Background and Comprehensive Program Mission

The project was awarded a grant by Ecology to complete the *Bonney Lake Coordinated Watershed Protection and Land Use Plan,* which includes by reference the *Bonney Lake Centers Plan* (City of Bonney Lake and BERK 2017). The scope of work was developed by the City with support from BERK Consulting and Parametrix, Inc. in late 2015. The project kickoff meeting with the joint City, BERK Consulting, and Parametrix team was held on January 14, 2016; a follow-up Vision and Mission meeting was held on February 4, 2016. The purpose of these preliminary meetings was to develop the Plan vision and team mission to complete the Plan, brainstorm the needs and goals of the Plan, and discuss risks and threats to project success. The team agreed on the following statements:

Vision Statement

A flourishing, growing, well thought-out community whose joint Watershed and Centers Plans protect the residents and preserve the area’s natural features while accommodating growth, redevelopment, and thriving urban centers.

Mission Statement

- Evaluate, coordinate, create, and execute a comprehensive stormwater plan that considers Growth Management goals that are compatible with the protection, design, and funding of current and future surface water needs.
- Evaluate, coordinate, create, and execute a Centers Plan that supports economic development and vibrant urban centers; protects and enhances stream health; facilitates stormwater management goals; and implements the goals and policies of *Bonney Lake 2035*, which serves as the City’s comprehensive plan.
- Address the City’s surface water needs to achieve and maintain an appropriate level of service for all existing and future customers and to accommodate system growth and expansion.

The needs and goals identified by the team were assembled by a facilitator and project risks were identified and ranked for their expected relative threat. The text from these project kickoff sessions is provided in Appendix A.

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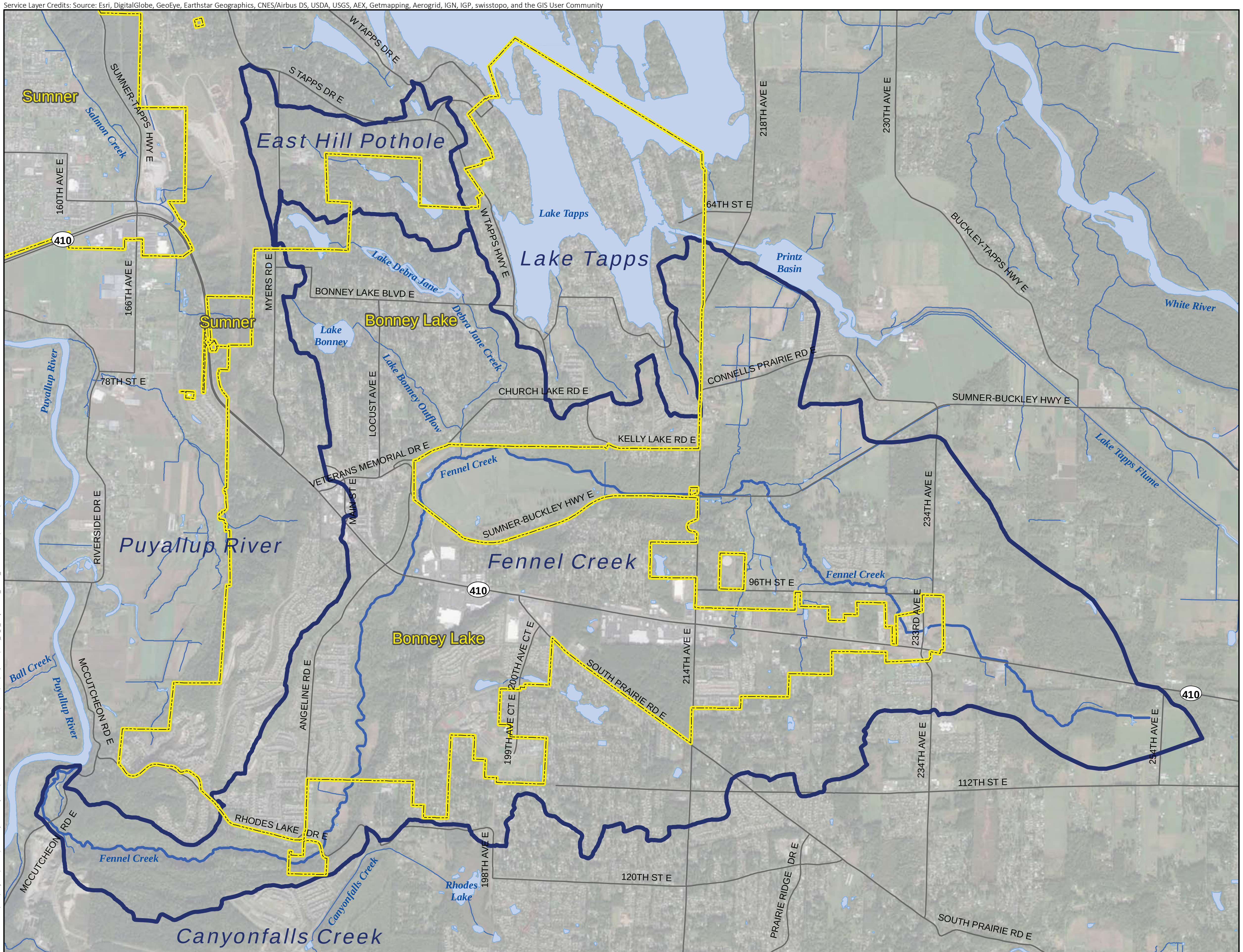

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FIGURE 1
PROJECT AREA WATERSHEDS

- City Limit
- Watershed Boundary
- Surface Water
- Fennel Creek
- Other Stream
- State Highway or Major Road

Miles
0 0.5 1

Source: City of Bonney Lake, Pierce County

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1.3 Public Process

The Plan's scope of work included public participation via workshops. The first public workshop was held on March 31, 2016, coordinated with a land use workshop, to present an outline of the Plan to the public and obtain input on Plan priorities and known problem areas. These public comments will be included in the Plan adopted by the Bonney Lake City Council.

In the fall of 2017, a stakeholder committee was formed to provide peer review and comments to the Draft Watershed Protection Plan. The committee's input was reviewed by the Plan team and included, where appropriate, in this final Plan. The information provided in the public workshops and from the peer reviewers is included in Appendix B.

Interim reports defined by the grant were prepared and provided to Ecology for their review and comment, including the Project Mission Statement, Draft Watershed Protection Plan Framework, Stakeholder Integration Plan, and Draft Watershed Protection Plan.

1.4 Coordinated Land Use Process

The City is conducting complementary and iterative land use planning in conjunction with the watershed protection planning. The goal of the land use planning is to prepare and refine a suite of land use scenarios, alternatives, and redevelopment concepts for analysis in this Plan to assist with resource-directed land use decisions. The coordinated effort between land use and watershed protection planning supports land use decisions that are directed by, located, and compatible with the landscape and watershed conditions; aligns stormwater feasibility and mitigation decisions; optimizes efficient development of greenfields; and incentivizes retrofit, redevelopment, and infill development.

The land use planning involves an update to the City's existing plans for Eastown and Midtown, and develops a new subarea plan for the area around Allan York Park identified as the Lake Tapps Center. The Centers Plan and Eastown Subarea Plan establish goals and policies for creating vibrant urban places in these locations while protecting—and where possible, enhancing—water resources. For each of these designated planning areas, a series of land use development scenarios have been considered to identify potential effects to water resources that might result from future growth in the City of Bonney Lake. In turn, based on preliminary results of the watershed analysis, the designated planning area boundaries and development scenarios were adjusted to minimize or avoid potential adverse impacts to water resources.

The watershed modeling analysis also provides guidance to the land use planning by recommending implementation measures for each planning area, including a list of necessary capital projects and possible regulatory initiatives. Existing and proposed land uses, development patterns, natural resources, and community design will result in unique approaches to watershed planning and stormwater management within each planning area, and yet allow for coordinated planning at the watershed level.

Finally, the coordinated land use planning effort also includes an audit of the City's municipal code. Sections reviewed include site planning, community design, parking, landscaping, environmentally critical areas, and stormwater standards. The municipal code review identifies areas where existing development regulations may be inconsistent with the basin and land use plans, and recommends code changes to support compatibility between land development regulations and watershed protection goals.

1.5 Plan Outline

This Plan is organized as follows: Section 2 describes the study area, focused on the Fennel Creek watershed, with a discussion of the physical features, biological parameters, water chemistry, hydrology, and flow regimes, including floodplains. Section 3 describes the current built environment in the context of how it affects water resources, such as land cover, land use, stormwater facilities, and drainage patterns. Section 4 describes the basis for stormwater planning, establishes flow control targets, and presents the proposed stormwater management plan. Section 5 describes the proposed capital improvement projects, and Section 6 discusses how the approaches and scenarios described in this Plan will be implemented.

2. WATERSHED CHARACTERISTICS

2.1 Study area Description

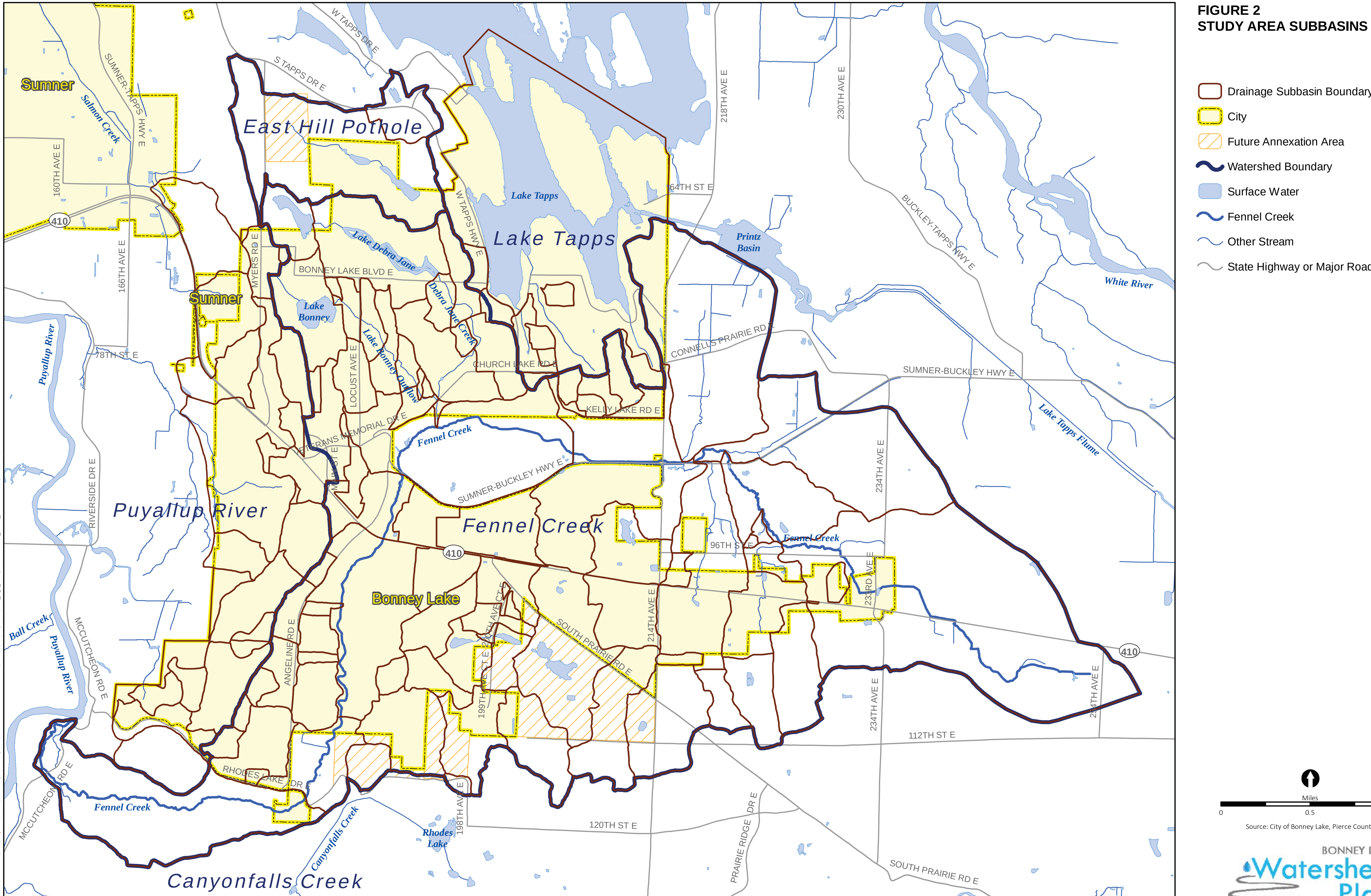
2.1.1 Watershed and Subbasins

Fennel Creek is a tributary to the Puyallup River in Pierce County (Figure 2). Of the Fennel Creek watershed's approximately 8,000 acres, roughly 4,700 acres discharge surface runoff to Fennel Creek. The remaining areas are closed subbasin that infiltrate surface water to the ground. Some areas now under County jurisdiction are proposed for annexation to the city of Bonney Lake by 2020 (see Figure 2). Subbasins in the Fennel Creek watershed, delineated using available topographic maps and supplemented with field verification, are shown on Figure 2. The areas surrounding the Fennel Creek watershed include a number of closed subbasins with no surface drainage outlets. Many of these are naturally developed systems; some have been modified to interconnect the subbasins or are defined by stormwater facilities with no surface drainage outlets (under normal rainfall). The majority of the watershed is underlain by glacial till. Based on the surface topography and geologic mapping, a significant portion of water infiltrated in the closed subbasins likely reaches Fennel Creek flowing laterally along the surface of the till layer (Barker 2018).

Not all of the city drains to Fennel Creek. Drainage subbasins for all areas in the city were delineated, including surrounding watersheds that drain to the Puyallup River, Lake Tapps, East Hill Pothole, and Canyon Falls Creek. These subbasins are shown on Figure 2. It is expected that these subbasin delineations can and should continue to be updated as additional or more detailed information is made available. The delineations shown are an appropriate level of detail and accuracy for the purposes of this planning document.

The topography of the Fennel Creek watershed is characterized in the upper reaches as a relatively flat and broad riparian area in the vicinity of the stream, including wetlands and poorly drained landscapes. In the lower reaches of the stream, the surrounding landscape forms a more distinct valley (Figure 3). The entire study area surrounding the Fennel Creek watershed is dominated by rolling low hills, closed subbasins (many with lakes or wetlands), and relatively steep slopes down to the Puyallup River.

FIGURE 2
STUDY AREA SUBBASINS



Source: City of Bonney Lake, Pierce County

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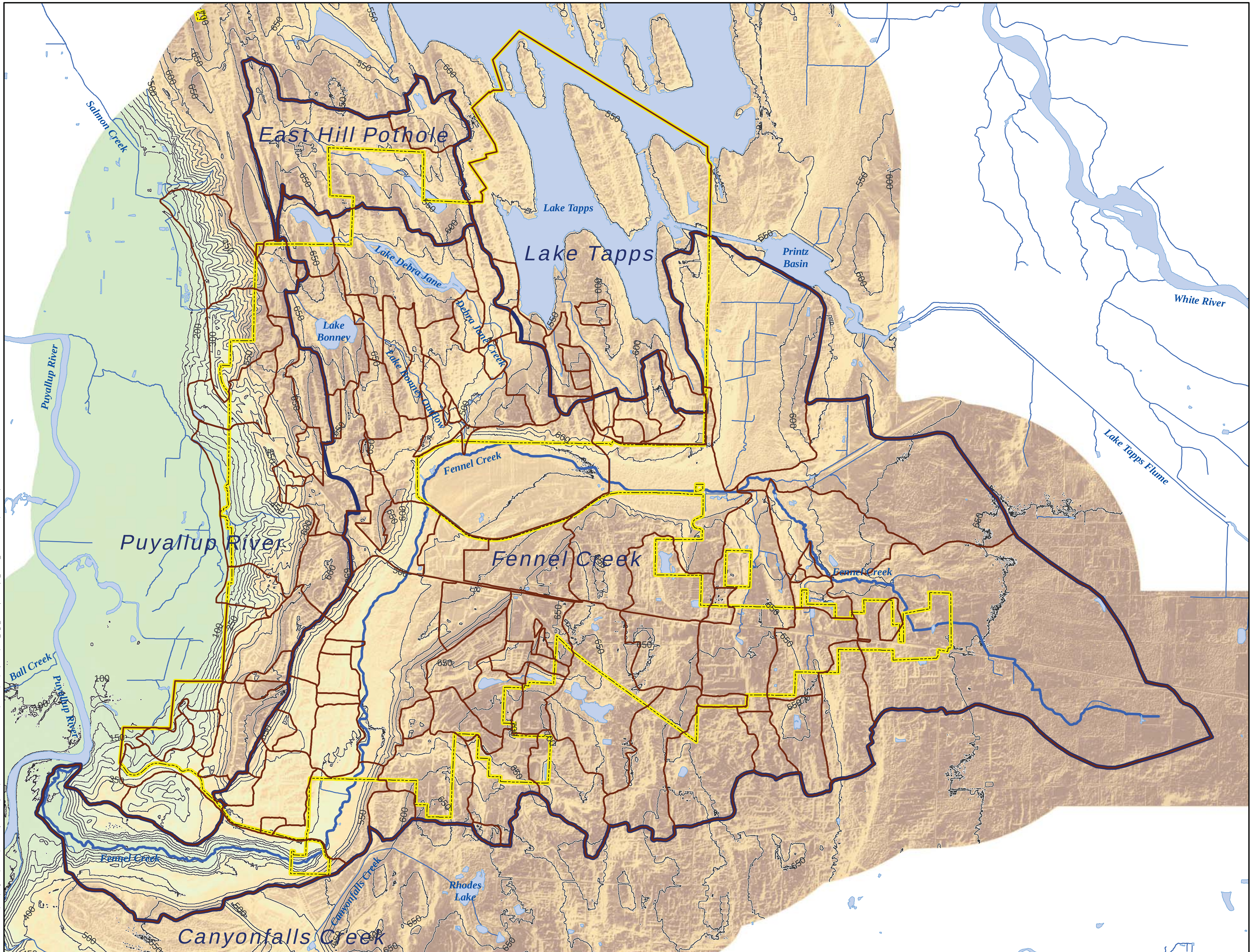

FIGURE 3
TOPOGRAPHY OF BONNEY LAKE

- Bonney Lake City Limit
- Watershed Boundary
- Drainage Subbasin Boundary
- Surface Water
- Fennel Creek
- Other Stream
- 50' Contour

Miles
0 0.5 1

Source: City of Bonney Lake, Pierce County

BONNEY LAKE Watershed Plan

2.1.2 Geology

The geology of the Fennel Creek watershed and the Bonney Lake area results in a unique landscape that influences the characteristics of the hydrology and hydraulics of the area. These characteristics may inform approaches to stormwater management and the preferred suitability of different land uses in the Fennel Creek watershed.

Bonney Lake is located in the Puget Sound lowlands, within a basin that ranges from the Cascade Range to the Olympic Mountains. The basin is a smooth plain of glacial drift containing wide stream valleys and unconsolidated deposits. The lowlands in the study area range from 50 to 1,100 feet elevation and are divided into smaller subdivisions: drift plain, Osceola mudflow plain, and several large valleys (the largest being the Puyallup Valley). The landscape of the basin is "youthful" in a geologic timeframe—drainage patterns are developing and still changing even without the changes that typically originate with urban and suburban development. The history of sediment and landforms in the area around and including the city is one characterized by glacial and interglacial activity (Crandell 1963). This area had glacial advances that left deposits of till and drift, streams formed by meltwater, and the remaining streams that had cut through glacial deposits. Post-glacial volcanic activity has left materials that, in part, affect the hydrology of the area, notably the Osceola mudflow. Fennel Creek is a glacial meltwater stream valley (Crandell 1963). The major waterway in the Bonney Lake area is the Puyallup River and its tributaries. Smaller streams include Fennel Creek, which drains most of the city through a drift plain south of Lake Tapps. Lake Tapps is the largest waterbody in the area—an artificially expanded lake that was created by raising the level of four pre-existing lakes: Church, Crawford, Kirtley, and Tapps (Crandell 1963).

In addition to the stream valleys, the landscape in Bonney Lake results, in large part, from repeated glaciation and landforms left from geological activity (Figure 4). There are a number of elongated northwest-southeast trending low hills, notably in the northwest portion of the city and basin area, which are referred to as drumlins (see Figure 3). The drumlins often form drainage and basin divides. In addition, there are lakes, including Lake Bonney (known as a "kettle" in stratified drift), Lake Debra Jane, the East Hill pothole, and a number of smaller closed depressions (there is no surface water outlet) that are scattered throughout the city and study area. Kettle depressions collect precipitation and store runoff, which affects the hydrology and flow in Fennel Creek and other nearby streams, and contribute water to the local groundwater system.

After glaciation, about 5,600 years ago, eruptions at Mt. Rainier resulted in a large mudflow, which flowed generally down the White River and all the way to Puget Sound. Known as the Osceola mudflow, it covered about 65 square miles, mostly in the area of Buckley and Enumclaw (see Figure 4). A lobe of the mudflow traveled down the Fennel Creek valley and comprises the surface geology in the floor of the valley down to Victor Falls. The surface of the mudflow is relatively flat, notably in the upper reaches of the Fennel Creek watershed. Most areas of the mudflow have resulted in poorly drained soil, mainly due to the fine-grained soils of the mudflow and the relatively flat topography. Shallow ditches have been excavated to improve surface drainage, although numerous wetlands remain (Figure 5). No mudflow was found downstream of Victor Falls, but the Osceola mudflow through the area to the Puyallup River is inferred by small outcrops on the banks of the Puyallup River (Crandell 1963).

2.1.3 Groundwater

There are no available groundwater studies that focus on local (i.e., Fennel Creek or the potholes) groundwater flow stages and movement. The pothole water levels are expected to be expressions of groundwater depth. Data on seasonal and peak lake stage fluctuations are insufficient for evaluating flooding and populating a model with data on groundwater storage and basin flows. However, regional groundwater parameters for Fennel Creek should be appropriate for the groundwater modeling.

2.1.4 Soils

The Natural Resources Conservation Service (NRCS) Web Soil Survey identified soil mapping units within the study area (Figure 6). Three soil types comprise most of the soils in the area: Buckley gravelly silt loam (the Osceola mudflow soils); Everett very gravelly sandy loam (8 to 15 percent slopes); and Alderwood gravelly sandy loam. None of these three soils is identified as "hydric," although the Buckley soils are considered poorly drained with a high water table. The other soils have primarily glacial sources.

Hydrologic properties of soils are categorized as A, B, C, or D type soils, with A being well-drained and D being poorly drained. About 37 percent of the soils in the Fennel Creek watershed are classified as A soils and 38 percent are classified as D soils. While much of the area consists of well-drained outwash soils, other glacial soils include "Vashon till…which is compacted and essentially impermeable." Generally, well-drained soil types, such as the outwash soils, can be indicators for feasibility of infiltration facilities and the use of low impact development (LID) strategies in stormwater management.

2.2 Fennel Creek Water Quality and Stream Condition

2.2.1 Surface Water Quality Monitoring

Surface water quality within the Fennel Creek watershed is tracked and evaluated by several organizations, including Ecology, Pierce County, the Puyallup Indian Tribe, and the Fennel Creek Preservation Group. Ecology has evaluated Fennel Creek and Lake Tapps for bacteria and classified these water bodies as Category 1, meaning they meet the state water quality standard for bacteria (Ecology 2016a). Pierce County prepares a Water Quality Index (WQI) of regional surface waters each year based on monthly sampling of fecal coliform bacteria, pH, dissolved oxygen, temperature, turbidity, total suspended solids, total nitrogen, and total phosphorus, with results ranging from 0 (poor) to 100 (excellent). The most recent WQI value for Fennel Creek was reported as 70, which is of marginal concern (Pierce County 2015a). Also, the Puyallup Indian Tribe has sampled water quality near the mouth of Fennel Creek for ammonia, dissolved oxygen, bacteria, nutrients, pH, temperature, and turbidity. Measured amounts from the Puyallup Tribe's monitoring have fallen within the acceptable water quality standards set forth in the Washington Administrative Code Section 173-201A-200 (NWQMC 2016).

Downstream of the confluence with Fennel Creek, Ecology has classified a reach of the Puyallup River as Category 1 for ammonia and bacteria. In addition, Ecology has classified the same reach as Category 2 for temperature and copper, meaning the data show some evidence of a potential impairment for these components, but it is inconclusive at this time (Ecology 2016a). Ecology has established a total maximum daily load (TMDL) for fecal coliform bacteria in the Puyallup River due to exceedances of the water quality criteria in several tributaries outside of the Fennel Creek watershed (Ecology 2011).

In general, the water quality in the Fennel Creek watershed is of a moderate to high quality that merits protection. With the aforementioned on-going sampling, additional data for this study are not required and monitoring by the City is not warranted at this time. In addition, the regional Stormwater Action Monitoring (SAM) program led by Ecology can inform approaches to be applied by the City now and in the future. This Fennel Creek planning effort is likely to be a good candidate for future monitoring and should be considered as a candidate project under SAM.

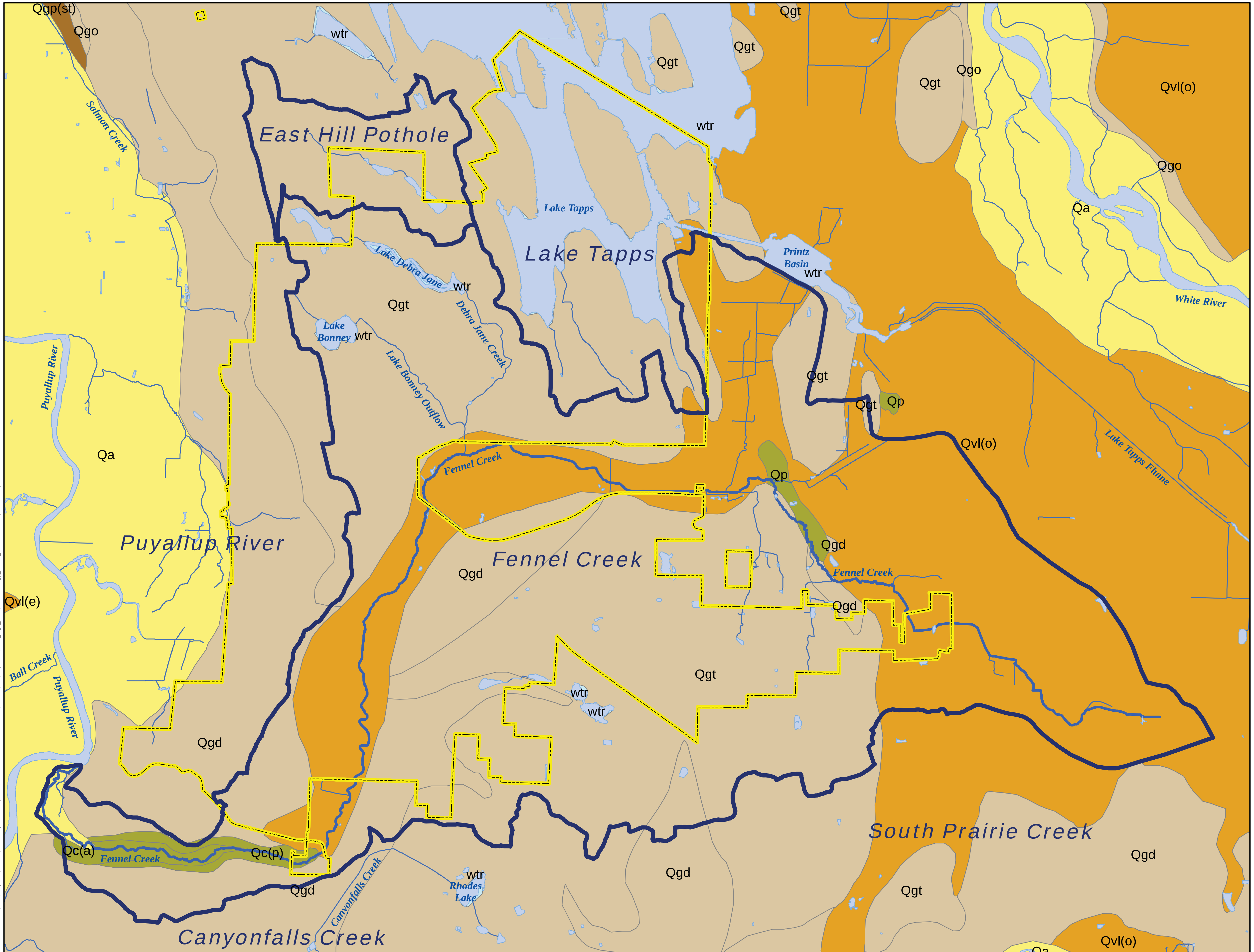

FIGURE 4
GEOLOGIC MAP OF THE STUDY AREA

Surface Geology*

- Quaternary alluvium, dune sand, loess, and artificial fill
- Quaternary alluvial fans, beach deposits, undifferentiated sedimentary deposits, lacustrine deposits, landslides, peat, terraced deposits, and talus
- Pleistocene continental glacial, glaciolacustrine, and outburst flood deposits, Fraser-age
- Pleistocene continental glacial deposits, pre-Fraser
- Quaternary volcaniclastic rocks, tuffs, lahars, and pyroclastic rocks (Osceola Mudflow)
- Water
- Bonney Lake City Limit
- Watershed Boundary
- Surface Water
- Fennel Creek
- Other Stream

* Plate 1, Surficial Geologic Map and Section of the Lake Tapps Quadrangle, Washington. *In* Crandell, D. R. 1963. Surficial Geology and Geomorphology of the Lake Tapps Quadrangle, Washington. USGS Professional Paper 388-A.

Miles
0 0.5 1

Source: City of Bonney Lake, Pierce County, WDNR

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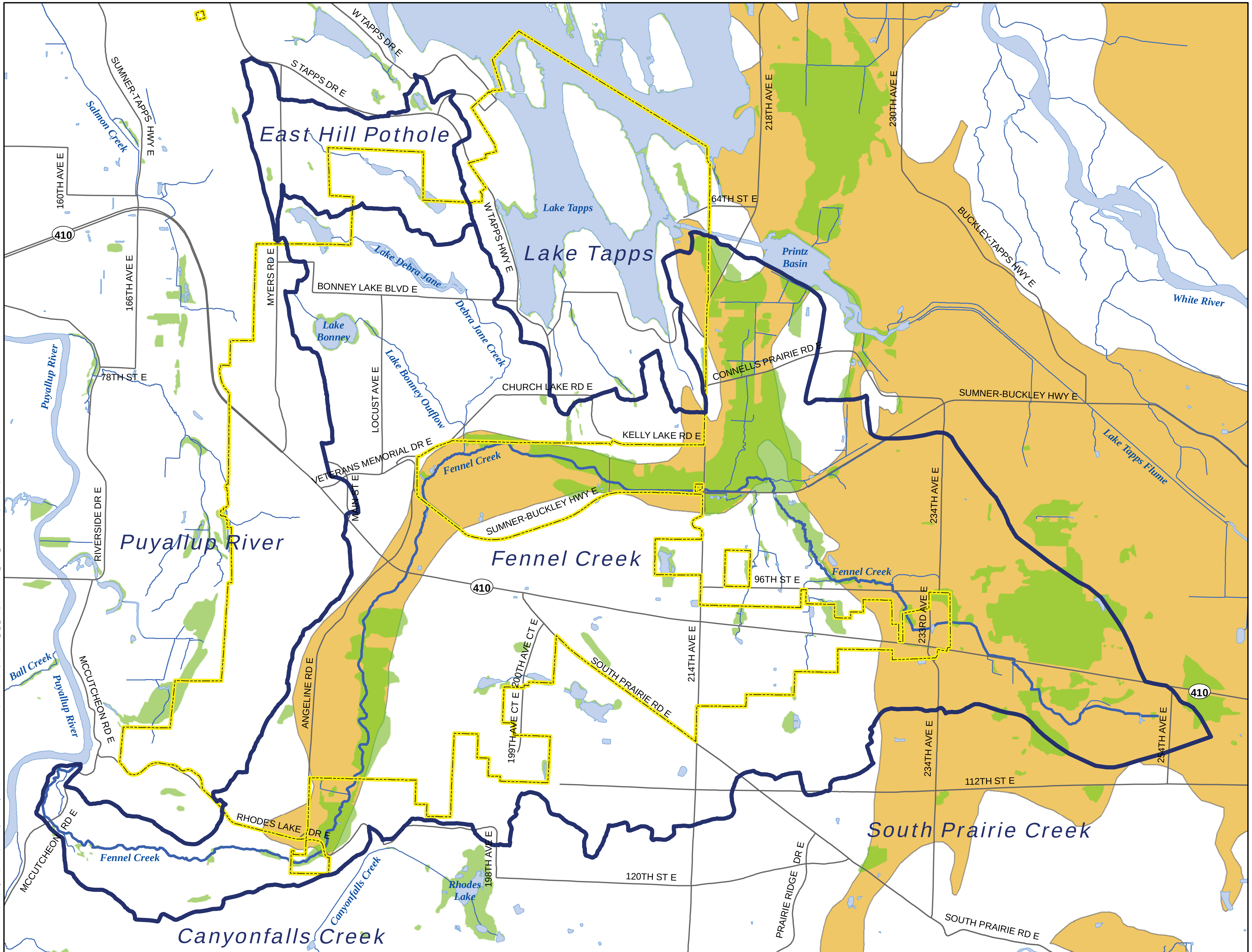
FIGURE 5
WETLANDS IN THE STUDY AREA



- Wetland (Pierce County)
- Osceola Mudflow
- Bonney Lake City Limit
- Watershed Boundary
- Surface Water
- Fennel Creek
- Other Stream
- State Highway or Major Road

Miles
0 0.5 1

Source: City of Bonney Lake, Pierce County, WDNR

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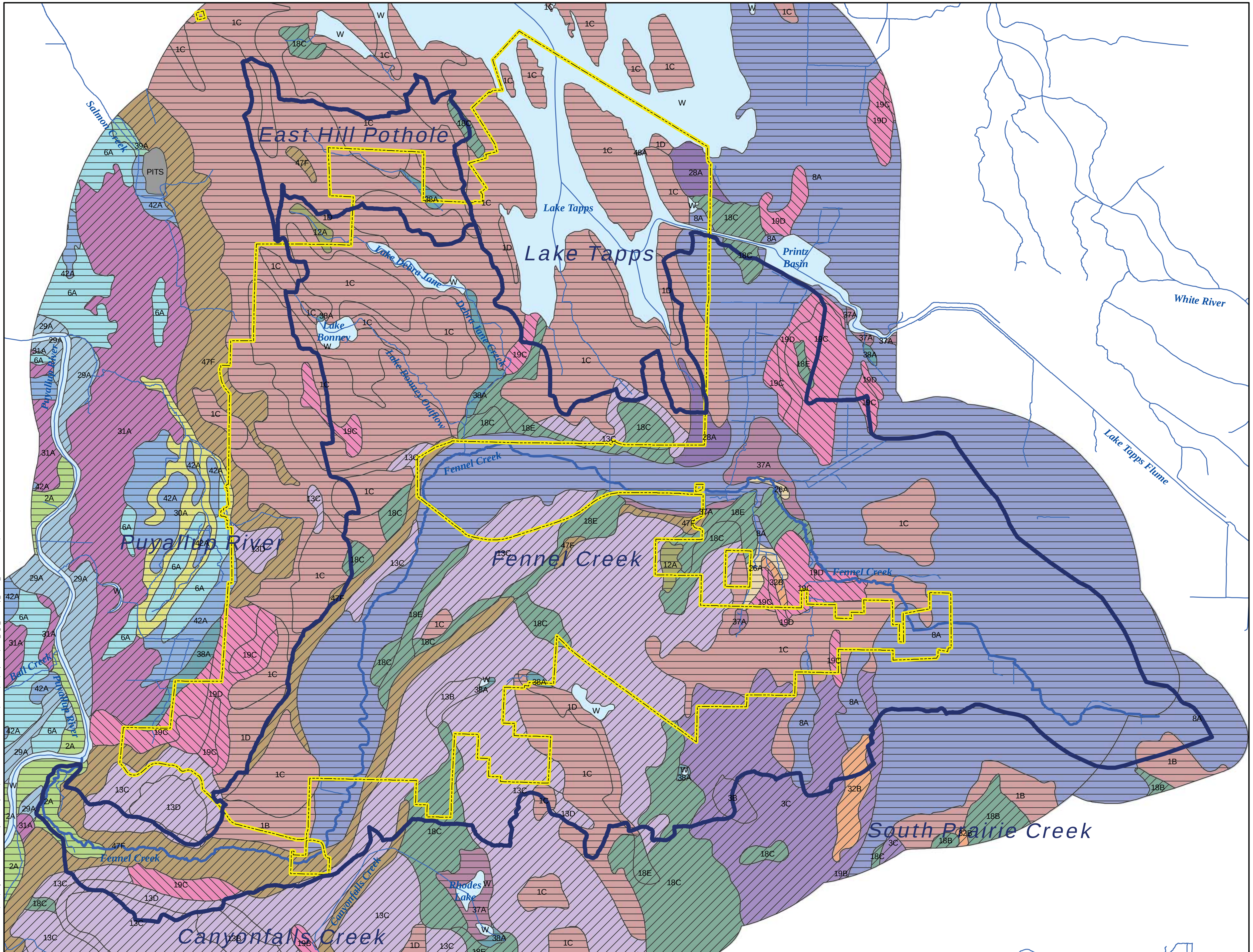
FIGURE 6
SOILS MAP



- Outwash (A)
- Till (C)
- Other (A/D, B/D, C/D, D)

Soil Map Unit

- 1: Alderwood gravelly sandy loam
- 2: Aquic Xerofluvents
- 3: Barneston gravelly coarse sandy loam
- 6: Briscot loam
- 8: Buckley loam
- 12: Dupont muck
- 13: Everett gravelly sandy loam
- 18: Indianola loamy sand
- 19: Kapowsin gravelly loam
- 26: Norma fine sandy loam
- 28: Orting loam
- 29: Pilchuck fine sand
- 30: Puget silty clay loam
- 31: Puyallup fine sandy loam
- 32: Ragnar sandy loam
- 37: Semiahmoo muck
- 38: Shalcar muck
- 39: Snohomish silty clay loam
- 42: Sultan silt loam
- 47: Xerochrepts
- 48: Xerorthents, fill areas
- Water
- Pits

- Bonney Lake City Limit
- Watershed Boundary
- Fennel Creek
- Other Stream

Miles
0 0.5 1

Source: City of Bonney Lake, Pierce County

BONNEY LAKE Watershed Plan

2.2.2 Freshwater Stream Benthos Monitoring

Pierce County monitors the health of freshwater streams based on the types of benthic macroinvertebrates (insects, crustaceans, worms, snails, and clams) that live on the stream bottom. The population data are measured and recorded as a score on the Benthic Index of Biotic Integrity (BIBI), which can range from 10 (very poor) to 50 (excellent). The BIBI score is considered a good indicator of water quality, because these macroinvertebrates spend their lifecycle in a small area, have a short life span, and different species have different tolerances to water pollution (Pierce County 2016). BIBI data have been collected at a station on Fennel Creek since 2003 (Figure 7). Table 1 summarizes BIBI scores for Fennel Creek over the past 14 years (Puget Sound Stream Benthos Data Management System 2017).

Table 1. Fennel Creek BIBI Scores

Year	BIBI Score[1]
2003	40
2004	44
2006	44
2008	36
2009	36
2011	38
2012	34
2013	44
2016	42
Average	**40**

1 BIBI scores in this table are based on data analyses for the Puget Sound region that were recalibrated in 2014 using a refined scoring system. These results may differ from analyses of the same data published before 2014 (Puget Sound Stream Benthos Data Management System 2017).

BIBI is evaluated over score ranges of 10-16 (Very Poor), 17-26 (Poor), 27-36 (Fair), 37-44 (Good), and 45-50 (Excellent).

A BIBI score of 40 is classified as “Good,” meaning that the richness of the benthic macroinvertebrate population is “slightly divergent from least disturbed condition” (Puget Sound Stream Benthos Data Management System 2017). This score for Fennel Creek indicates some change to the water quality and overall habitat health of the stream, but management would be focused on preserving that quality with modest improvements to reduce, remove, and mitigate existing water quality degradation sources. Stream flow modification due to development can also have an effect and should be controlled or improved to protect BIBI scores. Other subbasins in the Fennel Creek watershed do not have BIBI scores to consider, but the level of development is similar and the overall quality and health is expected to be similar.

2.3 Fennel Creek Channel Description, Geomorphology, and Habitat

Past studies on Fennel Creek have collected information and assessed the condition on portions of the stream. Additional recent data were collected as part of a critical areas study on the stream, as described below. A geomorphic analysis to inform a stream-based flow control standard was considered as part of this study, but has not been completed. The high percentage of the Fennel Creek watershed that consists of closed subbasins, which provide either controlled release, groundwater, or infiltrated discharges from developed areas, means that the Fennel Creek hydrology is very complex. Without significant calibration flow data, it is unlikely that a joint hydrologic and geomorphic assessment would provide reliable results. For this reason, this project element has been put on hold for future consideration until such time that an adequate record of stream flow data can be collected to calibrate the model and support a robust geomorphic evaluation. A summary of the stream and riparian corridor assessment is provided in Appendix C.

2.4 Hydrology, Hydraulics, Stream Flows, and Lake Stages

2.4.1 Precipitation

The Puget Sound Lowlands, including the Bonney Lake area, have a temperate maritime climate with cool, dry summers and moist, mild winters. From the Pacific Ocean, prevailing winds bring moist air inland. The precipitation in the area falls usually as rain with about 65 percent of the yearly precipitation occurring between October and March. Current hydrological parameters in the study area are:

- Average annual rainfall[1]: 44.85 inches
- Mean number of storm events each year[1]: 83
- Mean storm depth[1]: 0.492 inches

1 Data from the Auburn station located at latitude 47.19, longitude 122.14 (Perrich 1992).

Rainfall depths for selected 24-hour storm events are shown in Table 2.

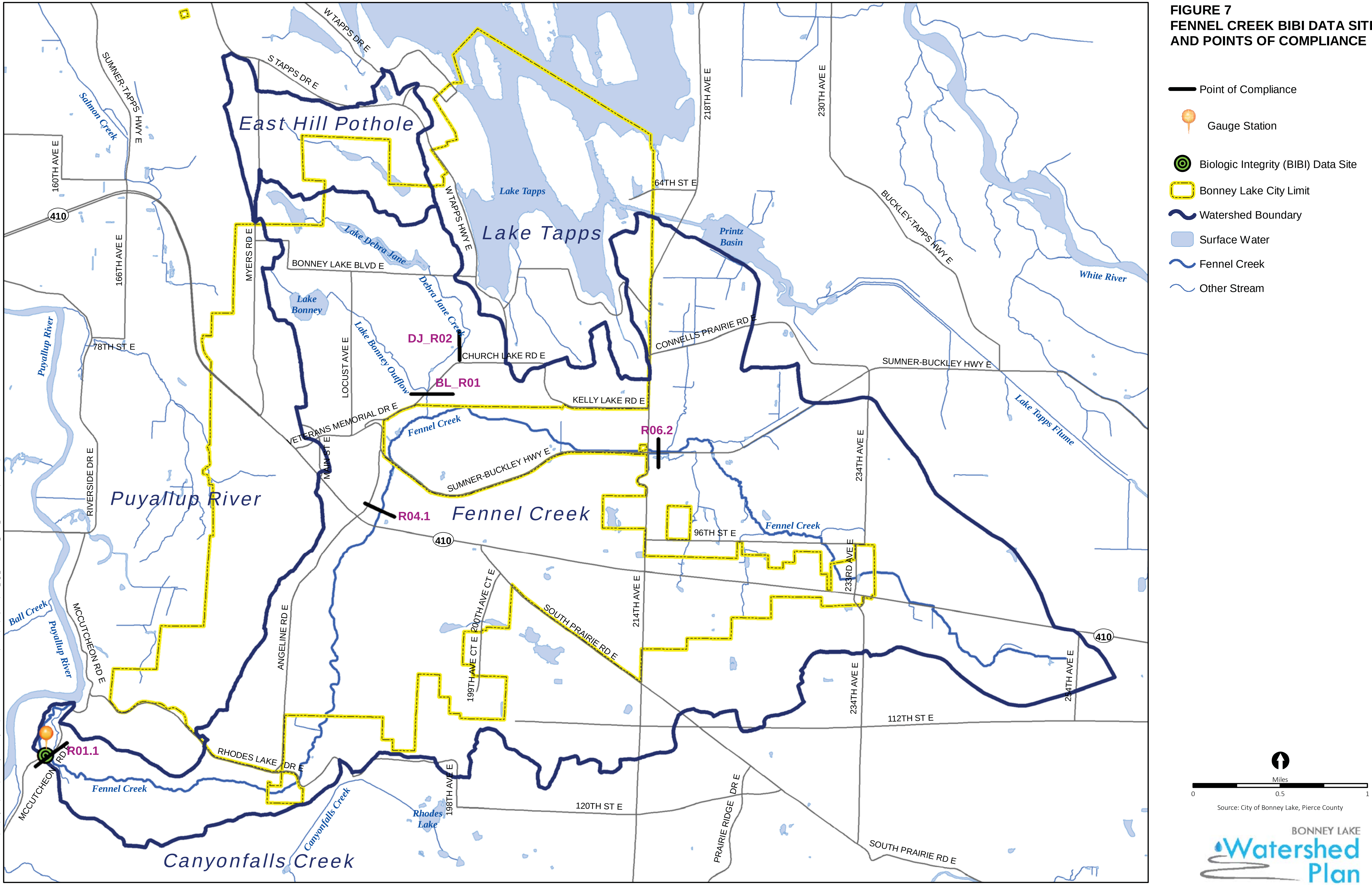
Table 2. Rainfall Depths in Bonney Lake Area[1]

Return Frequency	24-hour Precipitation Depth (inches)
2-year	2.5
10-year	4.5
25-year	5.1
100-year	5.8

1 Data taken from National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce (Miller, Frederick, and Tracey 1974).

The rainfall data to be used for modeling have been compiled in the MGSFlood model that will be used for any hydrologic modeling of the study area. No additional weather or rainfall data were compiled.

FIGURE 7
FENNEL CREEK BIBI DATA SITE AND POINTS OF COMPLIANCE



Source: City of Bonney Lake, Pierce County

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2.4.2 Stream Flow Records for Fennel Creek

Available stream flow records for Fennel Creek are limited. The available data include data from the U.S. Geological Survey (USGS) recorded at Fennel Creek near McCutcheon Road (latitude 47°09’10” and longitude 122°12’55” [North American Datum of 1927]) 1949 between July 1 and October 31. Stream flows for this period were documented between 8.7 and 22.0 cfs. Two additional field measurements taken on August 14, 1951, and August 31, 1967, at the same located recorded stream flow at 11.0 and 6.30 cubic feet per second (cfs), respectively (USGS Washington Water Science Center 2016). Peak flood levels for detailed flood studies have been determined by the Federal Emergency Management Agency (FEMA) (2017) for a portion of Fennel Creek and the two tributaries to Fennel Creek that drain Lake Debra Jane and Lake Bonney (Table 3).

Table 3. Historical Peak Flood Flow Summary

Location	10-year (cfs)	50-year (cfs)	100-year (cfs)
Fennel Creek at mouth	473	642	720
Fennel Creek at River Mile (RM) 0.68	484	647	719
Fennel Creek at RM 2.02	476	630	698
Fennel Creek at RM 3.78	340	459	512
Fennel Creek at RM 5.41	247	322	353
Debra Jane Creek at mouth	45	62	69
Debra Jane Creek at confluence with Lake Bonney outflow	26	34	38
Lake Bonney outflow at mouth	16	22	24

Source: FEMA 2017

More extensive stream flow data would be needed to provide a good calibration record for a Fennel Creek model. With these data lacking, other measures will be used for model calibration when needed for this project. Establishing a gauge now for long-term monitoring is recommended to support future adaptive management actions.

2.4.3 Lake Stages

Peak lake level stages were determined for Lake Debra Jane and Lake Bonney as part of the FEMA Flood Insurance Study (Table 4) (FEMA 2017). There are no known lake level records for any of the named lakes or potholes.

Table 4. Peak Lake Stage Summary (FEMA 2017)

Lake	10-year (feet)	50-year (feet)	100-year (feet)
Lake Debra Jane	568.2	568.9	569.3
Lake Bonney	612.0	612.1	612.2

Long-term lake level data are available for Lake Tapps from the USGS gauge located on the lake. Although lake stage modeling is proposed for this study, additional lake level data and outlet structure details were not collected for this study. Limited stage data were collected in the winter of 2015-2016 in the East Hill Pothole during a flooding event. These data may be used for the capital projects analysis and are provided in Appendix D.

2.4.4 Hydraulics and Floodplains

FEMA has prepared a detailed flood study for portions of Fennel Creek. In addition, detailed studies were conducted for the outlet stream from Lake Debra Jane and Lake Bonney, and included an evaluation of flood level in both lakes (see Table 4). The 100-year floodplain has been mapped for portions of Fennel Creek, Lake Debra Jane, Lake Bonney, Lake Tapps, and some isolated, unnamed low areas (Figure 8).

Detailed flood studies were not completed upper Fennel Creek (upstream of Kelley Lake Road to headwaters). The lower section is unlikely to have significant development pressure. The upper reach is included in the *Eastown Subarea Plan* study area; a detailed study is recommended to inform floodplain management for future development in these areas.

2.5 Data Availability Assessment

This Plan, as is common with most comprehensive plans, is conducted using best available existing data. In some instances, additional data can be collected for use in the Plan, and new assessments to process available data, such as new basin models, are prepared. The following is a brief summary of the data available for this study.

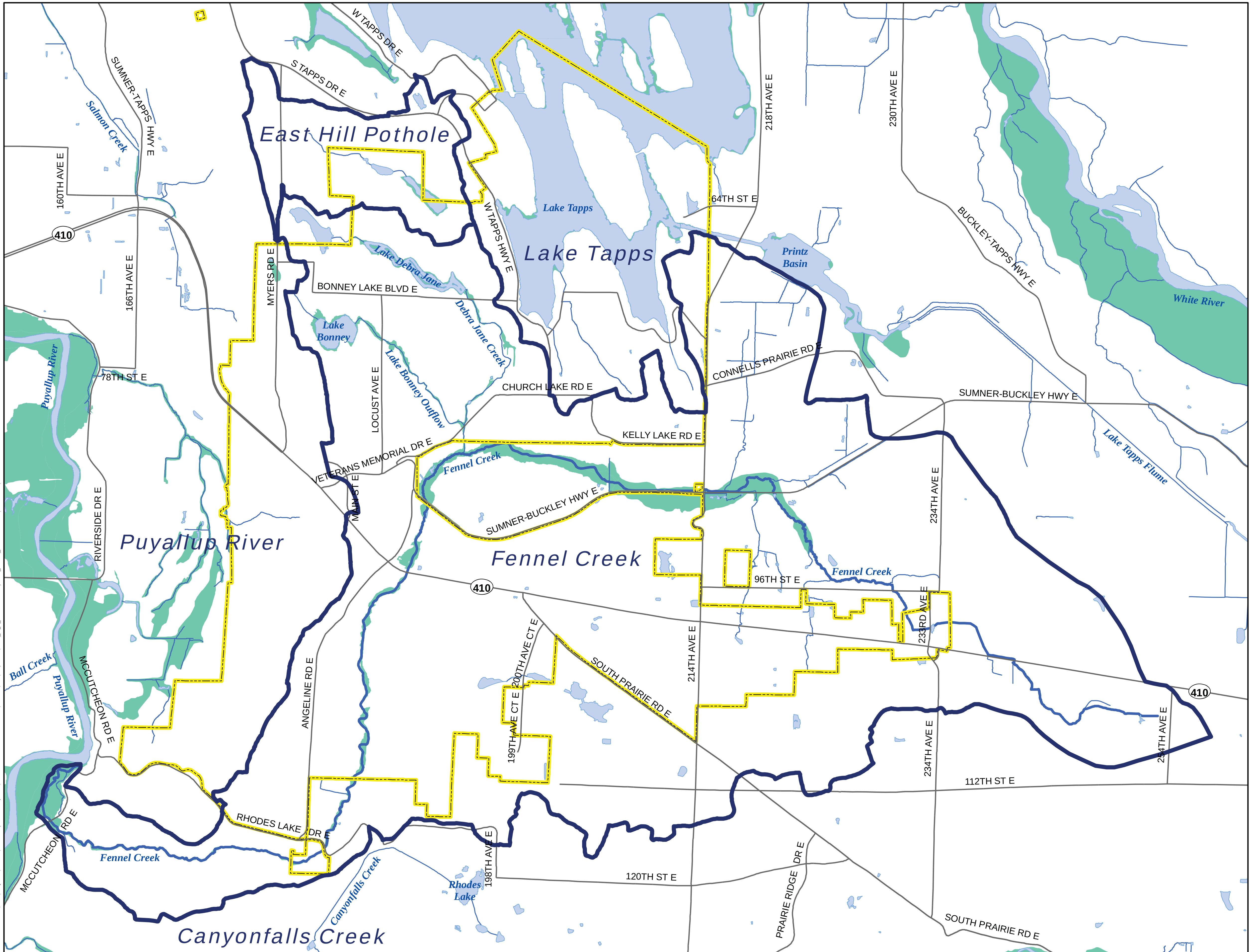
2.5.1 Drainage Subbasin Delineations

Parametrix developed drainage subbasin delineations for the study area using available geographic information system (GIS) data, notably topography, hydrography, pipe locations and flow directions, and existing stormwater facilities. Generally, catchment area size was selected by the configuration of the drainage system. For example, each mapped or identified tributary of a stream was used to define a catchment. Stormwater facilities were also used to define catchments draining to the facility. Field confirmation of catchments was limited because it can be an extensive and costly exercise, and additional detail for a planning effort does not normally provide additional accuracy. Site-specific projects do require additional refinement. As additional projects refine and revise subbasin delineations, these projects should be added to the mapped resource; additional detail developed in this study will be added, if needed. The level of detail in delineations used in the Plan were deemed an appropriate level for this planning effort.

2.5.2 Groundwater

Additional data on groundwater flows and connectivity would be useful for understanding flow patterns between closed subbasins, but obtaining this information is beyond the scope of this study and is not expected to have a significant influence on land use approaches and decisions. Additional lake and pothole water stage data would be useful to refine modeling and support flood management decisions. A comprehensive hydrologic model of Fennel Creek would require a more complete understanding of groundwater flow patterns.

FIGURE 8
100-YEAR FLOODPLAINS



- 100-year Floodplain
- Bonney Lake City Limit
- Watershed Boundary
- Surface Water
- Fennel Creek
- Other Stream

Miles: 0 — 0.5 — 1

Source: City of Bonney Lake, Pierce County

BONNEY LAKE Watershed Plan

2.5.3 Stream Flow

There was insufficient time to collect additional meaningful flow data for model calibration. Installing flow gauges should be considered for future adaptive management and monitoring. More data may be available than were collected in the past because there is a flow staff gauge and flow monitoring apparatus at a crossing on the Sumner-Buckley Highway; however, no data were found. Existing available peak flow data from the flood studies were considered to be applicable.

The models prepared for the basin planning assessment used applicable regional parameters but were not further calibrated. The planning assessment is comparative rather than absolute, which means that all flow management decisions are based on changes using the same subbasin parameters, but the actual flow rates determined by the model at points in the stream are not calibrated. Decisions should be made based on the assessment with these constraints in mind.

Additional lake level data are needed for full evaluation of lake and stream hydrology, as well as outlet structure controls on the lakes. Lake stage data are limited and should be collected in the future. Some data collected in the past two wet seasons are available for the East Hill Pothole.

2.5.4 Flood Studies

Segments of Fennel Creek do not have detailed flood studies, notably the upper reaches. Additional studies should be completed to inform floodplain management and protection when development is proposed in these areas. Additional floodplain analysis and studies are outside the scope of this project.

2.5.5 Geomorphic Assessments

A detailed geomorphic assessment of Fennel Creek was not completed, although data on stream reach conditions were collected (see Appendix C). The geomorphic assessment could provide a baseline for developing stormwater control targets that are suitable for the current or preferred condition of Fennel Creek. Early findings and understanding of the watershed have evolved since the project inception. The unique landscape, geology, and hydrologic conditions of the area have led the project team to reconsider the efficacy of this approach. A more detailed geomorphic assessment of Fennel Creek should be considered as one metric for long-term adaptive management, although the proposed controls are expected to protect the stream from further hydromodification.

3. THE BUILT ENVIRONMENT

Stormwater plans are prepared to address current and proposed land development, and to evaluate the effects of land conversion on stream hydrology and pollution-generating activities on water quality. Land drainage has been included in design for centuries; stormwater management has been the norm for the past several decades in Washington and continues to evolve as the practice learns from the past and new issues come to the forefront. Existing land use and land cover have created the conditions described in the previous section. Vacant lands, redevelopment, and infill portend future potential impacts, if not properly controlled, which provide one basis for identifying future stormwater management. Stormwater management and water resource protection are two key aspects of land use planning and growth management addressed in this Plan because they can strongly influence proposed developments, among other factors.

The primary stated purpose of this grant-funded Plan is to proactively address the intersection of stormwater management and water resource protection with land use. Consequently, an in-depth description of existing and proposed land use strategies and change potential is needed to address future stormwater planning. This discussion includes defining existing land use and land cover conditions as a basis for modeling existing and projected impacts and identifying needs; reviewing vacant lands and redevelopment patterns; and describing the three centers (Downtown, Midtown, and Lake Tapps) and the Eastown Subarea.

Existing stormwater system coverage is also needed. The goal of any stormwater plan is to provide stormwater controls for all of the developed land in the jurisdictions to the extent practicable. Maps showing land covered by existing stormwater systems and existing development without coverage are referenced in Section 3.3. In Section 4 below, an approach to providing stormwater coverage is described.

3.1 Stormwater Management Guidelines for Development

The Bonney Lake Municipal Code Section 15.13.020 has adopted the *Pierce County Stormwater Management and Site Development Manual* (Pierce County 2015b) as the City's guidance on stormwater best management practices (BMPs).

3.2 Land Use

The hydrologic response of a watershed is driven in large part by the land uses within that watershed and their associated land covers. When development occurs in a watershed and land cover is modified to increase density, such as conversion from forest to impervious surface or pasture to lawn, it affects stormwater runoff amounts in a subbasin. The conversion of land cover from pre-development conditions can reduce rainfall interception, evapotranspiration, and soil infiltration. As a result, groundwater recharge decreases and runoff volumes increase, which can escalate flooding and peak flow frequency. In turn, increased flow magnitude and peak frequency in streams can lead to scouring of stream banks and changes in sediment transport patterns that can damage fish habitat.

Land development can also affect the water quality conditions of stormwater runoff. Roadways and parking lots that typically comprise a large percentage of the impervious surfaces in developed areas produce runoff with levels of contaminants that can pollute surface water bodies or infiltrate into groundwater aquifers. Other land use activities, such as chemical-based landscape management, hazardous material storage, and industrial processes in contact with precipitation, can discharge pollutants into nearby receiving waters.

An accurate inventory of land use within the watershed and assignment of appropriate land covers to associate with each use has been a crucial part of the watershed protection analysis. Furthermore, through evaluation of the potential hydrologic response of various land cover scenarios, recommendations can be made for future zoning and land uses that will both protect watershed health and support future development.

3.2.1 Existing Land Uses

Bonney Lake is bisected by State Route (SR) 410 and bordered on the north by Lake Tapps. Two large master planned communities are located to the south: Plateau 465 and Tehaleh. The City of Bonney Lake was incorporated in 1949 with a population of 327; however, by 2015 the city had 19,490 residents and ranked as the fifth largest City in Pierce County. Bonney Lake ranked 29th in Washington State for numeric change in population between 2010 and 2015, indicating the city's rapid growth.

Bonney Lake is predominantly residential, with approximately 50 percent of the current land in the study area used as low-density residential, including single-family dwellings, mobile and manufactured homes, and small duplex and fourplex units. Less than 2 percent of the current land in the study area is used for high-density residential, such as multi-family apartment buildings. In addition to its large residential community, the city also has a significant portion of vacant land and protected open spaces. Just over 20 percent of the study area is classified as undevelopable or protected land. This area includes water bodies, greenbelt common areas, designated forest land, agricultural land, public utility land, and parks and protected open spaces. Approximately 10 percent of the study area contains non-residential high-density uses, such as commercial, institutional, and government facilities. The remaining portion of the study area, which accounts for just over 16 percent, is currently vacant land and could be used for future new development.

Most of the non-residential uses in Bonney Lake are concentrated within the Downtown, Midtown, Lake Tapps Centers and the Eastown Subarea. The Downtown Center is currently developed with a mix of single-family, high-density residential, and commercial uses; however, approximately 44 percent of the Downtown Center could support new development. About one-third of the Midtown Center has been developed with residential uses, but also contains a significant commercial corridor along SR 410. In addition, Midtown contains large parcels of publicly-owned land, most of which are set aside for parks, open space or conservation. The Lake Tapps Center generally contains low- and medium-density residential uses; but also contains a large protected open space in the form of Allan York Park on the shores of Lake Tapps. The Eastown Center was annexed into Bonney Lake in 2002 to accommodate commercial development demand. However, commercial uses in Eastown are more localized than Midtown, and a third of the land in Eastown is vacant. The most dominant current use in Eastown is low-density residential development (City of Bonney Lake and BERK 2017).

3.2.2 Land Use and Basin Planning Collaboration

The City has designated centers at Lake Tapps, Downtown, and Midtown to focus future development into distinctive, active centers by addressing land use, transportation, community design, and public gathering spaces. By integrating the planning for these centers with the watershed planning effort, the City intends for development of the centers to be balanced with the preservation of the Fennel Creek Watershed. The Eastown Subarea, while not included in the Town Centers planning, is a targeted area for future development and a proposed regional stormwater facility.

Collaboration between the land use and watershed planning efforts focused on the following:

- Mapping and evaluation of the Fennel Creek watershed to identify key stormwater management geographic siting considerations or limitations—with focus on application of LID approaches—that could facilitate or hinder future development in each area. This information was used to adjust and validate future city center locations.
- Adjustment of city center boundaries to align with subbasin boundaries where possible. This facilitates the planning, implementation, and enforcement of subbasin-specific stormwater management standards where needed.
- Watershed analysis scenarios that incorporate assumptions of dense build-out and associated regional facilities in the city center areas.

- Attention to areas outside of the city centers as candidates for possible future stormwater retrofits, based on the assumption that these areas are less likely to trigger stormwater management through new development or redevelopment.

3.2.3 Future Land Use and Zoning

As vacant lands are developed, the City zoning designations control density and distribution of new impervious surfaces and other land covers that impact surface water runoff; making zoning a significant factor in the health of the watershed. However, the goal of this watershed analysis focused less on evaluating the City's future zoning as presently adopted in the City code, but instead evaluates a range of potential categories of future subbasins. These subbasin categories are:

1. Stormwater Manual Subbasins – Areas where the expected level of future development would trigger stormwater management requirements of the Pierce County Manual to the extent that all runoff in the subbasin would be managed. Many of the developable lands outside of the city centers fall within this category.
2. New Regional Facility Subbasins – Subbasins in which future development is expected or encouraged on a magnitude that the City would plan and build a regional stormwater management facility to protect receiving waters. The Eastown Subarea contains this type of subbasins.
3. Existing Regional Facility Subbasins – Subbasins for which the City has either anticipated or is encouraging denser development and has already installed regional stormwater management facilities. The Downtown and Midtown Centers fall within this category.
4. Closed Subbasins – Areas that do not drain to a surface water body and all runoff is instead infiltrated into the ground directly or through a pond or wetland. Development within these subbasins has less of an impact on stream hydrology because runoff changes are dampened by the infiltration to the ground.
5. Direct-discharge Subbasins – Areas where runoff flows directly to a major receiving water, such as Lake Tapps or the Puyallup River. Development in these areas would require water quality management only.

3.3 Existing Drainage and Stormwater Management

The City has prepared GIS maps of the stormwater management infrastructure, including drainage maps with pipes, inlets, and flow directions. Stormwater facility configuration and locations are included. City map data are available at:

www.ci.bonneylake.wa.us/section_business/development_resources/maps.shtml

The locations of the stormwater control facilities are shown on Figure 9; details of the facilities are provided in Appendix E. The detail and accuracy of the maps or stormwater facility inventory was not assessed but were assumed to have sufficient quality for planning level assessments.

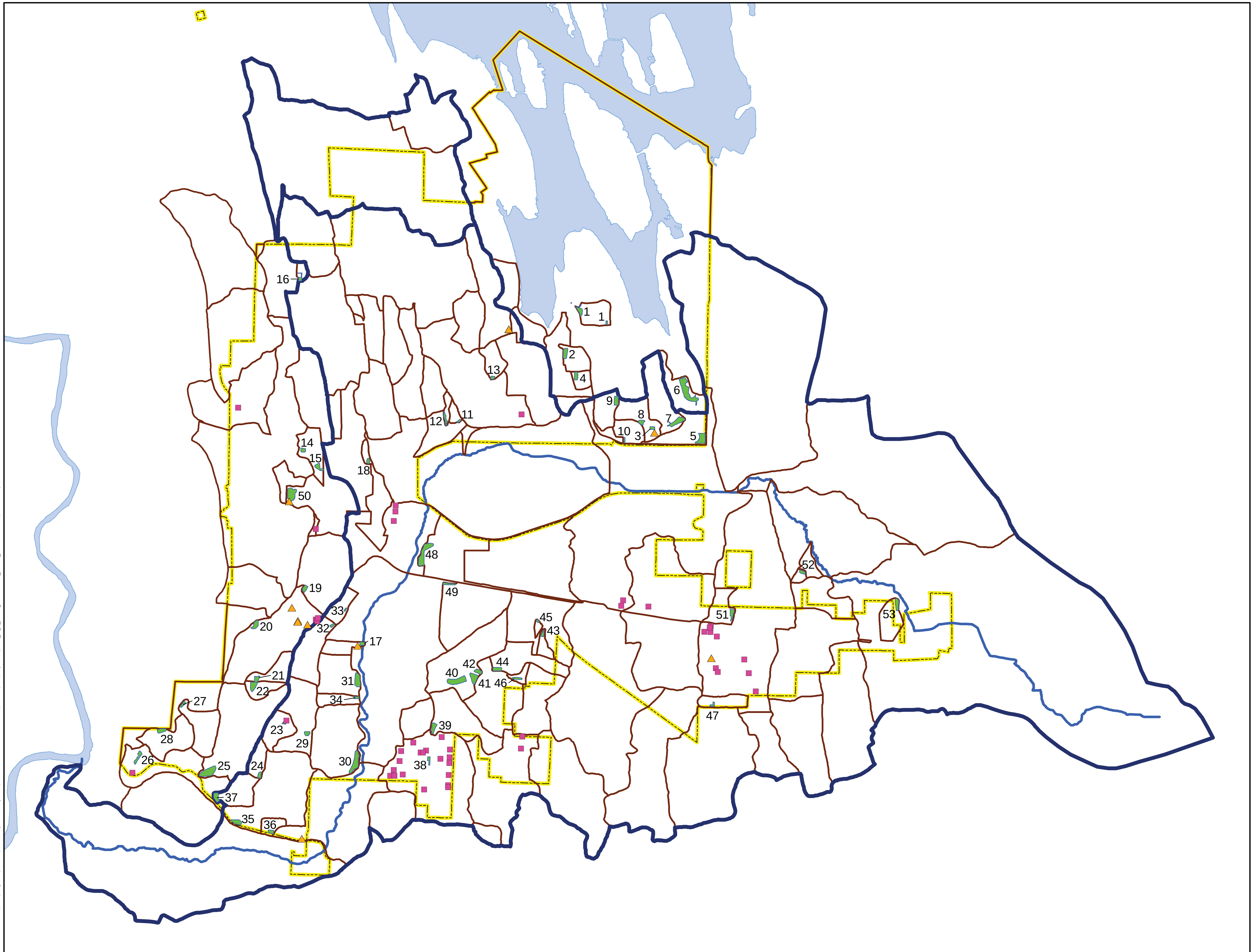


FIGURE 9
STORMWATER MANAGEMENT FACILITY LOCATIONS

- Dry Well
- Vault
- Pond
- Bonney Lake City Limit
- Watershed Boundary
- Drainage Subbasin Boundary
- Fennel Creek
- Surface Water

Miles
0 0.5 1

Source: City of Bonney Lake, Pierce County

BONNEY LAKE Watershed Plan

Parametrix
ENGINEERING . PLANNING . ENVIRONMENTAL SCIENCES

3.4 Basin Modeling

3.4.1 Goals and Metrics

A key part of the basin planning process is to develop predictive models to establish baseline conditions, test proposed alternatives, establish standards and guidelines for future change, and predict future conditions due to development and plan proposals. The foundation of the predictive models will be hydrology and hydrologic change due to basin response to rainfall. Water quality models were not prepared, although approaches to minimize and reduce contaminants in stormwater runoff are included in this Plan.

The modeling addressed the three general hydrologic conditions found in the Bonney Lake area: the Fennel Creek watershed, the lake systems, and the closed subbasins. Fennel Creek, the focus of this planning effort, will consider application of several modeling metrics to assess stormwater flow controls needed to protect or enhance the stream's flow regime. The lake systems will be evaluated for how the storage in the lake ameliorates runoff, and if flow controls are needed upstream of lake discharges (i.e., can the lakes be considered flow-exempt receiving waters). The closed systems will be evaluated to assess if changes in flow rates can cause adverse hydrologic impacts.

3.4.2 Modeling Software

Stormwater runoff and hydrologic response from drainage basins in the Pacific Northwest is characterized by the long, wet winters and peak runoff that results from many days of continuous precipitation. Consequently, a model is needed that considers the cumulative effects of multiple storms over a period of time on soil saturation, surface abstraction, and associated runoff conditions. This basin planning analysis needs continuous simulation modeling rather than a single event method to address the conditions present to develop planning solutions for these watersheds. The U.S. Environmental Protection Agency's Hydrological Simulation Program—FORTRAN (HSPF) simulates hydrology in natural and artificial water systems using existing meteorologic and hydrologic data. This program is considered the most appropriate model for application on a watershed scale. Because the HSPF data requirements are extensive, two state agencies have each commissioned an HSPF-based software package that provides default input parameters specifically calibrated for urban and suburban areas in the Puget Sound watershed, and user-interface tools geared toward stormwater facility design. These are Ecology's Western Washington Hydrology Model (WWHM) and the Washington State Department of Transportation's MGSFlood model.

When using a continuous hydrologic model, successful application is dependent on having a high-quality, long-term, precipitation time-series that is representative of the watershed under study. A record length of at least 50-years is desirable so that flood-frequency statistics for recurrence intervals up to 100-years can be accurately estimated. However, long-term, high-quality precipitation records are seldom available for a project site and a nearby record must be transposed on the watershed of interest. WWHM transposes precipitation with a single factor representing the ratio of the 25-year, 24-hour precipitation volume for the site versus that of the gauge. This approach can result in over-scaling rainfall amounts in some areas for durations shorter than 24 hours and under-scaling for durations longer than 24 hours. MGSFlood uses a series of scaling functions to match the storm statistics expected for the site of interest and maintains more representative precipitation amounts across the range of storm durations, rather than only the 24-hour duration. Also, MGSFlood analysis uses an extended time series of 158-years, which allows for better estimation of rare events, such as the 100-year storm. When using the same inputs, MGSFlood and WWHM produce identical results (Barker 2018).

The MGSFlood model was selected for the Fennel Creek watershed analysis based on its faster runtimes, stability, and more representative precipitation time series.

3.4.3 Calibration

Stream flow and water surface elevation data were not available to calibrate the model runoff parameters specifically for Fennel Creek. Therefore, all default HSPF input settings within the model were used because these settings are based on a general Western Washington calibration.

3.4.4 Input Data and Key Assumptions

Detailed discussions of model land cover analysis and model inputs are presented in Appendix F. Several key assumptions regarding the input data are highlighted below.

- The Ecology Stormwater Manual recommends that all hydrologic soil groups with a subgroup Type D should be modeled as saturated soils. However, in the Bonney Lake area, it was assumed that there are various soil types underlain by glacial till that may saturate to the surface from water perched on the till surface in specific areas (Barker 2017). These areas were classified as shown in Table 5.

Table 5. Modeled Soil Group Categories

Hydrologic Soil Group	Model Soil Group
A/D	Outwash
B/D	Till
C/D	Till
D	Till
Wetland for All Groups (overrides designations above)	Wetland

- In areas that were classified as wetlands through field surveys, the land was modeled as wetland/saturated, regardless of the underlying soil type.
- The water surface elevations of Lower Lake Debra Jane and Lake Bonney were surveyed near each lake outlet structure during the summer when lake levels were expected to be at the lowest. It was assumed that lake geometry below the summer water surface elevation is dead storage. Geometry above the surveyed water surface elevation was extrapolated from known bank slopes in each lake based on GIS Light Detection and Ranging (LiDAR) data.
- The outlet structures of Lower Lake Debra Jane and Lake Bonney were surveyed, and stage discharge rating curves were developed for model input based on nomographs. If the downstream conveyance pipe was smaller than the surveyed lake outlet structure, then the pipe geometry was used to create the rating curve. It was assumed that once the water leaves the lake and enters the conveyance system, it was free-flowing without any backwater effects. Therefore, inlet control nomographs were used to develop the rating curves.

- Preliminary channel cross-section geometry and elevations were selected every 300 feet from GIS LiDAR data. From the preliminary cross-sections, locations of significant changes in the channel geometry were identified and set as the representative cross-section for the downstream stream reach. Where channel geometry remained consistent for more than 300-feet, the redundant cross-sections were not used in the model.
- In the reach between Upper Lake Debra Jane and Lower Lake Debra Jane, the channel is less defined and spreads out into a marshy area. In this reach, cross-sections were taken 100 feet apart to define the channel for modeling purposes.
- Manning's "n" roughness values were calculated using stream characteristics assumed from aerial imagery and surface photographs of the channel.
- All known existing stormwater flow control facilities in the City's available inventory were included in the model.
- The groundwater component in the MGSFlood/HSPF regional parameter set represents base flow from deeper aquifers beneath the uppermost till layer. In general, if the receiving stream has perennial flow, then this flow is typically supplied by groundwater and the MGSFlood/HSPF groundwater component is connected to the stream. Otherwise, only surface and interflow components from basin runoff contribute to the stream-flow. In many watersheds, the glacial till provides a barrier that prevents the groundwater from reaching upland streams. Lower in the watershed, if the stream cuts through the till and intersects the geologic layers below, year-round base flow appears, and the model groundwater component should be connected (Barker 2017). For the Bonney Lake study area, it was assumed that the groundwater should be disconnected for all subbasins on the plateau area north of SR 410. Downstream of the plateau in the Fennel Creek ravine, it was assumed that groundwater from the surrounding subbasins would be hydrologically connected to the stream.
- It was assumed that there was zero infiltration from the stream back to the surrounding area.

3.4.5 Modeling Approach

Basin planning uses models to quantify, evaluate, and compare existing conditions with expected future conditions, idealized historic conditions (e.g., forest), and various planning scenarios to assess the outcomes from control or retrofitting strategies. Forested and existing land cover conditions were modeled as follows:

1. <u>Forested Condition</u>: Areas identified as wetlands by Pierce County and the State of Washington were modeled as wetlands; water bodies were modeled as impervious; and all remaining areas in the subbasin were modeled as forested, with till or outwash soils depending on the hydrologic soil group associations in Table 5.
2. <u>Existing Condition</u>: Existing land cover was based on Pierce County planimetric data, converted for model input as described in Appendix F. The modeled land cover categories and areas are summarized in Table 6. Waterbodies were included in the impervious land coverage to account for precipitation and evaporation over their surfaces. Detention functionality of the lakes and other waterbodies was included in the model as user-defined rating tables.

Table 6. Fennel Creek Watershed Surface Runoff Subbasins—Existing Land Cover

MGSFlood Land Cover	Area (acres)	Percent
Till Forest	962	20
Till Pasture	660	14
Till Grass	957	20
Outwash Forest	471	10
Outwash Pasture	78	2
Outwash Grass	342	7
Wetland	486	10
Lakes, Ponds, and Water	68	1
Impervious	732	16
Total	**4,720**	**100**

Future expected land cover scenarios were defined using a combination of the Centers Plan and *Eastown Subarea Plan*, future zoning, and existing conditions that are not expected to appreciably change. For basin planning scenarios, it is generally expected that the following would apply:

- Land in existing subbasins with stormwater treatment would remain unchanged or the facility would be upgraded to provide the same hydrologic input.
- Wetlands, floodplains, and steep slopes would not be developed.
- Vacant lands would develop to the allowable density under the land use and zoning plan, but would apply under the current stormwater manual, resulting in the equivalent of "forested" runoff.
- Roads would remain unchanged.
- Land draining to the proposed regional detention facility would be equivalent to "forest" runoff.

The remaining land would stay the same or be changed according to the proposed scenario. There are two types of stormwater retrofitting expected: 1) retrofitting via redevelopment of a site, where the existing stormwater manual requires that (most) redeveloping sites control stormwater to forested hydrology; and 2) proactive retrofitting where an area is designated for retrofit and a capital project is constructed or modified to address existing stormwater impacts.

3.4.6 Model Evaluation Locations

Basin planning evaluates runoff conditions at points in the watershed where a drainage catchment gathers subbasin water and discharges it to the next downstream waterbody. For each scenario, runoff was simulated in the model and the resulting runoff time series was exported for five selected points of evaluation. The evaluation points are (see Figure 7 on page 21):

- The Fennel Creek outfall to the Puyallup River.
- Halfway up Fennel Creek at the downstream point of the plateau near SR 410.

- The upstream portion of Fennel Creek at the confluence of its headwater tributaries.
- The Lake Debra Jane outfall into Lake Bonney Lake outflow.
- The Lake Bonney outfall into Fennel Creek.

Using the exported runoff time series, stream metrics were calculated in Microsoft Excel. Peak flow metrics were taken directly from model output.

4. BASIN PLANNING

4.1 Planning Objectives

When jurisdictions set out to complete stormwater planning, the intended form, process, and outcomes are as varied as the communities that prepare them and the landscapes that they cover. This Plan is focused on coordinating stormwater planning efforts with land use planning where stormwater controls and standards are focused on subbasins, and land use and development standards are adjusted to consider subbasin specific conditions.

This Plan describes approaches for:

- Future anticipated growth
- Basin-specific targets for stormwater control, when appropriate
- Standards for redevelopment
- Solutions for existing site-specific problems
- A framework for planning future stormwater retrofits

4.1.1 Future Growth

Most basin plans address existing and future development as a "given" or unchangeable project consideration. The intent of this Plan is to identify where planned development or planning areas can be adjusted to follow the landscape or take advantage of favorable site conditions, such as good soils. The vacant lands, Centers Plan, and *Eastown Subarea Plan* described in Section 3 provide a strong basis for future development potential and stormwater management needs. Other anticipated or potential future development distributed throughout the subbasins and City are also addressed using current stormwater management manuals, regional stormwater facilities, or redevelopment retrofitting.

4.1.2 Subbasin-Specific Stormwater Control

The drainage subbasins in the city are not all the same, as described in previous sections. Subbasins drain to lakes, ponds, or wetlands; have no outlets to streams; or already have regional or area-wide stormwater controls. The purpose of this planning effort is to identify the important characteristics of the different subbasin types and establish the most appropriate stormwater control measures for that subbasin's future development or retrofitting. Applying appropriate controls has many benefits: 1) new development is more likely to develop stormwater runoff controls based on the receiving water needs and risks to the resource; 2) the preferred control for the landscape is selected; 3) retrofitting and regional controls are selected for need and, to the maximum extent practicable, to reserve limited resources; and 4) the benefits are prioritized and targeted.

4.1.3 Standards and Approaches for Redevelopment

Sites that were developed before the requirement to apply stormwater management may in the future be required to retrofit to existing stormwater control standards. These sites are often constrained by buildings, roads, and the existing drainage system. The Plan will describe where retrofitting through site redevelopment is the preferred approach, where proactive retrofitting projects should be planned or proposed, and where redevelopment should be directed because of suitable conditions.

Approaches can be used other than retroactively applying stormwater controls according to the current stormwater manual. If a subbasin-specific standard is developed, this standard can be applied to retrofitting projects. If regional stormwater controls are identified for future developing areas, additional controls can be included to retrofit existing development in those subbasins. If other projects are proposed, such as a road improvement, stormwater retrofits can be added opportunistically. If limited land or resources are available, a regional retrofit project can be applied to the maximum extent practicable based on what is available, rather than applying a standard.

4.1.4 Existing Areas that Flood

Frequently flooded sites tend to be isolated and not related to subbasin-wide problems with stormwater controls or drainage. Solutions will be site-by-site and are unlikely to influence other subbasins or planning strategy. Section 5 describes the capital projects to address existing and acute flooding problems.

4.1.5 Framework for Planning Proposed and Future Stormwater Retrofits

Stormwater retrofitting on a subbasin scale can be costly. A comprehensive evaluation of Juanita Creek retrofitting by the City of Kirkland found that completely retrofitting the subbasin (about 7 square miles in size and 68 percent impervious) to full Ecology Stormwater Manual standards would cost $1.4 billion in 2011 dollars (King County 2012). The analysis projected that BIBI scores could rise to 38 from their existing level of 17. The existing high BIBI score (40) and relatively low level of impervious surface in the Fennel Creek watershed (about 15 percent) mean that full retrofit costs is expected to be lower, and the City is placed in a preservation position rather than an improvement position (of the BIBI score). Also, the amount of cost carried by private entities as a retrofit via redevelopment versus the cost borne by the public for proactive retrofits influence potential needs and costs dramatically, as does a "maximum extent practicable' approach. For public projects, criteria for identifying priorities that are consistent with the basin planning framework will be identified, and approaches presented when opportunistic projects arise. For example, if a road improvement or large redevelopment is proposed, the stormwater control approach would be identified.

Stormwater basin planning has a primary goal of protecting existing resources and improving conditions in areas that are degraded or have the potential to degrade due to lack of stormwater controls applied when the development originally occurred. The applicable stormwater manual is expected to provide the protection for new and proposed development or redevelopment, including potential adjustments to subbasin-specific conditions and needs. The basin plan addresses the impacts that are present or potentially imminent. The Plan develops an approach to identify and address the problem and establish a plan to begin to reverse the course of degradation.

4.2 Future Growth Patterns

As described in Section 3 above, future development and growth potential is primarily through the City's three Centers development. Some development is also expected across the city on vacant lands to allowable intensity based on zoning, including infill or redevelopment on a lot or parcel scale. A key goal of this Plan is to direct development to areas more suitable for development or that are less likely to cause resource impacts. These suitable or preferred areas would include:

- Land already developed with existing stormwater controls
- Land in subbasins with area-wide or regional stormwater facilities
- Land with soils highly suitable for infiltration
- Basins with no surface drainage outlet that discharge only to groundwater

Lands with existing stormwater controls were identified at the subbasin scale. Additional parcels and smaller development sites within a subbasin may also have controls that can be considered on a site-by-site basis if redeveloped. The type and efficacy of the stormwater facility was not considered in this assessment and facilities were considered protective and not requiring upgrade. Lands with existing stormwater facility coverage are shown in Figure 10. There are no immediate incentives to direct redevelopment or infill development to these subbasins, although the potential for not requiring new stormwater controls could make a site more desirable for redevelopment.

Some of this stormwater coverage is provided by regional stormwater facilities that serve multiple parcels or sites. Adding development, infill, or redevelopment to these subbasins is preferred because it uses existing available stormwater infrastructure. If proposed development draining to an existing regional facility is changed, the site may be required to reduce stormwater flows before discharge to that system or the facility may require an upgrade. The boundaries of the Centers were modified to match subbasin boundaries of regional facilities (see Figure 10) when applicable. The Midtown and Downtown Centers are now completely included in existing regional detention facilities.

An LID suitability evaluation was prepared to identify lands that may be more suitable for LID applications and land that may be infeasible for LID. This feasibility analysis is provided in Appendix G. In general, land in Hydrologic Soil Group A are likely to have good infiltration and can effectively mitigate stormwater impacts near the site or with LID-type stormwater controls. Lands feasible or preferential for LID are shown in Figure 11.

Stormwater management controls required in the Pierce County Stormwater Manual encourage the infiltration of stormwater flows through infiltration and LID facilities. Generally, land in closed subbasins with no outlet is less impactful to regional surface water resources because the surface runoff is infiltrated on a subbasin scale in a manner similar to what occurs on a site scale with LID. These areas would be preferred for development, provided that local conditions in the subbasins were not affected by flooding (Barker 2018). Town center areas were modified to match soil suitability (see Figure 11). Land development policies and standards will also consider suitability and are further discussed in Section 6.

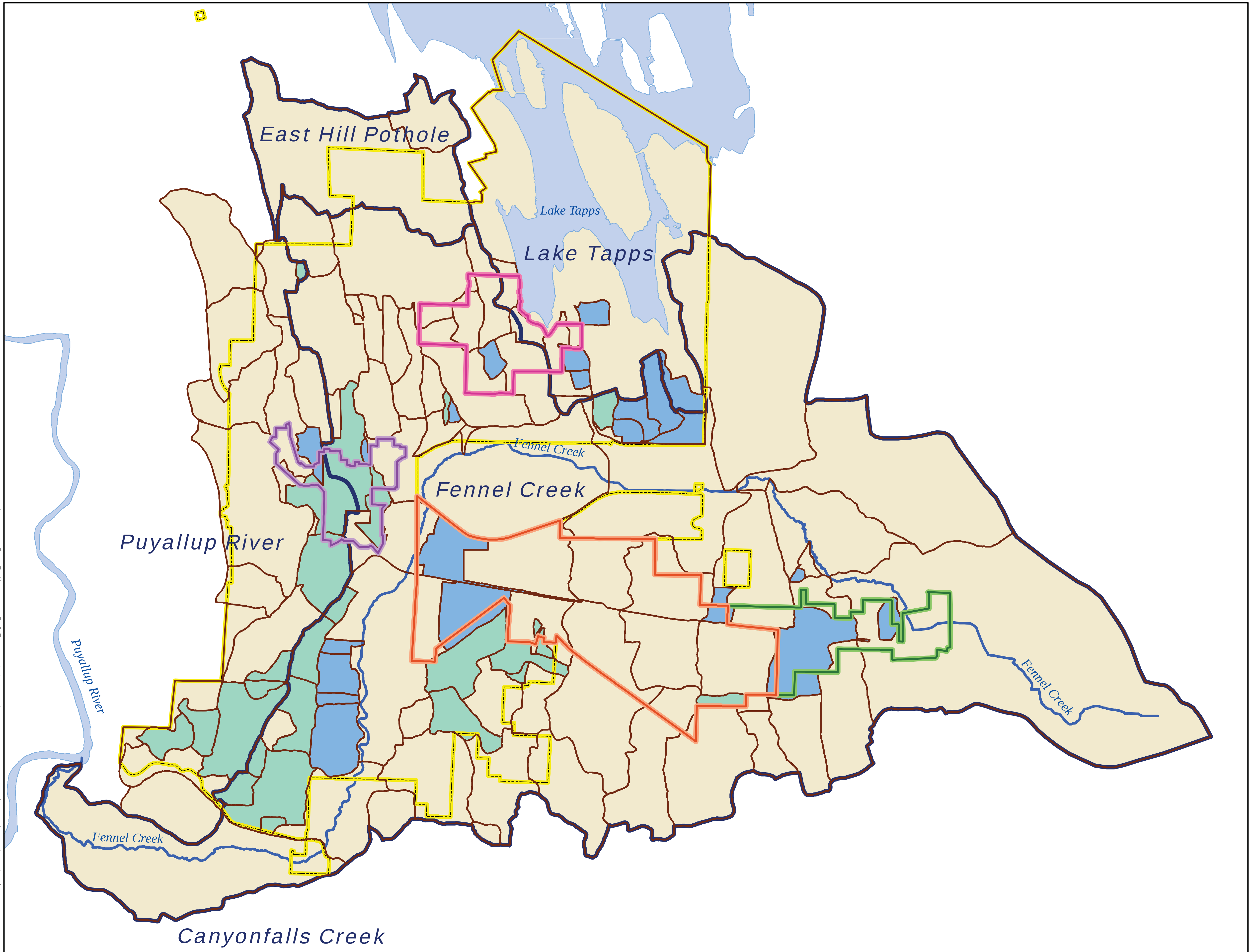


FIGURE 10
EXISTING STORMWATER MANAGEMENT COVERAGE

Subbasin Treatment

- Detention Pond
- Infiltration Pond
- No Treatment
- Downtown Region
- Lake Tapps Region
- Midtown Region
- Eastown Subarea
- Bonney Lake City Limit
- Watershed Boundary
- Fennel Creek
- Surface Water

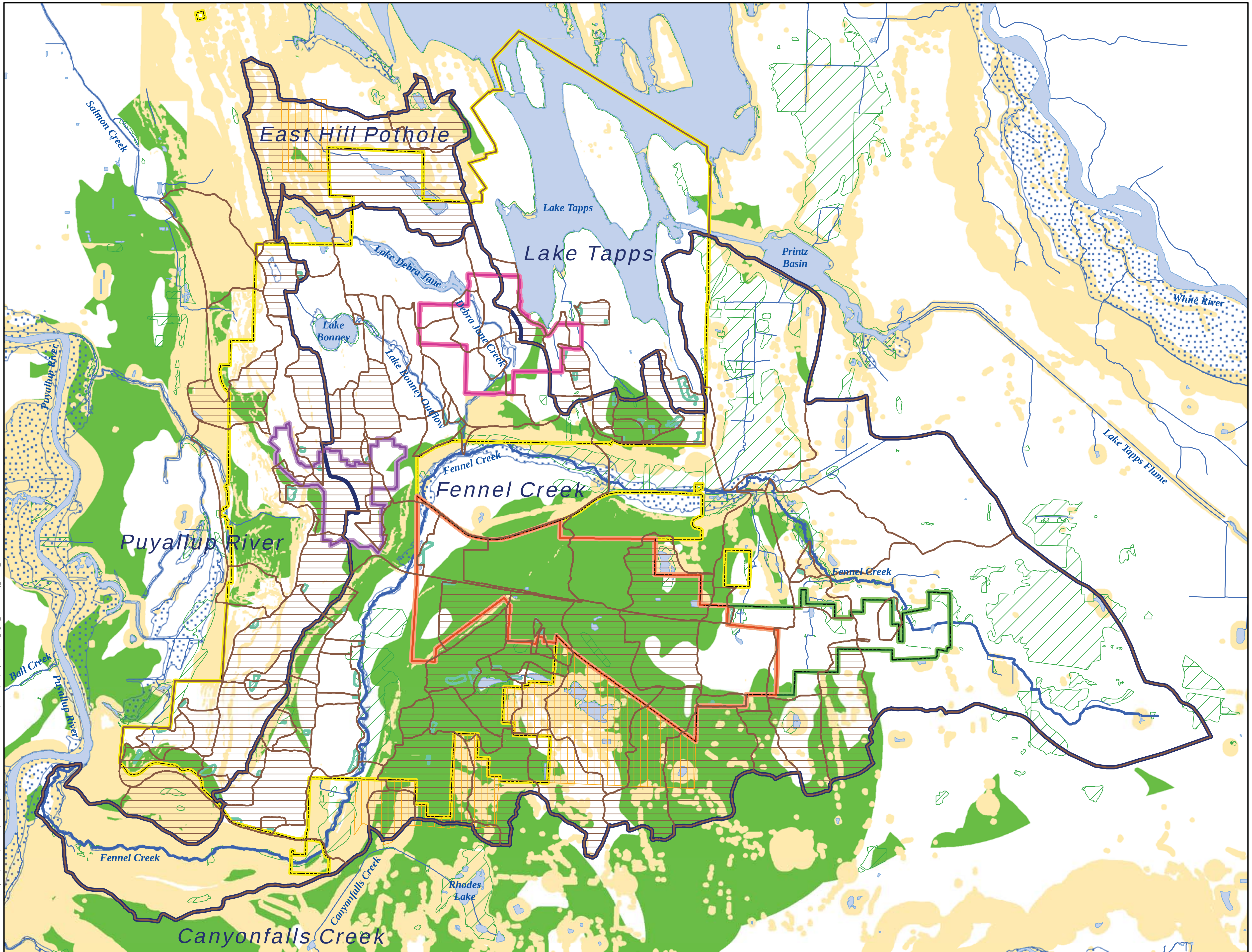
Miles
0 0.5 1

Source: City of Bonney Lake, Pierce County

BONNEY LAKE Watershed Plan

Parametrix
ENGINEERING . PLANNING . ENVIRONMENTAL SCIENCES

FIGURE 11
SUITABILITY FOR DEVELOPMENT AND LID



- Downtown Region
- Lake Tapps Region
- Midtown Region
- Eastown Subarea

Drainage Subbasin

- Open
- Closed
- Bonney Lake City Limit
- Future Annexation Area
- Watershed Boundary
- Surface Water
- Fennel Creek
- Other Stream
- Stormwater Pond
- Wetland (Pierce County)
- 100-year Floodplain
- Slope/Erosion/Landslide Hazard
- Soil Hydrologic Code A

Miles
0 0.5 1

Source: City of Bonney Lake, Pierce County

BONNEY LAKE Watershed Plan

Parametrix
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4.3 Subbasin Classification and Stormwater Management Coverage

Potential stormwater controls not directed by the adopted stormwater manual may have standards that vary based on the disposition of runoff from that subbasin. Six subbasin discharge-type categories are listed below:

- Fennel Creek
- Surface discharges via natural channels to the Puyallup River
- Discharge to lakes that feed tributary streams to Fennel Creek[1]
- Closed subbasins discharging to lakes, ponds, or wetlands
- Closed subbasins discharging to the groundwater table[2]
- Direct discharge to Lake Tapps

[1] These subbasins are also included in the Fennel Creek watershed for the modeling analysis.

[2] Many of the subbasins discharging to groundwater are via constructed stormwater infiltration facilities.

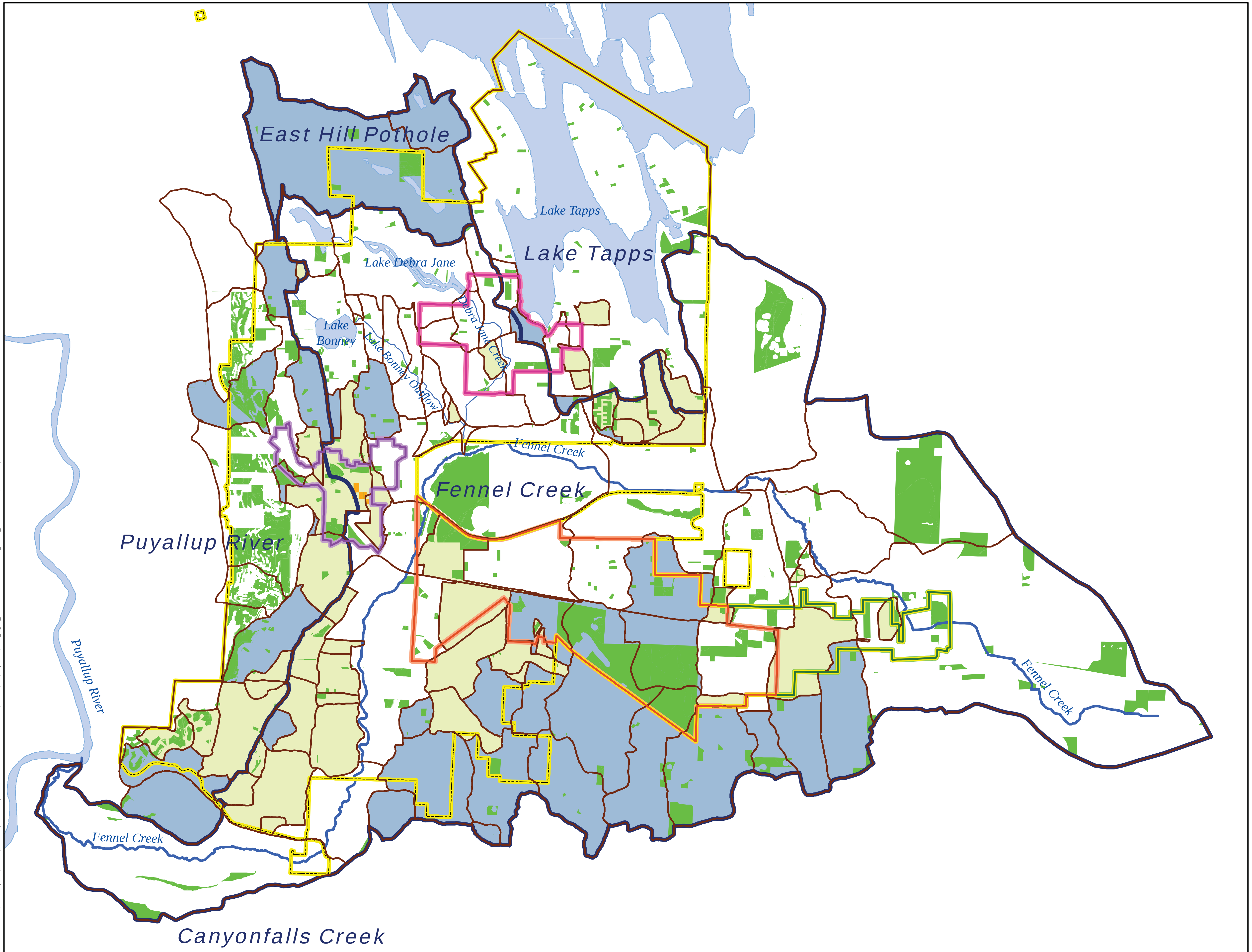
Each of the subbasin types can cause different stormwater impacts and need different control measures. The Fennel Creek and surface water discharges to the Puyallup River can require stream protection controls for hydromodification or other flow regime metrics (see Section 4.4). Lakes with outlets that drain to Fennel Creek may have different control approaches due to lake storage and downstream channel protection (see Section 4.4.2.4). Closed subbasins to ponds or wetlands may require no controls if there are no impacts to those systems, and closed systems discharging to the water table may not require any controls. Lake Tapps is a flow-exempt waterbody, which means water quality control is required but flow controls are not. If a subbasin is already treated (see Figure 10), additional stormwater controls will not be required. When and where these controls apply are described in Section 4.7.

New development and redevelopment may be considered separately when establishing flow metrics and combined when assessing future expected outcomes. Existing vacant lands will provide a basis for new development potential (if the area is included as developable in the land use plan). An overlay of vacant lands on the treatment map is shown in Figure 12.

4.4 Establishing Flow Control Targets

As described earlier, stormwater basin planning has a primary goal of protecting existing resources and improving conditions in areas that are becoming degraded or have the potential to degrade because stormwater controls were not applied when the development was built. The adopted stormwater manual is expected to provide the needed protection for new and proposed development or redevelopment. The need in the basin plan is to understand the impact that is present or potentially imminent and to develop an approach to address the problem and establish a plan to begin to reverse the course of degradation.

FIGURE 12
VACANT LANDS AND SUBBASINS WITH EXISTING STORMWATER MANAGEMENT COVERAGE OR NO DISCHARGE TO SURFACE WATER



Vacant Land (City-owned)

Vacant Land (Not City-owned)

Drainage Subbasin

Treatment

Closed

Downtown Region

Lake Tapps Region

Midtown Region

Eastown Subarea

Bonney Lake City Limit

Watershed Boundary

Fennel Creek

Other Stream

Surface Water

Miles

0 0.5 1

Source: City of Bonney Lake, Pierce County

BONNEY LAKE Watershed Plan

The first step is to establish the need for improvements based on existing measurable or observed conditions. The second is to establish potential impacts based on an understanding of the prescriptive nature of stormwater management. For example, if development has occurred with no controls, impacts would be manifested in the downstream system in the future. Consequently, improvements would be identified based on either undoing or mitigating (retrofitting) the development that could cause the impacts. In this circumstance, the metric would be based on “area treated” or “area retrofit.” In circumstances where a regional system is proposed for retrofitting existing development or preparing for future development, the design standard would be based on the stream receiving water target or the presumptive standard set forth in the Ecology Stormwater Manual.

4.4.1 Measurable Observations and Metrics

Data are often collected by local jurisdictions, Ecology, U.S. Department of Fish and Wildlife, and USGS under programs to assess water quality, flows, or habitats. Some of these observations can provide the basis for a stream metric by which to evaluate stream health (see Section 2 for a discussion of available data). The Pierce County Stream WQI was reported in 2015 at 70, which is considered “marginal concern” (Pierce County 2015a). While total suspended solids (TSS) are included in the WQI, metals such as zinc and copper, which are typical constituents of concern in urban stormwater, are not. Although this data point will be useful to evaluate long-term water quality changes, the Plan does not set out to establish a relationship between proposed actions and improvements in the WQI rating. Rather, improvements in the subbasin due to regional facilities or retrofits will be expected (presumed) to result in improvements in water quality. No subbasin-specific water quality control measures or targets are proposed. However, the retrofitting analysis below identifies target subbasins for improvement, and it can be expected that presumptive application of water quality facilities will have commensurate improvements.

As described in Section 2.2.2 above, BIBI scores have been developed intermittently for Fennel Creek since 2003 and show a range of results between 34 (fair) and 44 (excellent/good), with an average of 40 (good) (see Table 1) (Puget Sound Stream Benthos Data Management System 2017). BIBI scores are being used or considered as useful indicators of stream health (King County 2017), although it is difficult to make a strong correlation between proposed actions in the stream or watershed and the resultant BIBI score. One measure is considering the relationship between impervious area or subbasin development and BIBI scores. Figure 13 shows this comparison for a number of Puget Sound lowland streams over the past several years (DeGasperi et al. 2009). While there is a general relationship between impervious area and BIBI, it is not a strong correlation. For example, “fair” BIBI scores of about 30 can be found in basins between about 15 and 35 percent total impervious area (see Figure 13). Therefore, reducing impervious area or hydrologic impacts through stormwater controls is expected to improve the BIBI, but the expected change cannot be readily targeted.

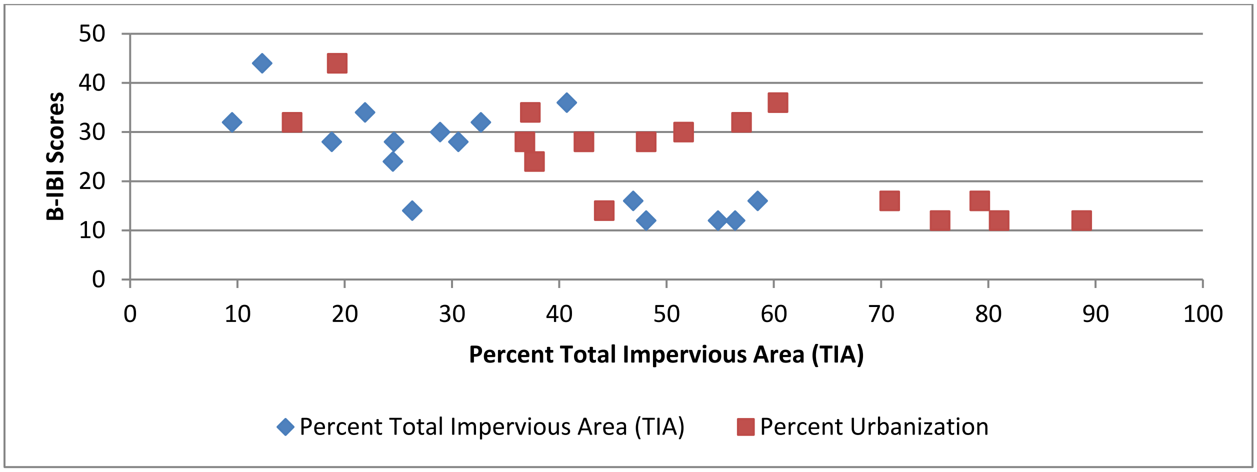


Figure 13. BIBI Scores versus Total Impervious Area

The other systems—closed subbasins, wetlands, and the lakes and potholes—have limited data on which to make measured response or are outside the scope of this evaluation (e.g., Lake Tapps).

4.4.2 Subbasin Control Measures

Several flow control metrics were considered for evaluating proposed subbasin projects and development design standards. The Ecology Stormwater Manual standard to retrofit all sites to a predevelopment target (forested) can provide a basis for a control target and is generally appropriate for site or subdivision design. On a subbasin scale, however, it is very unlikely that the extent of existing development can be retrofit to that level. Consequently, other hydrologic regimes were considered as the basin planning standard for upgrades.

4.4.2.1 BIBI

As described earlier and shown in Figure 13, there is an apparent relationship between the level of development indicated by total impervious area and BIBI scores. A strong relationship could provide a basis for an effective impervious area hydrologic response runoff regime, and this metric may be used to set assumed BIBI targets based on effective impervious area reductions in the Plan. For example, if an effective impervious area of 10 percent can be expected to have a BIBI score of 30 (see Figure 13), this can provide the basis for a flow control retrofitting target.

The average BIBI score in Fennel Creek is good (40), which is well above the score expected for the total impervious area (15.5 percent) of the Fennel Creek study area where scores below 30 could be more typical (see Figure 13). Therefore, the targets for Fennel Creek will focus on protecting existing hydrology and making measured improvements when possible, such as retrofitting in regional facilities, retrofitting to infiltration systems when redevelopment occurs on good soils, and opportunistic flow control during roadway or highway upgrades. Other targeted flow control retrofitting is not proposed to target BIBI changes, although a prioritization approach is described in Section 4.5.

4.4.2.2 Stream Channel Stability Approach and Flow Frequency

Another approach to setting retrofit flow control targets is to establish a target flow regime that corresponds to the existing or preferred geomorphic conditions of Fennel Creek. This approach was applied in the *Des Moines Creek Basin Plan* (King County 1997), which established a land cover ratio for determining predevelopment flow frequency targets. This approach was originally contemplated for the Fennel Creek watershed. However, the Fennel Creek watershed is not as well-suited for this approach. The watershed model is not calibrated to a Fennel Creek gauge and the watershed has a wide range of highly variable runoff conditions. The upper watershed is dominated by the poorly drained soils of the Osceola mudflow, while the lower watershed is glacial drift and outwash. Many adjacent subbasins are closed surface water systems that probably provide a relatively large amount of groundwater and base flow to the stream. Two lakes, Lake Bonney and Lake Debra Jane, provide delayed storage in the system, which cannot be easily characterized in a subbasin-wide hydrologic response parameter. Future stream flow monitoring and model calibration are recommended to continue to refine the establishment of subbasin-specific metrics and expected outcomes from retrofitting and restoration actions.

The target hydrologic response characteristics used on Des Moines Creek—10 percent effective impervious area, 15 percent "grass," and 75 percent forest—were used as a basis for comparison to predevelopment forested and developed conditions for Fennel Creek, and to provide a target for a weight-of-evidence approach to flow control standards. Figures 14a, 14b, and 14c show the flow-frequency curves for existing conditions (15 percent impervious, 28 percent grass, 30 percent forest and 15 percent pasture), pre-development forested conditions, and the "stream-stability" 10-15-75 target distribution of land cover in the Fennel Creek watershed at selected locations (see Figure 7 on page 21). The 2-year flow and 1.4-year flow for each condition are shown on Table 7. This shows that the differences found between the forested condition and the 10-15-75 target is small at the 2-year flow return frequency, and some differences between the forested and the 10-15-75 scenarios appear at the +1-year lower return frequencies.

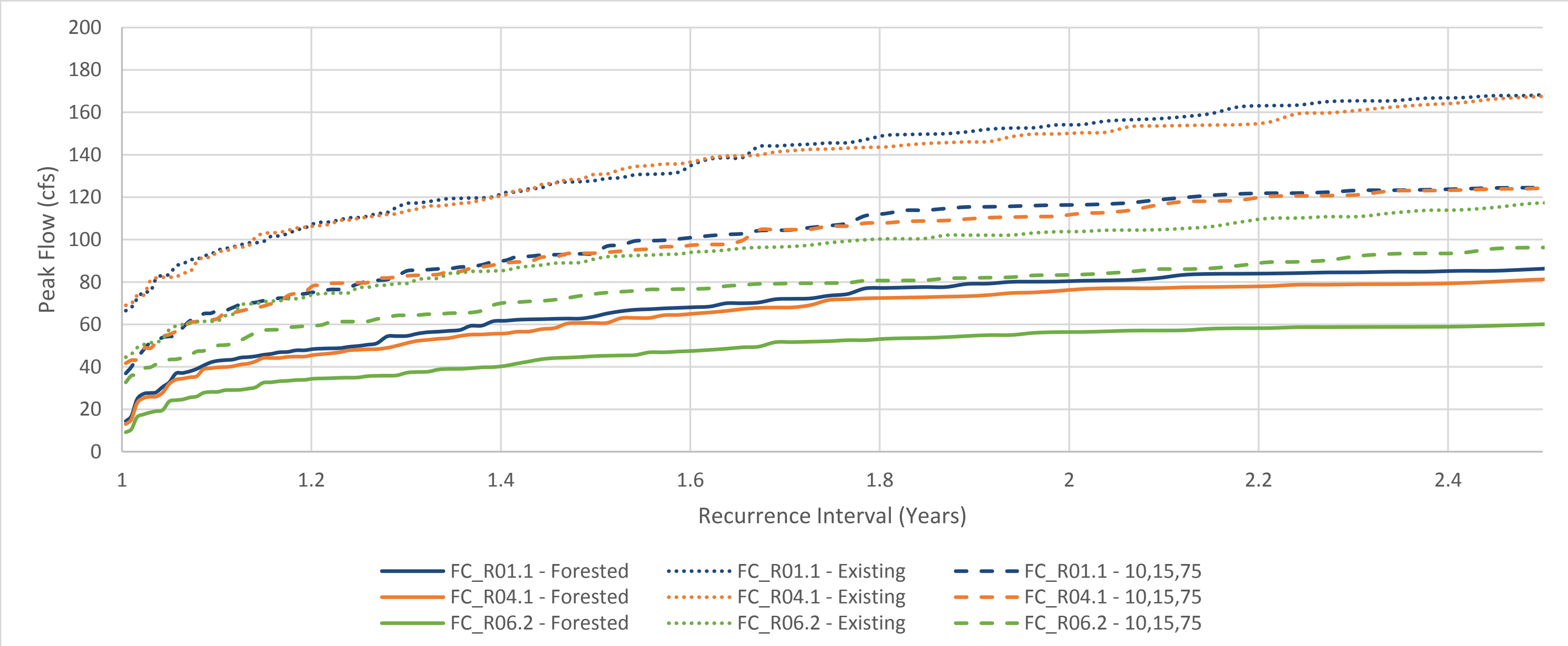


Figure 14a. Flow Frequency Curves for Fennel Creek

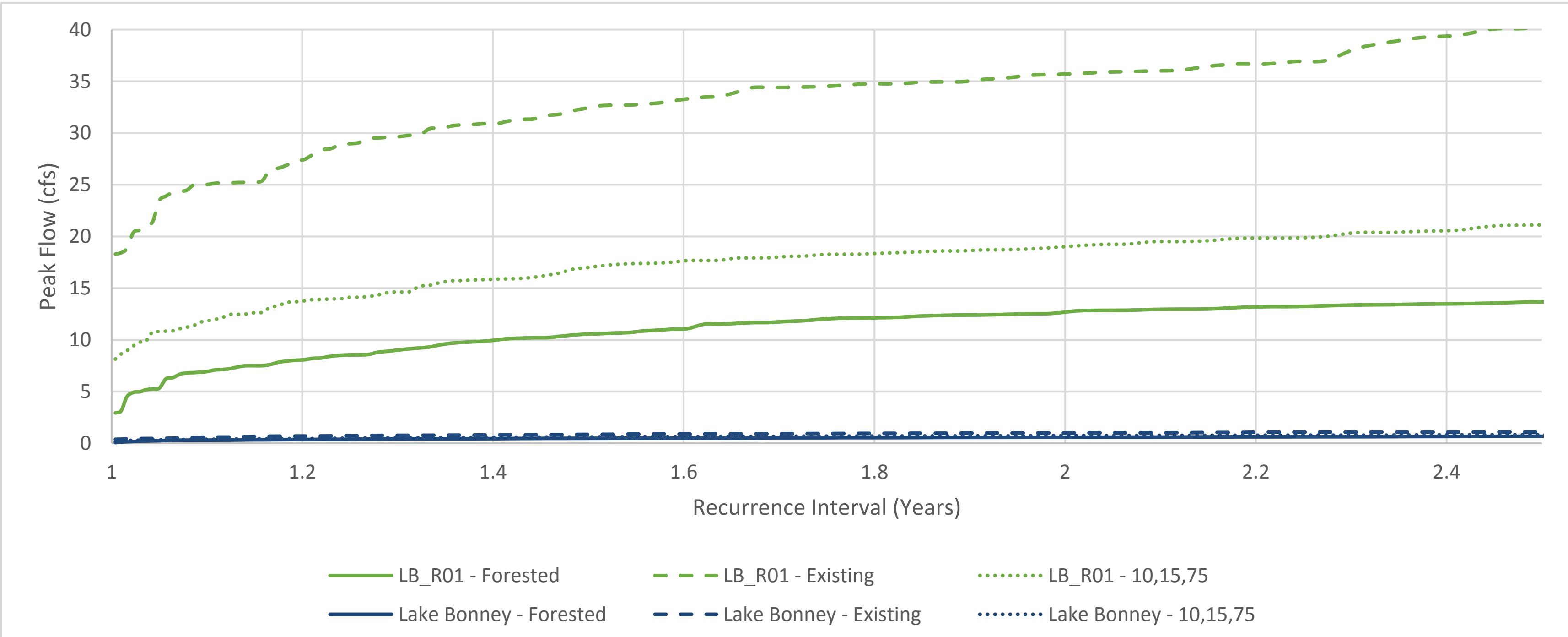


Figure 14b. Flow Frequency Curves for the Lake Bonney Subbasin

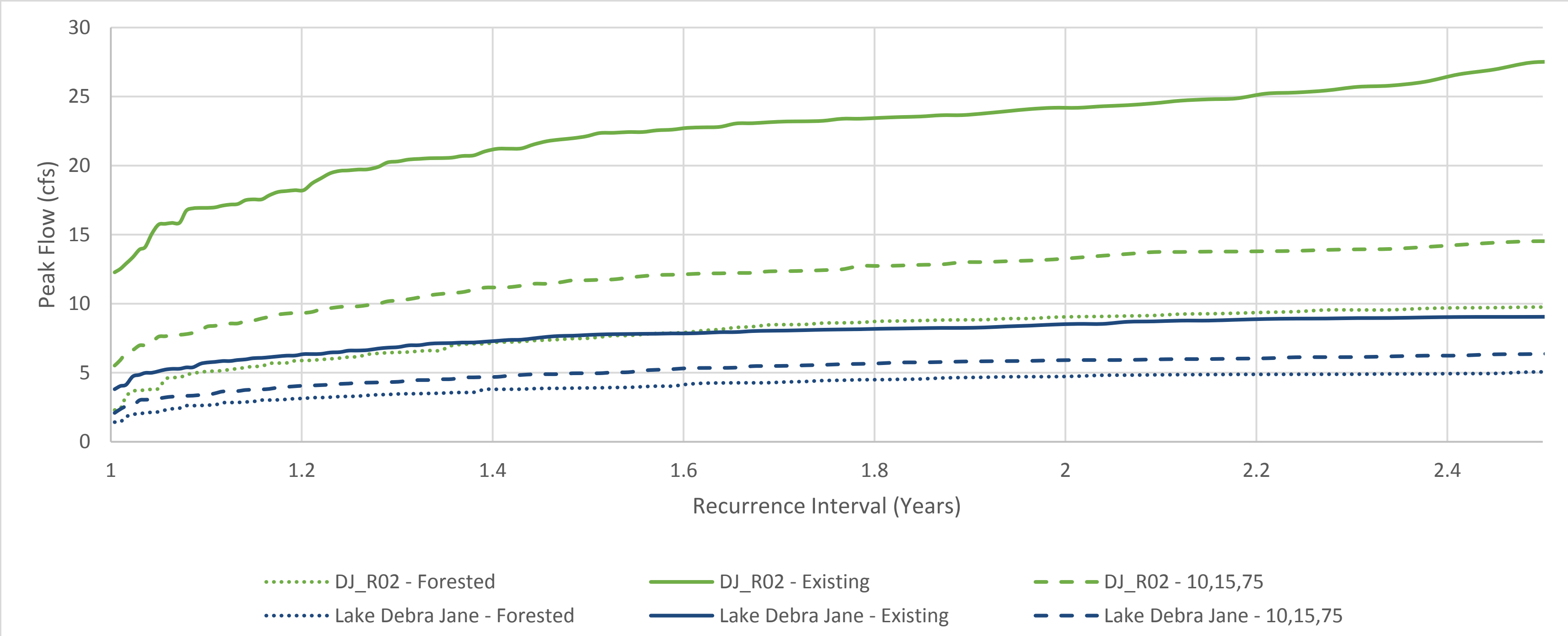


Figure 14c. Flow Frequency Curves for the Lake Debra Jane Subbasin

Table 7. Comparison of Flow Frequency for Different Development Scenarios

Point of Compliance – Scenario	Forested	Existing	10-15-75
2-year Flow (cfs)			
FC_R01.1	80.2	154.1	116.3
FC_R04.1	75.8	149.8	111.0
FC_R06.2	56.4	103.7	83.4
LB_R01	12.7	35.7	19.0
DJ_R02	9.0	24.2	13.3
Lake Bonney Outfall	0.6	1.0	0.8
Lake Debra Jane Outfall	4.7	8.5	5.9
1.4-year Flow (cfs)			
FC_R01.1	61.7	122.2	90.2
FC_R04.1	55.7	121.1	89.0
FC_R06.2	40.5	85.5	70.3
LB_R01	10.0	30.9	15.9
DJ_R02	7.2	21.2	11.2
Lake Bonney Outfall	0.5	0.8	0.6
Lake Debra Jane Outfall	3.8	7.3	4.7

4.4.2.3 Flow Pulses and Flashiness

Recent studies have begun to consider the number, magnitude, or distribution of peak flow "pulses" (when compared to an undeveloped, forested condition) as a metric to evaluate the magnitude of stream flow modification (DeGasperi et al. 2009). These evaluations assign a number against which to compare existing conditions versus historic forested or other "developed" conditions, and to estimate the changes that can occur due to retrofitting sites and subbasins for flow control. Four pulse-type evaluations were made for the undeveloped/forested, existing, and 10-15-75 scenarios. These include mean-annual pulse counts, pulse duration, pulse range, and flashiness (Richards-Baker Flashiness Index [R-B Index]). Pulses are storm events that are equal to or exceed a threshold of two times the mean annual flow. The pulse duration is the average number of days that the pulse exceeds the threshold of two times the mean annual flow, and the pulse range is the number of days between the first and last pulse during a water year. Both pulse count and range have a generally proportional relationship with urbanization while duration has an inversely proportional relationship.

Flashiness or R-B Index is a dimensionless index of how flow oscillations compare to the total flow based on the water year daily average discharge. Flashiness is linked with the rate of change in flow—flashy streams have rapid rates of change and stable streams have slow rates of change. Urbanization and the R-B Index have a directly proportional relationship (DeGasperi et al. 2009). Table 8 shows the results of the pulse evaluation for each approach for the entire Fennel Creek basin at FC_R01.1 (see Figure 7 on page 21).

Table 8. Comparison of Hydrologic Metrics in Fennel Creek

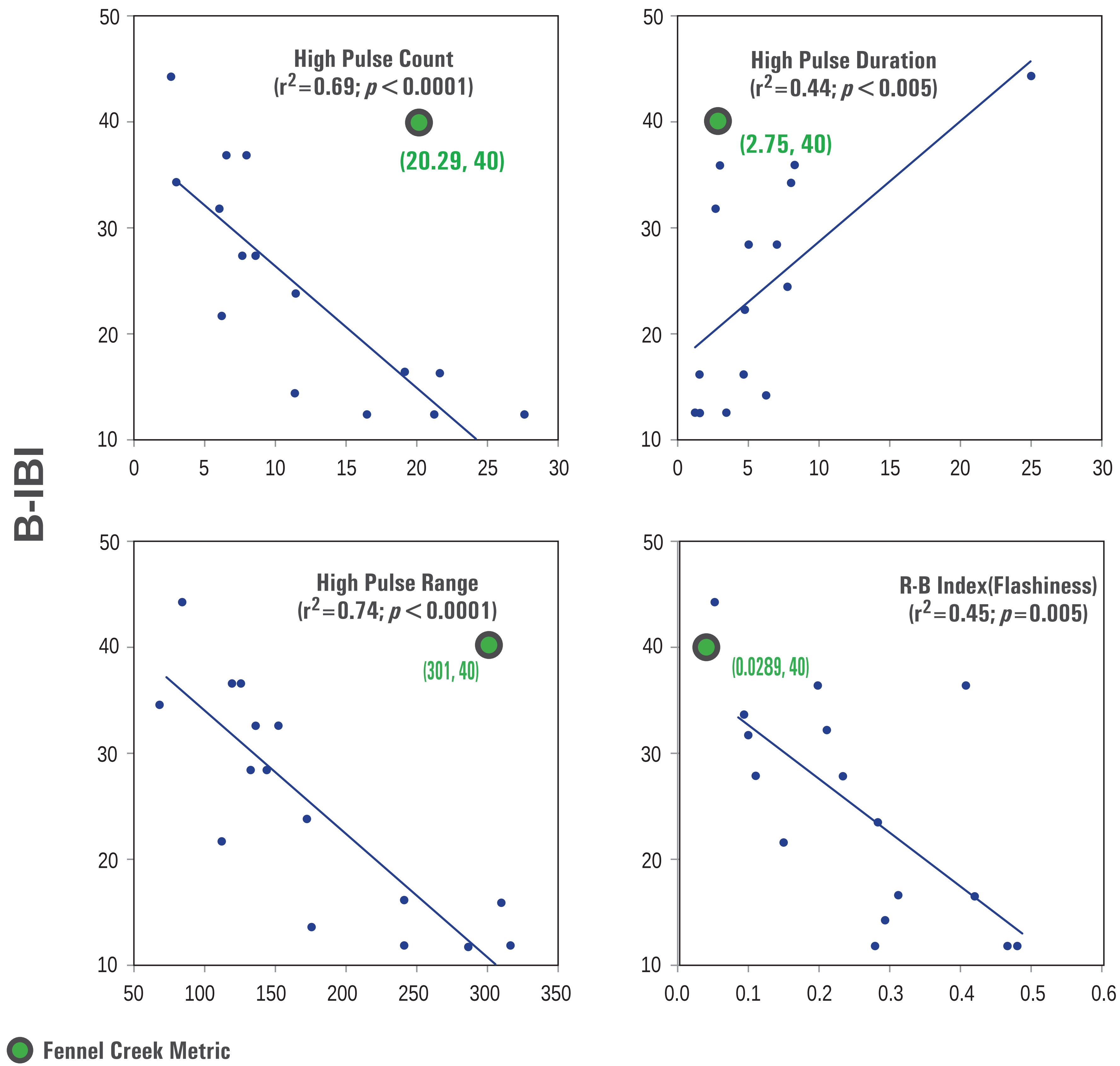
	Scenario		
Evaluation Metric	**Forested**	**Existing**	**10-15-75**
Pulse Count	11.4	20.3	17.7
Pulse Duration	4.6	2.8	3.1
Pulse Range	156	301	274
Flashiness	0.02784	0.02953	0.02894

The findings in Table 8 were compared to other recent Western Washington stream evaluations. DeGasperi et al. (2009) provided linkages between these parameters and the BIBI scores, as shown in Figure 15. The hydrologic metric findings in Fennel Creek do not closely follow the findings in DeGasperi et al. (2009). However, if the BIBI scores in Fennel Creek (average 40) are plotted on the graphs, the very low pulse counts, pulse duration, or pulse range expected are unlikely to be found, even if a more detailed calibration were prepared. The unique conditions in the Fennel Creek watershed, such as the geology, closed subbasins, lake attenuation, and extensive use of existing stormwater controls, are likely to contribute to findings that are outside of the range of outcomes found in more typical basins across the Puget Sound Lowlands. These findings do not change the fundamental understanding of impervious areas and their effects on basin hydrologic response—pulses change in Fennel Creek with increased impervious surface—therefore, control measures will continue to address those expected modifications. It may also indicate that other expected development impacts to BIBI scores, such as those from reduced water quality or direct stream and riparian zone modification, are small as well, and in combination would result in unusually high BIBI scores when compared to watershed development levels.

4.4.2.4 Hydrologic Parameters and Change in Impervious Surface

The sensitivity of the watershed to changes in impervious surface cover or conversion to or from forest was also assessed to evaluate the relative benefits of potential retrofitting. In other words, how much reduction of impervious area is needed to provide meaningful benefits to these stream metrics? To estimate this decrease, impervious amounts were added in 1 percent increments from zero percent impervious to 15 percent, then increased at 10 percent up to 100 percent impervious. This was done for all four pulse matrices. Figures 16a and 16b show that pulse counts begin to change at approximately 3 percent impervious then increase until 15 percent before gradually leveling off. Pulse duration and range do the opposite. Flashiness continuously increases without ever flattening out. When taking the derivative of each line (measure of the rate of change for each point), the most significant rate of change for pulse count, duration, and range is at around 7 percent impervious (Figure 17). This suggests that a reduction to about 7 percent impervious area will produce an optimal desirable result for resources used to reduce impervious area. Additional improvements (a reduction in effective impervious area) are expected to continue to improve the result, but at a rapidly diminishing rate, as shown by the steep change in line slope.

Hydrologic Metrics



DeGasperi et al. 2009. Linking hydrologic alternation to biological impairment in urbanizing streams of the Puget Lowland, Washington, USA. JAWRA 45(2):512-533.

Figure 15. Hydrologic Metric Findings from Western Washington Stream Evaluations

One conclusion to make from this result is to demonstrate that the benefits of protecting existing forest hydrology has value, as can be expected, and that the cost of fully restoring to a forested hydrology has a lower value threshold. The Plan recommends that a 7 percent effective impervious area threshold be used as a goal for targeted subbasin retrofitting in the Fennel Creek watershed. This is reasonably consistent with findings of other similar planning efforts, such as *Des Moines Creek Basin Plan* (King County 1997) where 10 percent impervious targets were established. When considering that the existing total impervious area in the Fennel Creek subbasins is at about 15.5 percent impervious, and the stream is exhibiting good stream health metric results, such as good BIBI and WQI scores, the 7 percent target is expected to be protective of the resource and would be expected to maintain current health and lead to improvements.

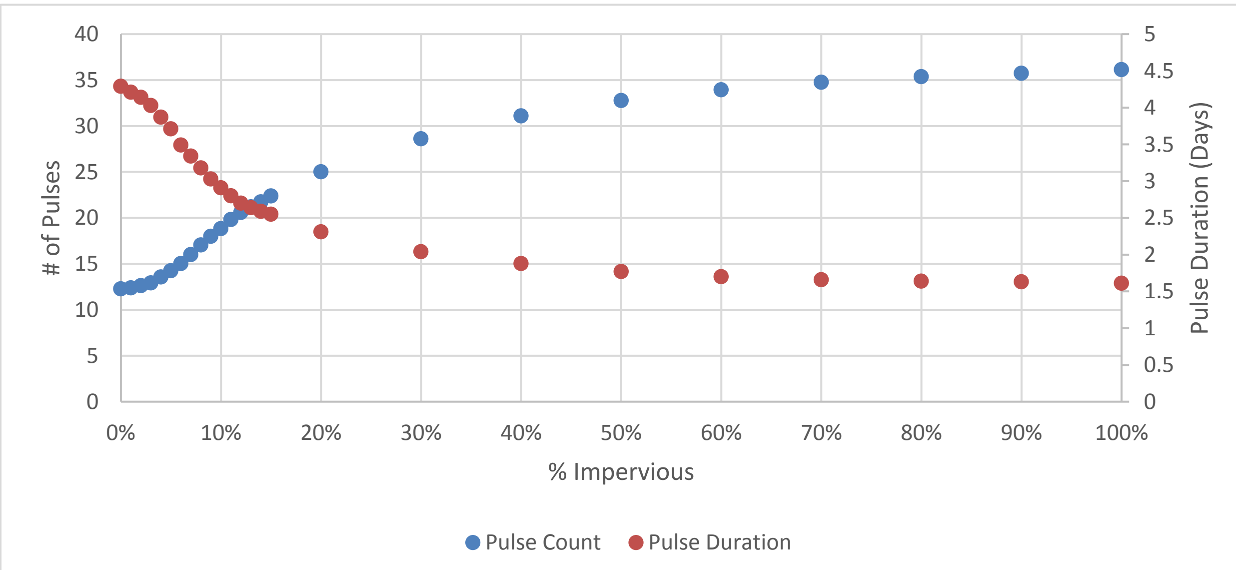


Figure 16a. Hydrologic Metrics Versus Impervious Surface in the Fennel Creek Watershed at FC_10

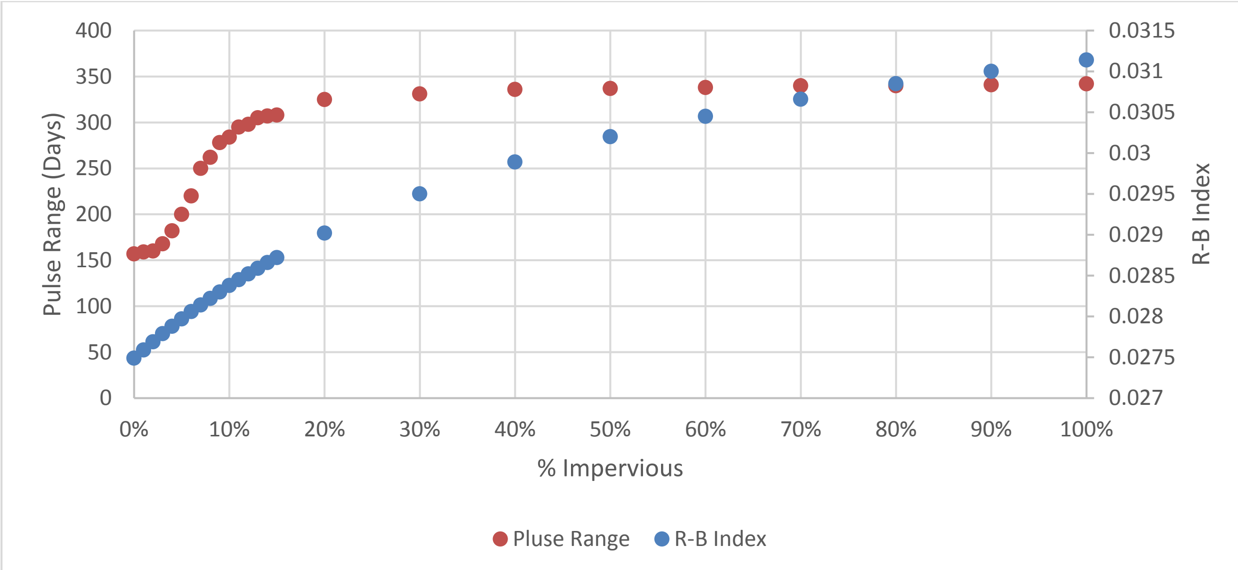


Figure 16b. Hydrologic Metrics Versus Impervious Surface in the Fennel Creek Watershed at FC_10

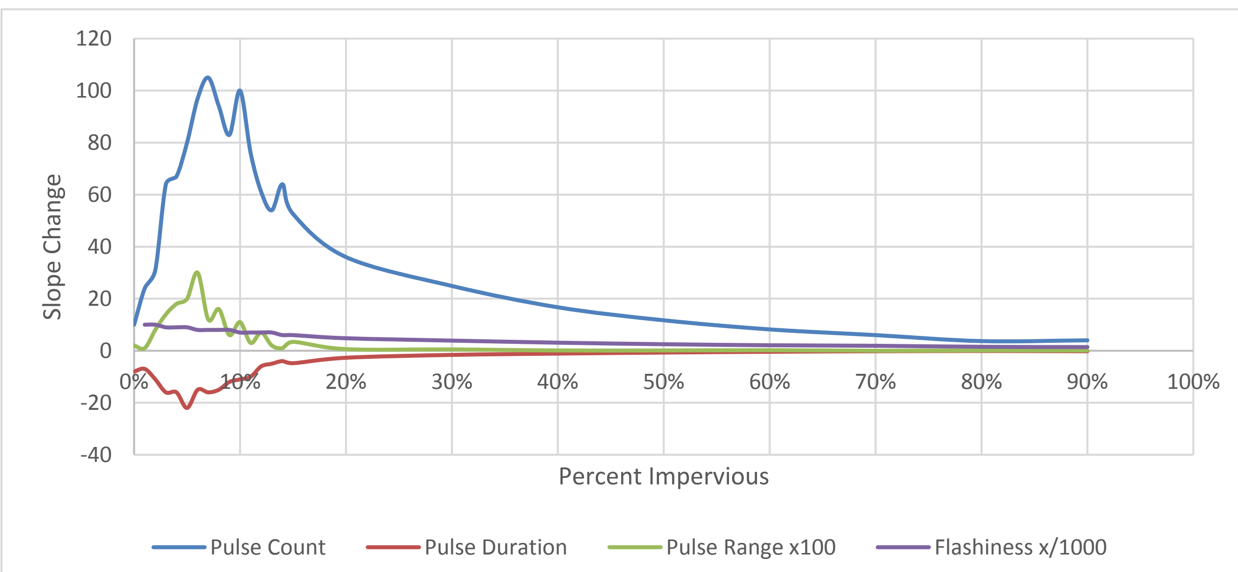


Figure 17. Slope Change for Hydrologic Metrics versus Impervious Surface in the Fennel Creek Watershed at FC_10

4.4.2.5 Lake System Hydrology

The lake systems in the Fennel Creek watershed, with outlets to Fennel Creek, Lake Bonney, and Lake Debra Jane, have runoff storage that can reduce the potential impacts of development or the benefits of flow control for new development or subbasin retrofitting. Subbasin discharging into the lakes may have different flow control standards and still provide adequate control compared to the stream segments downstream of the lake outlets. The stream segments were evaluated using the same metrics as used for the Fennel Creek watershed to determine if the effect of the lake system storage may result in a different approach in those subbasins. For subbasin discharging into Lake Bonney and Lake Debra Jane, the evaluation was made in two parts. First, the resultant lake stages for the forested and existing conditions were compared with estimated changes in stage due to future full build-out (Figures 18a and 18b). Figure 18a shows that there is no appreciable change in stage at the 10-year event on Lake Bonney (less than 0.1 feet). Figure 19 shows a change in stage of 0.5 feet for the 10-year event on Lake Debra Jane. The amount of impervious surface that results in no significant change in lake stages can be used as the target for future development and the retrofitting target for the watershed. This potentially modified flow control standard in the upper subbasin was tested to determine the impacts on the stream metrics at the point of evaluation in the lower watershed streams.

The results show (Figure 18a) there are minimal expected changes to Lake Bonney stages due to potential development. For example, a reduction of impervious surface from 21 percent to 10 percent in the Lake Bonney subbasin would result in only a 0.07-foot reduction in stage for the 100-year event. One outcome of this finding could be that flow controls could be reduced and retrofitting would not be recommended for flow control. For Lake Debra Jane, the changes are still small (0.21 feet in the 100-year event) but may result in some impact. Therefore, flow control may still be needed for redevelopment but the upper subbasin would be a lower priority for planned or opportunistic retrofitting.

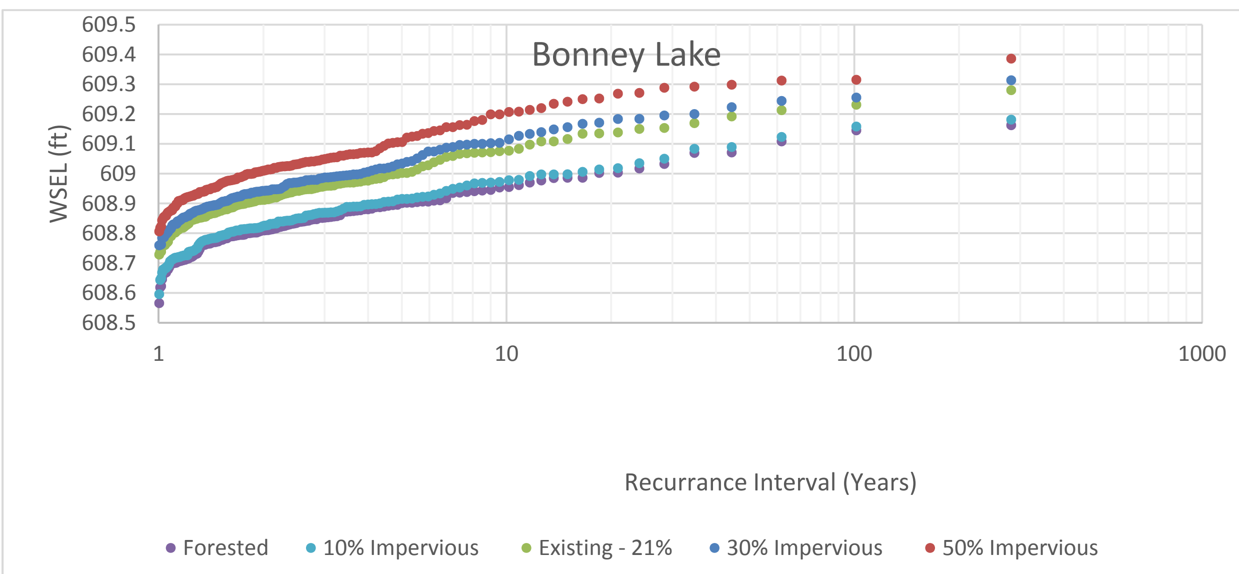


Figure 18a. Stage Change for Different Subbasin Impervious Area Scenarios on Lake Bonney

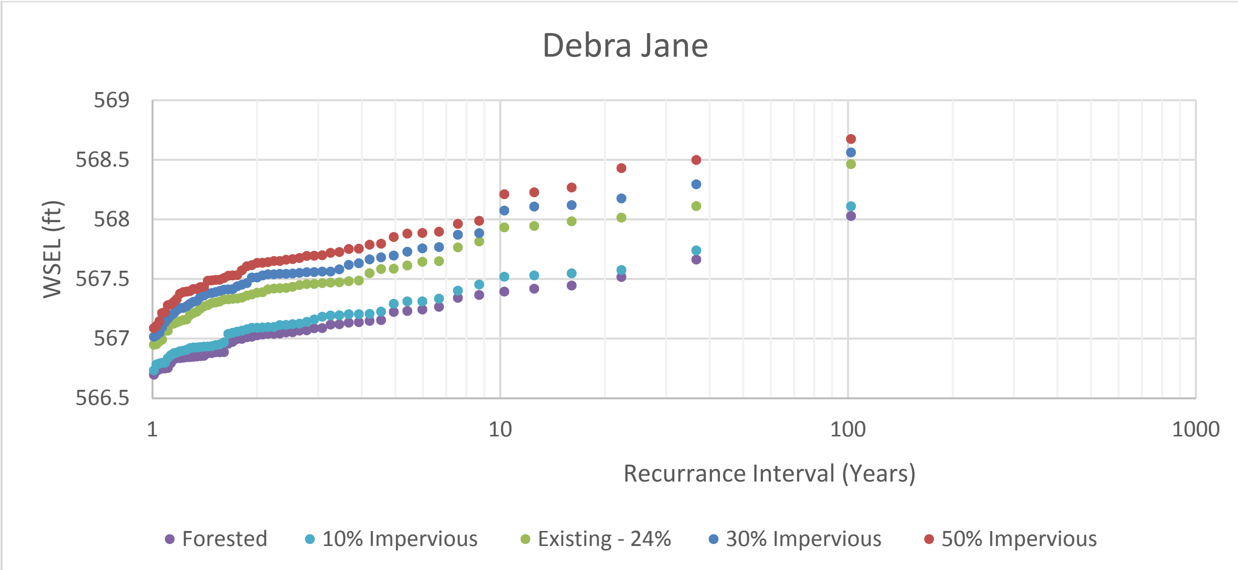


Figure 18b. Stage Change for Different Subbasin Impervious Area Scenarios on Lake Debra Jane

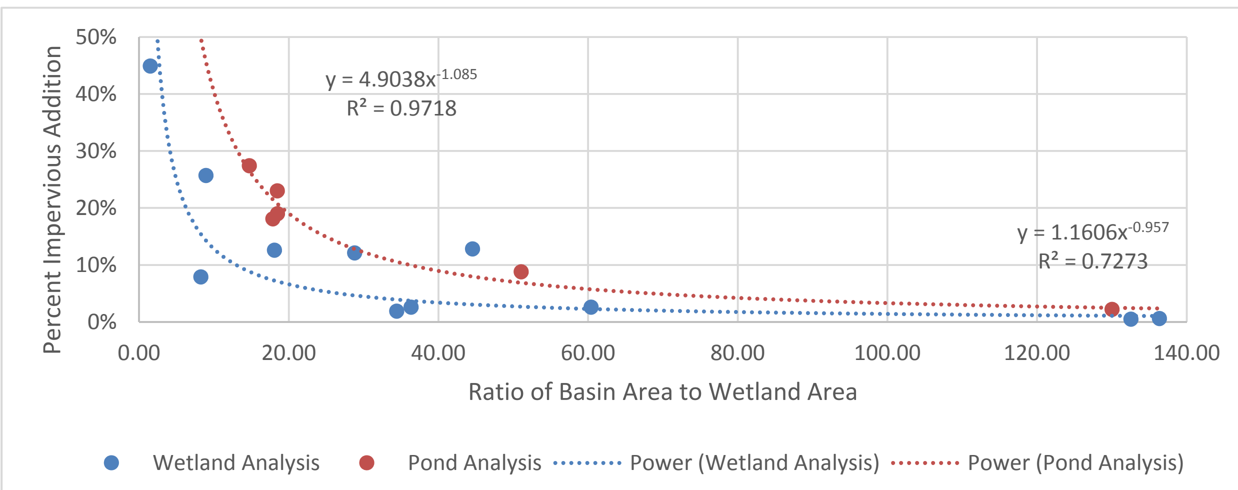


Figure 19. Allowable Additional Impervious Area for Wetland and Closed to Natural Pond Subbasin

4.4.2.6 Closed System Wetlands and Ponds

Several subbasins in the Fennel Creek watershed have no natural surface outlet (Figure 11 on page 43). Stormwater runoff drains to wetlands or small open water areas or ponds in the subbasin and can only leave via evaporation, transpiration, or infiltration into the shallow groundwater. There are no straightforward hydrologic metrics for closed systems with temporary or permanent water. Expected changes in runoff volume and wetland stages were evaluated. Wetland hydroperiods or peak stage and duration of water in ponds can be evaluated. The amount of impervious surface that results in no significant change in stage can be used as the target for future development and the retrofitting target for the subbasin.

According to the Pierce County Stormwater Manual, the mean annual water level fluctuation for wetlands should not exceed 5 centimeters to minimize impacts on vegetation. An analysis was made to compare the size of the drainage subbasin to the size of the wetland and the allowable increase in impervious area to achieve the allowable water level rise of no more than 5 centimeters. This is shown in Figure 19.

The amount of additional impervious area depends on the size of the subbasin and wetland. The closer the ratio is to 1, the more impervious surface can be added without negatively impacting the wetland. For example, using Figure 19, if the ratio of the drainage subbasin to wetland is 20 to 1, the increase in impervious area allowed is about 6 percent (of the existing total).

To calculate this additional impervious area use Equation 1:

$$\boldsymbol{Percent\ of\ Additional\ Impervious = 1.1606 * Basin{:}Wetland\ Ratio^{\,-0.957}}$$

Closed subbasin in which flows discharge to surface ponds were modeled similarly to wetlands, except the water fluctuation level was 6 inches. The corresponding curve can be seen in Figure 19 as well with its impervious calculation shown as Equation 2:

$$\boldsymbol{Percent\ of\ Additional\ Impervious = 4.9038 * Basin{:}Wetland\ Ratio^{\,-1.085}}$$

4.4.2.7 Closed Systems Discharging to Ground

Several subbasins in the Fennel Creek watershed discharge to the ground either naturally or via a constructed infiltration facility (see Figure 10 on page 47). For natural systems, the infiltration occurs throughout the subbasins, and some runoff generated by developed and undeveloped areas can ultimately flow to the lowest area in the subbasin. These low areas are often privately owned land. The available infiltration capacity of these areas was not determined because a significant amount of site-specific data would be required to do so, notably seasonal high groundwater levels and infiltration rates. However, the lack of apparent establishment of natural ponds or wetlands in the subbasins indicates that water tables are seasonally below the surface and that infiltration capacity is at least as high as existing subbasin runoff. Consequently, the recommended future runoff standards should be maintenance of existing runoff rates.

Retrofitting new development or redevelopment to historic forested condition is not expected to provide a meaningful benefit, unless downslope flooding has been identified. However, no capital projects that indicate closed subbasin flooding were identified (see Section 5). No proactive retrofitting in these subbasins is recommended because there is little expected benefit to surface water resources.

Water quality treatment before discharge is not expected to provide additional benefits not provided by the natural infiltration areas, provided Ecology's soil suitability criteria for existing soils are met, but source controls are still recommended.

For constructed infiltration systems, the design assumptions for impervious area and subbasin served will be maintained or reevaluated for a new development proposal in those subbasins. The applicant must demonstrate that the runoff conditions assumed are still met. The City may elect to require infiltration to the extent practicable for these sites to improve the reliability of the built infiltration system. Water quality treatment should be applied to extend the life of the infiltration systems. No proactive retrofitting is proposed in these subbasins.

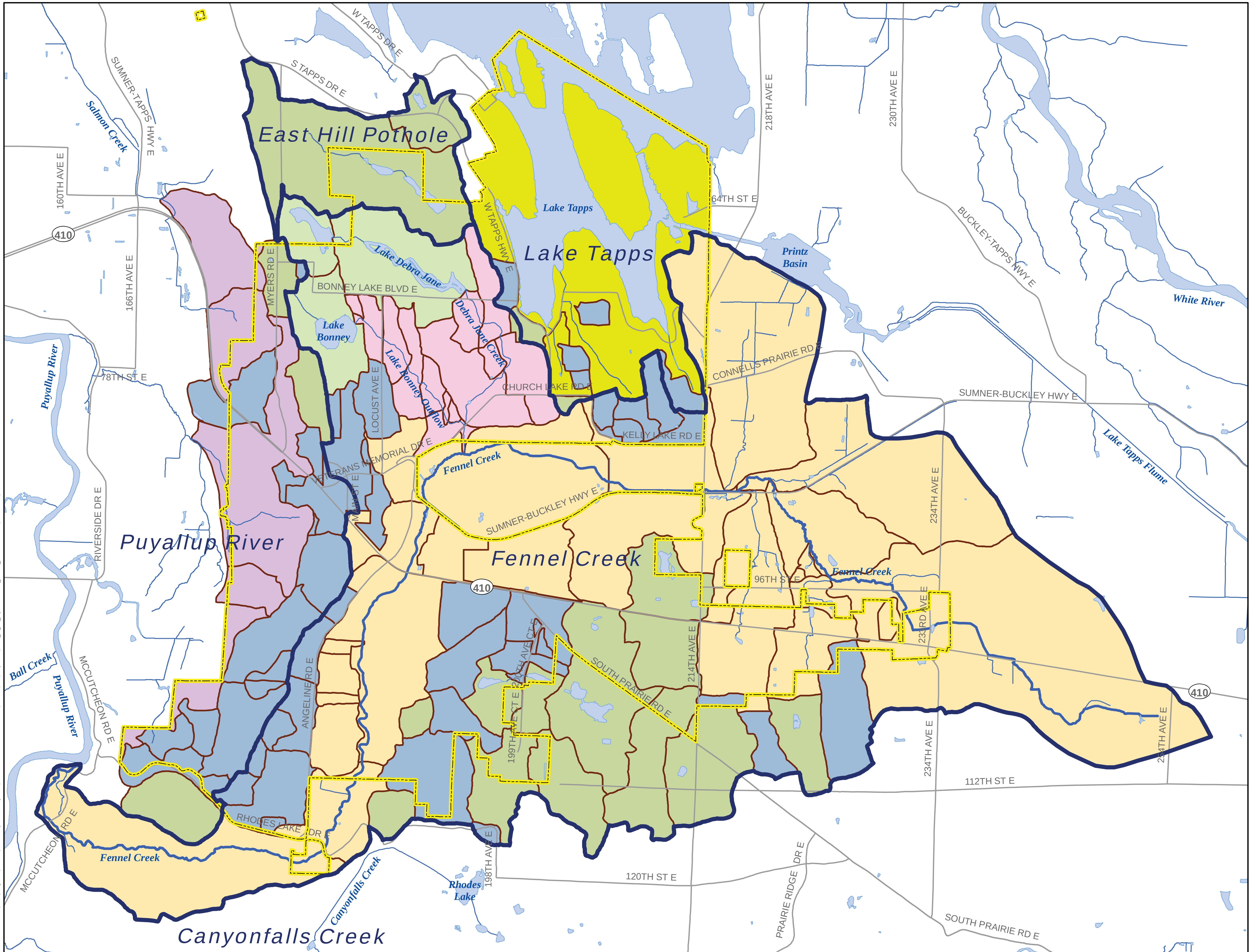
4.5 Stormwater Control Metrics by Subbasin Type

The previous section describes metrics that can be used to establish standards that can be applied to new development, redevelopment, and retrofitting planning by the type of subbasin being affected. The hydrologic impacts and potential for degradation varies by subbasin type and the measures already taken to control stormwater. The metrics to be used for the subbasin types are shown in Table 9. The subbasins corresponding to those types are shown in Figure 20. Establishing targets for each subbasin type are described below.

Table 9. Hydrologic Metric that can be Applied to the Subbasin

Metric (Subbasin Type)	BIBI Scores	Flow-Frequency Curve Fit	Pulse Counts	Pulse Duration	Flashiness	Hydro-periods and Stages	Direct Discharge – Water Quality Only	Existing Flows Maintained
Fennel Creek	x	x	x	x	x			
Upper Lakes Subbasins						x	x	
Lower Lakes Tributaries		x	x	x	x			
Closed Subbasins to Groundwater								x
Closed Subbasins to Ponds or Wetlands						x	x	x
Discharge to Puyallup Tributaries								x
Discharge to Lake Tapps							x	

FIGURE 20
SUBBASIN IDENTIFIERS FOR HYDROLOGIC METRICS TO BE USED



- Fennel Creek Subbasin
- Upper Lakes Subbasin
- Lower Lakes Tributary
- Closed Subbasin to Groundwater
- Closed Subbasin to Pond or Wetland
- Discharge to Puyallup Tributary
- Discharge to Lake Tapps
- Watershed Boundary
- Surface Water
- Fennel Creek
- Other Stream
- State Highway or Major Road

Miles
0 0.5 1

Source: City of Bonney Lake, Pierce County

BONNEY LAKE Watershed Plan

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As discussed earlier, the planning objective for all of the subbasins in the study area is to preserve existing water resource characteristics and to make improvements to existing conditions. The focus of the proposed planning will be on the hydrology metrics for subbasin-specific standards and evaluating protection or improvement measures. Stormwater quality is also important, and it is assumed that specific controls and measures for flow controls taken to protect waters from new development or redevelopment will also include water quality measures, when applicable. Some subbasins will include specific measures for water quality only, such as the Lake Tapps subbasin.

Presumably, the ideal hydrologic conditions in these stream watersheds are when the entire subbasin is forested (or in its historic natural condition) or is controlled to a 100 percent forested hydrology. The 100 percent forested hydrology is used to demonstrate the optimal outcome for comparisons to the range of possible outcomes. Land clearing, road building, and development, with or without stormwater controls, have changed the baseline forested condition hydrology. While a goal might be to return to fully forested hydrologic conditions, this is likely not attainable due to the very high cost of retrofitting existing sites and the practical consideration that any number of applied controls and techniques will not fully mitigate the human footprint on the landscape.

The other end of the range of hydrologic condition is the existing development condition or the fully developed watershed. The existing condition, with a combination of stormwater controlled development and development that was constructed before controls were required, results in a set of hydrologic conditions that can be evaluated using the metrics discussed above. A fully developed watershed means additional hydrologic modifications are possible. However, the current stormwater control requirements specifically address hydrologic modification and set the target as fully forested hydrology; therefore, a reasonable assumption is that the baseline hydrologic condition will be sustained for new development. Consequently, basin planning targets would 1) focus on confirming that the new development controls are well-applied and maintained, and 2) describe the opportunity to retrofit existing development. Because resources to reduce existing uncontrolled stormwater flows are very limited (when compared to the overall cost) and the cost to retrofit redeveloping property (which is an important and more sustainable growth management strategy) can be prohibitive and discourage redevelopment, careful consideration of the benefit of retrofitting is critical to basin planning.

The basin planning effort focuses on maintaining existing hydrologic conditions and finding likely improvements that are expected to beneficially move the hydrologic metrics. For example, as described above, there is a relationship between impervious area and BIBI, pulse counts, pulse durations, etc. Reductions to impervious surfaces should move these numbers, but the sensitivity of these numbers to watershed changes is not always a linear relationship. Section 4.4.2 described the sensitivity of these parameters to the level of impervious surface. The point of inflection on where the change and benefit relationships increase or decrease (depending on metric) was evaluated in Section 4.4.2.4, and is used to determine the amount of change that is reasonably possible and that would result in a measured improvement in the metric. Impervious surface was the “currency” used to evaluate the improvement scenarios.

4.5.1.1 Subbasin-Type Analysis and Results for Proposed Standards

The analysis described above was performed on the subbasins in the study area to determine if subbasin-specific standards were appropriate under the conditions described. A baseline assumption is that any new development that applies the 2015 Pierce County Stormwater Manual, which has been adopted by the City of Bonney Lake for stormwater control, will maintain or improve existing conditions and will add no effective impervious area to the subbasin. In addition, it is assumed that if full redevelopment retrofitting is applied when needed, it will reduce effective impervious area in those areas.

There are three primary considerations in each subbasin when considering proposed stormwater control standards: 1) the flow control standard required; 2) the pre-development assumption to use; and 3) direct discharge allowance, which means only water quality is required. For each of the subbasin types in Bonney Lake, these three items were considered. In addition, if there is an existing stormwater control facility in operation, the design modifications, if any, would be evaluated. Table 10 presents the results and proposed subbasin-specific standards. The remaining proactive retrofitting needed to achieve impervious area targets are described in Section 4.6.

Table 10. Summary of Stormwater Flow Control Standards by Area

Location Type	New Development	Existing Condition Assumption for New Development	Existing Condition Assumption for Redevelopment	Development in an Existing or Proposed Facility Basin[1]	Flow Control or Water Quality Required
Fennel Creek	Full Flow Control according to the 2015 Pierce County Stormwater Manual	Forest	Forest	Existing conditions or same target as set when the facility was planned	Flow Control and Water Quality
Fennel Creek tributaries below lakes	Full Flow Control according to the 2015 Pierce County Stormwater Manual	Forest	Forest	Existing conditions or same target as set when the facility was planned	Flow Control and Water Quality
Upper Lake subbasins	Discharge to lakes use direct discharge	Existing	Existing	Existing conditions or same target as set when the facility was planned	Flow Control and Water Quality
Closed subbasins discharging to the ground	Controls to match existing conditions	Existing	Existing	n/a	Flow Control to Extent Practicable
Closed subbasins discharging to wetlands, lakes, and ponds	Controls to limit discharges to allowable increases	Existing	Existing	Existing conditions or same target as set when the facility was planned	Flow Control and Water Quality
Other Puyallup River tributaries	Bonney Lake Stormwater Manual	Forest	Forest	Existing conditions or same target as set when the facility was planned	Flow Control and Water Quality
Discharge to Lake Tapps	Direct discharge	n/a	n/a	n/a	Water Quality

[1]This category refers to a proposed project that is included in the drainage area of an existing regional or subbasin stormwater facility, as indicated on Figure 10. A "proposed facility subbasin" refers to the Eastown facility subbasin or Lake Tapps retrofit facilities.

4.6 Redevelopment and Retrofitting Approaches and Priorities

Stormwater manuals provide standards and approaches to address and manage stormwater runoff from new development. In addition, the manuals include requirements for considering redevelopment as if it were new development, effectively retrofitting old developed areas to meet current stormwater standards. However, existing residential development, commercial land uses, and roadways have few requirements or obligations to add stormwater management to areas that were built before current standards were in place. An approach to addressing stormwater management for existing development was developed that estimates the potential retrofit that can be provided by redevelopment and the remaining amount of proactive retrofitting needed to meet targets established in this analysis. The approach is generally focused on Fennel Creek and its two lake outlet tributaries (Lake Bonney and Lake Debra Jane) due to its prominence in the City of Bonney Lake as the largest surface water system. Other subbasins in the Fennel Creek watershed would benefit from water quality retrofitting; however, as described in Section 4.4.2, additional reduction of flow control discharges would have little meaningful benefit to the other subbasins or discharge locations. One exception is the Puyallup River tributaries, although these subbasins have very little existing development that is untreated. Guidance in existing stormwater management manuals would assist in effectively protecting these resources.

Section 4.3 describes the metrics for evaluating stream hydrology and hydrologic targets for healthy streams. The metrics also demonstrate the potential for improved metrics due to changes in impervious surfaces. For example, Figure 17 shows that the benefit curves for several of the hydrologic metrics shifts at about 7 percent impervious area, which can indicate a useful target for redevelopment and proactive retrofitting. In addition, Section 4.4.2.2 shows that applying the 10-15-75 standard is similar to the forested results for the flow-frequency curves (Figure 14a, 14b, and 14c) and has been used in past adopted basin plans or development policies (King County 1997). Figure 13 depicts data from the region that shows Fennel Creek is performing for the BIBI score better than would be indicated by the level of imperviousness found in the watershed; therefore, more extensive retrofitting is not proposed.

Using this information and Table 10, the Plan evaluates how much impervious surface needs to be retrofitted to move the needle on stream metrics and if the potential exists for improvements under reasonable circumstances.

When redevelopment occurs, the projects are required to upgrade stormwater controls to current standards. While this is an effective approach to seize the opportunity to make improvements, it cannot be expected to improve stream health alone because it can take decades of redevelopment to achieve even modest gains. However, it is reasonable to consider the benefit of retrofitting through redevelopment. As shown in Table 11, about 1.3 percent of the impervious area in the Fennel Creek watershed can be expected to be retrofitted by redevelopment using the assumptions applied. This leaves about 13.9 percent of impervious area in the watershed.

The Lake Tapps subbasin is a direct discharge subbasin; therefore, flow control retrofitting is not proposed. However, the capital projects plan includes retrofitting projects for stormwater quality improvements. There are no water quality targets; therefore, water quality improvements other than the proposed capital projects would be provided during redevelopment.

Table 11. Fennel Creek Watershed Retrofitting Potential

	Undevelopable	Vacant	Residential	Commercial and Institutional	Industrial	Roads	Other	Total
Impervious area can change	no	no	yes	yes	yes	yes		
Total area (acres)	959.8	258.8	751.1	24.2	54.6	469.2	2,202.5	4,720.2
Impervious area (acre)	26.2	0	137	4.5	0	469.2	93.3	730.2
Percent impervious area	3%	0	18%	19%	0%	100%	4%	15.2%
Source of change			redevelopment	redevelopment	redevelopment	opportunity for retrofitting		
Percent change assumption			10	50	50	10		
Area changed (acres)			13.7	2.25	0	46.92		62.87
Future impervious percent			16%	9%	0%	90%		13.8%

4.7 Retrofitting Planning for the Fennel Creek Watershed

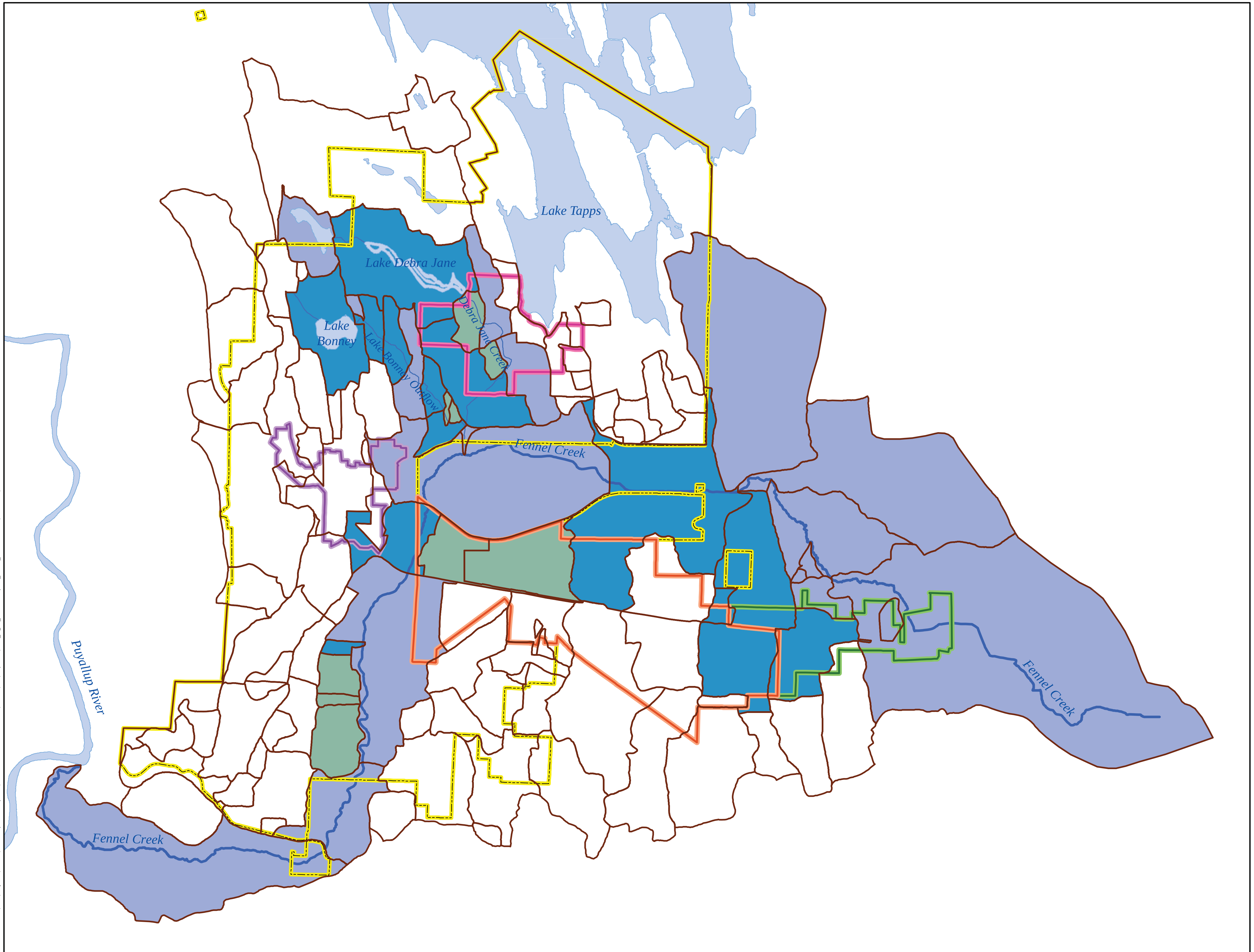
As described above, the projections for retrofitting through redevelopment are expected to reduce impervious surfaces by about 1.3 percent. To achieve the target goal of reduction to 7 percent impervious area in the Fennel Creek basin, additional impervious surface would require proactive retrofitting.

Figure 21 shows the highest percentages of impervious surfaces for developed sites and roads. Using this analysis, the order of retrofitting priority or regional facility siting by need is shown in Table 12. Using the analysis in Table 12, generally all of the non-roadway impervious areas would require retrofitting to achieve the 7 percent impervious goal. This would require large areas of existing Bonney Lake development (about 261 acres) to be retrofitted. Figure 21 and Table 12 can be used to plan proactive retrofitting in the Fennel Creek watershed, notably the Lake Bonney and Lake Debra Jane tributaries. The subbasins not included were either already treated, closed subbasins, planned for regional facilities, in upper lakes subbasins, or less than 7 percent impervious today. A preliminary review of the remaining subbasins found little vacant land that could be used for regional stormwater facility retrofitting (see Figure 12). Using cost estimates from the City of Kirkland Juanita basin (King County 2012), an order of magnitude estimate to retrofit 100 acres of Fennel Creek basin could cost over $32 million. These retrofit priority data can be used to inform an opportunistic retrofitting program, where subbasin retrofitting can be added to future proposed construction projects such as road improvement and open space facilities. The Fennel Creek tributaries are the recommended highest priority retrofitting basins, flowed by the highest impervious basins shown in Table 12.

If the roadways could be retrofitted, this would address the single largest area of effective impervious surface in Bonney Lake. It could still be costly but would also put the City in a better position for success because the Plan can be prioritized, partners can be found (e.g., WSDOT), existing public lands and rights-of-way could be used, and coordination with other infrastructure improvements in roadway corridors is possible. To assess potential for roadway retrofitting in the most impervious subbasins, as shown on Table 12, the right-of-way width, road widths, and street slopes can be evaluated. Right-of-way over 60 feet in width, with 25 feet or less roadway at a slope of less than 5 percent, would be considered reasonably viable. Using these criteria, low percentages of roadway are available for retrofit. Road segment-specific analyses would be needed to fully evaluate retrofit opportunity and feasibility.

The remaining subbasins in the Fennel Creek watershed are not proposed for retrofitting except as described, required by the stormwater manual during redevelopment, or when opportunities arise during roadway improvement projects.

FIGURE 21
PERCENT IMPERVIOUS FROM ROADS BY DRAINAGE BASIN



Paved Road % Impervious (Not Closed or Wetland)

- <= 5%
- > 5%, <= 10%
- > 10%, <= 20%
- > 20%, <= 30%
- > 30%, <= 40%
- > 40%, <= 50%
- > 50%, <= 60%
- Downtown Region
- Lake Tapps Region
- Midtown Region
- Eastown Subarea
- Bonney Lake City Limit
- Fennel Creek
- Other Stream
- Surface Water

Miles
0 0.5 1

Source: City of Bonney Lake, Pierce County

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Table 12. Highest Percentages of Impervious Areas in the Fennel Creek Watershed

Rank	Subbasin	Impervious Percentage due to Roads	Impervious Percentage due to Urban Development	Impervious Percentage due to Combined Roadways and Development
1	DJ_06	10.4	24.9	35.3
2	DJ_07	5.7	23.5	29.2
3	LB_07	5.9	23.0	28.9
4	DJ_02	7.8	21.0	28.9
5	LB_06	4.7	23.6	28.3
6	LB_02	5.9	20.2	26.1
7	FC_17b	4.2	21.5	25.7
8	FC_04	9.5	15.5	24.9
9	LB_10	5.1	19.7	24.8
10	LB_08	6.5	17.9	24.4
11	LB_05	6.0	18.1	24.1
12	DJ_05	3.1	20.5	23.7
13	FC_13	6.5	17.1	23.6
14	FC_06	6.5	13.4	19.9
15	DJ_08	4.2	14.3	18.5

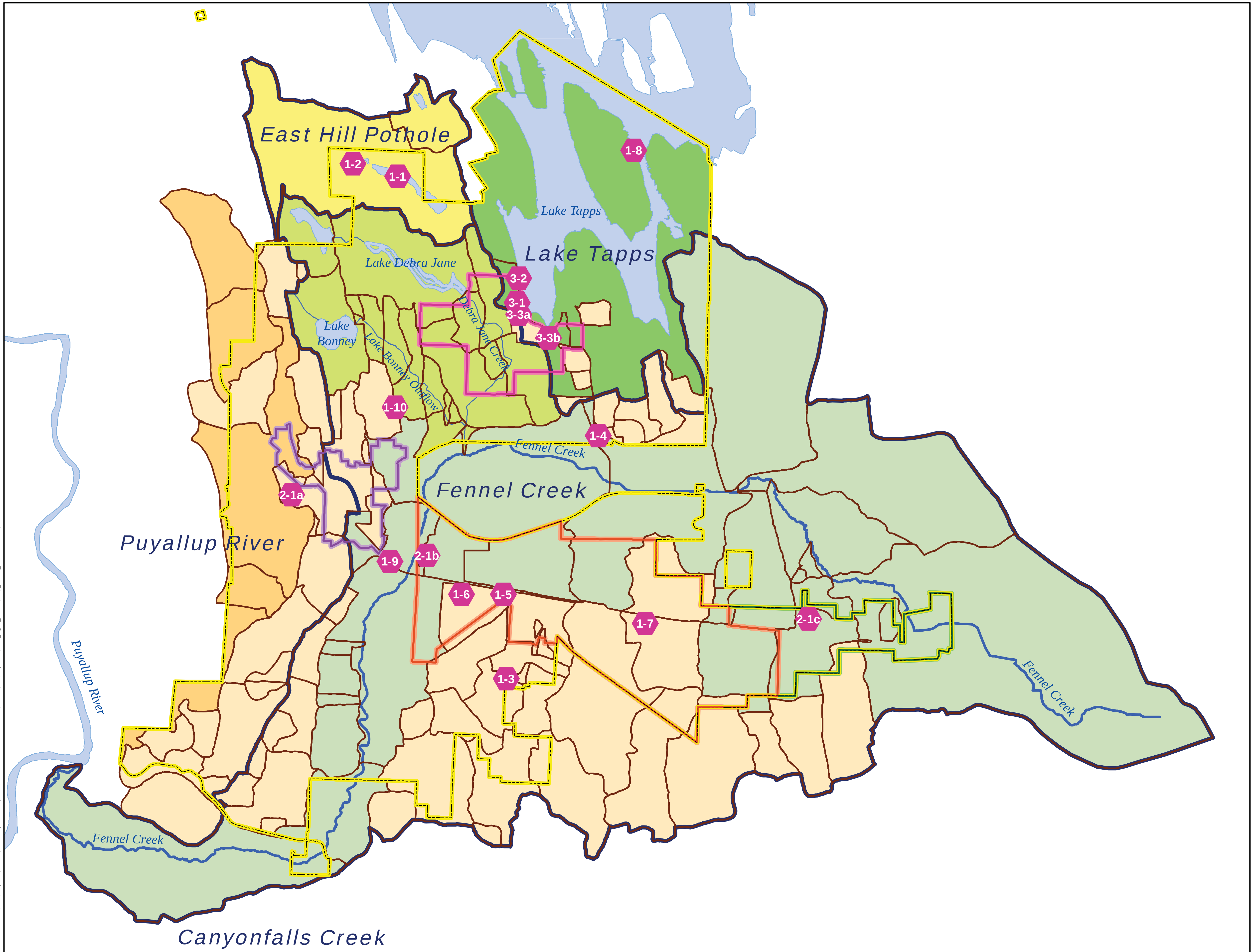
5. CAPITAL PROJECTS PLAN

Capital projects are identified in basin plans to describe, estimate, and provide a basis for design of proposed constructed facilities to address the stormwater needs identified in the basin plans. Most stormwater capital project plans include:

- Solutions for chronic, known flooding, and drainage problems
- Regional or neighborhood stormwater management facilities to support existing and future development
- Stormwater retrofit projects to retroactively address stormwater impacts from existing development
- Habitat or stream restoration
- Capital acquisition, such as land or equipment
- Studies to address potential needs, such as floodplain modeling

Twenty capital projects have been developed for the Plan, covering several of the typical categories listed above (Figure 22). A brief description of the problem and proposed solution for each project is shown in Table 13, Table 14, Table 15, and Table 16. Project plan sheets showing the preliminary design approach and planning-level costs are provided in Appendix H. Implementation plans for prioritizing and scheduling the capital projects plan are described in Section 6.

FIGURE 22
CAPITAL IMPROVEMENT PROJECTS KEYMAP



Standards to Apply

- Fennel Creek: Stormwater Manual
- Upper Fennel Creek: Special, Stormwater Manual
- Closed Basin
- Lake Tapps: Direct Discharge
- Puyallup River: Stormwater Manual
- East Hill Pothole: Special
- Downtown Region
- Lake Tapps Region
- Midtown Region
- Eastown Subarea
- Bonney Lake City Limit
- Drainage Subbasin Boundary
- Watershed Boundary
- Fennel Creek
- Other Stream
- Surface Water
- Capital Project

Source: City of Bonney Lake, Pierce County

BONNEY LAKE Watershed Plan

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Table 13. Bonney Lake Capital Improvement Projects (CIP) Area Summary

Project No. and Title		Estimated Cost	Problem Description	Proposed Solution	Location
1-1	East Hill Pothole	$3,514,980	Site consists of a series of small surface water ponds and wetland areas with 100-year floodplains that includes portions of roadways. During sustained rainfall events, these potholes fill with water and flood roadway and yards.	Installing a pressure main and pump to convey high water events to an outfall on Lake Tapps.	City Limits
1-2	Whipple Pothole	See CIP 1-1	See CIP 1-1	See CIP 1-1	City Limits
1-3	200th Avenue Court E and 102nd Street E	$97,440	The City determined that a culvert crossing beneath 200th Avenue Court is covered on the east side and is a flowing half pipe on the west side. An infiltration pond located north of 104th Street E and west of 200th Avenue Court E appears to not be functioning, thereby backing up water into the wetland area west of 200th Avenue Court E.	Reconstruct the stormwater conveyance system beneath 200th Avenue Court with revised invert elevations to drain water from east to west. Redesign emergency outfall from HOA infiltration pond.	City Limits
1-4	Kelley Lake Road E and 214th Avenue E	$67,200	Reports state that culvert crossing at Kelly Lake Road is undersized in capacity and unable to meet stormwater requirements, resulting in overtopping of Kelly Lake Road.	Technically conservative approach proposes replacement of culvert with revised inverts and excavation at inlet to increase head pressure at culvert inlet. Analysis of capacity of culverts at two driveways downstream required.	City Limits
1-5	The Market at Lake Tapps – SR 410	$105,700	Swales on south side of SR 410 are subject to severe erosion.	Propose grading channel. Quarry spalls placed at inlets and outlets of culverts and ditch lined with compost blanket, seeded, and fertilized.	Midtown
1-6	The Market at Lake Tapps – Walmart	$19,880	Reports indicate that the Walmart parking lot is discharging impervious pavement flow onto and down 192nd Avenue to the north.	Propose the addition of a catch basin to an existing storm system draining to a pond located immediately south of the Walmart building.	Midtown
1-7	Fred Meyer at Tall Firs	$73,080	Broken curb at Fred Meyer parking lot leading stormwater runoff to SR 410 roadside ditch. Scour occurring downstream of 211th Avenue culvert.	Repair broken curb at Fred Meyer lot. Regrade channel upstream of 211th Avenue.	Midtown
1-8	Inlet Island – Lake Tapps	$254,475	Stormwater conveyance system is surcharging near outfalls to Lake Tapps in two locations.	Propose storm sewer plugging and new storm sewer pipe conveyance south along N Island Drive E to proposed ditch along Cascade Drive E with outfall into Lake Tapps.	City Limits
1-9	Simmer Property	$92,960	Drainage from SR 410 is causing erosion in an open ditch running between the property and the SR 410 bridge abutment.	Propose replacing open channel with closed conveyance on the north side of Angeline Road E and a new culvert on the southeast side of Angeline Road E to convey drainage beneath the gravel road adjacent to the treatment facility.	Midtown
1-10	Locust Avenue and 82nd Street E	$3,735,480,	Pothole located at the northeast corner of Locust Avenue and 82nd Street E fills with water during sustained storm events and floods 82nd Street.	Propose City purchase of Parcel 5640000200, and modification of existing pond, and raise the roadway surface of 82nd Street E to increase the available storage capacity. Finally, cost of pump system and stormwater pipe required to convey excess pond water east along 82nd Street E to a stream connected to the Lake Bonney outflow. Downstream analysis would be necessary to determine the impacts of this diversion.	City Limits
	Total Cost	**$7,961,195**			

Table 14. CIP Area Summary—Regional Ponds

Project No.	and Title	Estimated Cost	Problem Description	Proposed Solution	Location
2-1a	Downtown Regional Storm Pond	N/A	In the time since the Downtown Regional Stormwater Pond was designed, changes have been made to zoning and allowed impervious area. This analysis determined that the target land cover for the Downtown facility changed from 66.6 acres of impervious to 81.3 acres, and from 27.1 acres of pervious to 22.0 acres. Additionally, full build-out percent impervious surface requirements have changed from 0.6 to 0.8 for downtown commercial zoning, and 0.90 to 0.75 for public facility zoning.	Potential changes in stormwater facility size and performance may be needed in this infiltration facility. However, the facility provides stormwater management needed, as described under the parameters of this plan. Additional evaluation of the sizing or proposed future land development should be made if additional changes are considered.	Downtown
2-1b	Midtown Regional Pond	N/A	The Midtown Regional Stormwater Facility is a detention pond designed to provide flow control and water quality for 49.2 acres of area. It was determined that in full build-out of current zoning rules, the amount of impervious surface tributary to the facility increases from 31.9 acres to 45.4 acres in comparison to design parameters used in the original pond design. In addition, total pervious area tributary to the pond decreased from 17.3 acres to 4.3 acres.	Potential changes in stormwater facility size and performance may be needed in this detention facility. A retrofit of the outfall structure orifice size from 5.35” to 5.45” will reduce the future discharge to below the target discharge. Additional evaluation of the sizing or proposed future land development should be made if additional changes are considered.	Midtown
2-1c	Eastown Regional Pond	$2,080,540	A large regional facility is needed to treat development within the Eastown region of the city.	The Eastown Regional Pond is a proposed stormwater facility designed to detain stormwater runoff from 91.6 acres of area located within the Eastown boundary.	Eastown
	Total Cost	**$2,080,540**			

Table 15. CIP Area Summary – Subbasin Retrofits

Project No. and Title		Estimated Cost	Problem Description	Proposed Solution	Location
3-1	Allan York Park Subbasin Retrofit	$442,820	The Allan York Park Subbasin Retrofit consists of a proposed stormwater facility designed to treat stormwater runoff from pollution-generating surfaces.	Propose to install Filterra stormwater treatment systems to treat the 2.88 acres of tributary area.	Lake Tapps
3-2	Lake Tapps Waterfront Subbasin Retrofit	$145,040	The Lake Tapps Waterfront Subbasin Retrofit consists of a proposed stormwater facility designed to treat stormwater runoff from pollution-generating surfaces.	Proposed stormwater swale designed to treat stormwater runoff from West Lake Tapps Highway and possible development adjacent to the roadway.	Lake Tapps
3-3a	Lake Tapps Park/West Tapps Highway East Subbasin Retrofit, Option A	$1,434,860	The Lake Tapps Park/West Tapps Highway East Subbasin Retrofit consists of a proposed stormwater facility designed to treat stormwater runoff from pollution-generating surfaces.	Proposed Stormwater Detention Ponds with outfalls to Lake Tapps.	Lake Tapps
3-3b	Lake Tapps Park/West Tapps Highway East Subbasin Retrofit, Option B	$1,212,400	The Lake Tapps Park/West Tapps Highway East Subbasin Retrofit consists of a proposed stormwater facility designed to treat stormwater runoff from pollution-generating surfaces.	Proposed Stormwater Detention Pond with outfall to Lake Tapps.	Lake Tapps
4-1	Water Quality Swale Retrofit Program	$319,200 per mile; one mile per year	Roadways are the single largest source of impervious surface and pollution-generating surfaces. Most available public land is in road rights-of-way.	A swale retrofit program is proposed as a measure to provide water quality improvements to stormwater discharge from city roadways.	Citywide
	Total Cost	**$3,554,320**			

Table 16. CIP Area Summary – Non-Construction Capital Elements

Project No.	and Title	Estimated Cost	Problem Description	Proposed Solution	Location
5-1	Fennel Creek Stream Gauge	$23,690	Lack of flow data on Fennel Creek.	An automated stream gauge is proposed to provide long-term flow data collection for the upper reach of Fennel Creek.	Lower reaches of Fennel Creek
6-1	Fennel Creek Floodplain Study	$290,000	Lack of floodplain study in the upper reaches of the Fennel Creek watershed.	A Floodplain Study to be conducted on the Upper Fennel Creek watershed to determine the floodplain limits to aid in the application of appropriate floodplain management practices.	Upper subbasin of Fennel Creek, from upstream of Kelley Lake Road to 230th Avenue.
	Total Cost	**$313,690**			

Preliminary designs and cost estimates were performed on selected areas with known flooding and drainage problems. The performance of existing regional stormwater facilities was evaluated. Also, concept design and cost estimation was performed on a new Eastown regional facility, as well as several subbasin retrofit facilities. Non-construction capital elements include a stream gauge and floodplain study of the upper subbasin of Fennel Creek. Together, these elements are defined as Capital Improvement Projects (CIPs).

A meeting between Parametrix and the City of Bonney Lake on March 31, 2016, revealed a list of known problem areas. The projects vary in location within the city limits, which include Downtown, Midtown, and Lake Tapps Centers, and the Eastown subarea. A total of 10 drainage problem areas were identified. Each improvement area was visited in the field on August 10, 2017, to collect data to aid in determining appropriate solutions. Preliminary solutions were determined using information gathered in the field and in discussions with the City, as well as problem call logs, maintenance notes, and schematic design drawings supplied to Parametrix by the City.

Table 13 summarizes the drainage problem area CIPs. The total project costs are based on the conceptual plan layouts shown in Appendix H, associated quantities, mobilization costs equal to approximately 15 percent of subtotal, traffic control costs equal to a minimum of 2 percent of the subtotal, and erosion and sedimentation control equal to a minimum of 2 percent of the subtotal. In addition, environmental permitting and documentation, administration, and design and management costs have been taken into account. Lastly, a contingency factor of 30 percent has been added to the final cost.

Table 14 summarizes the regional facilities. The Downtown and Midtown Regional Facilities were analyzed for changes in future land use conditions. This analysis determined that the target land cover for the Downtown facility changed from 66.6 acres of impervious to 81.3 acres, and from 27.1 acres of pervious to 22.0 acres. Potential changes in stormwater facility size and performance may be needed in this infiltration facility. However, the facility provides stormwater management needed, as described under the parameters of this plan. Additional evaluation of the sizing or proposed future land development should be made if additional changes are considered.

The Midtown facility target land use conditions have changed from 31.9 acres of impervious surface to 45.4 acres, and 17.3 acres of pervious surface to 4.3 acres. Potential changes in stormwater facility size and performance may be needed in this detention facility. However, the facility provides stormwater management needed, as described under the parameters of this plan. Design standards of the era of original design require maintaining developed discharge flow rates below the 10-year and 100-year flows in existing conditions, as well as ½ of the 2-year event. The full-build out future discharge flow rate (13.8 cfs) exceeds the target condition flowrate (13.7 cfs) in the 100-year event. A retrofit of the outfall structure orifice size from 5.35" to 5.45" will reduce the future discharge to below the target discharge. Additional evaluation of the sizing or proposed future land development should be made if additional changes are considered.

The Eastown facility has been proposed to control stormwater runoff from 91.6 acres of area located within the Eastown subarea.

A programmatic capital element includes roadway retrofit. The annual budget for roadway retrofit totals $319,200 per year, for an estimated 5,000 linear feet of roadway per year of retrofit. Table 15 summarizes these retrofit projects.

In addition, there are non-construction capital projects and studies totaling $313,690. Table 16 summarizes the proposed Fennel Creek stream gauge and floodplain study.

6. IMPLEMENTATION

The previous sections provided a description of the Plan project goals, background conditions, analyses, and findings. This section provides a summary of recommendations and approaches to implement the Plan. The program elements include recommended stormwater control standards; coordinated land use and stormwater planning, including the Town Centers; retrofitting strategies; regional stormwater facilities; and capital projects.

During the course of this analysis, additional data needs that could not be addressed in the time frame of the Plan or were in other ways not ready for inclusion were identified. These are shown in Section 6.5. The implementation items described are then summarized in general order of recommended adoption or implementation order in Section 6.6.

6.1 Stormwater Control Standards and Policies

The basin planning analysis described in Section 4 identified stormwater control approaches that could be applied in the City to achieve the desired protections and improvements (Table 17). The overall objective of the Plan is to protect the existing water resources health of the watershed, notably in Fennel Creek, and to make opportunistic improvements when possible.

Table 17. Stormwater Control Implementation Items

Section No.	Action	What it is	Benefit	Effort and Cost	Timeline Priority
6.1.1	Adopt basin plan	Adopt the basin plan as guidance for stormwater management policy, land use recommendations, and capital projects.	The Plan establishes City approaches and priorities to provide orderly application and strategic implementation.	Low	Early and High
6.1.2	Obtain Ecology approval for adopted basin plan	The Ecology Stormwater Manual allows the adoption of area-specific stormwater controls.	The proposed changes will be authorized by Ecology and require no further action.	Moderate	Year 1 and Moderate
6.1.3	Adopt subbasin-specific standards	Adopt stormwater controls that are focused on the specific resource needs of the subbasin.	Stormwater controls will be applied that are commensurate with need and benefit.	Low	Early and High
6.1.4	Adopt redevelopment retrofitting standards	Redevelopment is required to retrofit stormwater facilities. Establish approaches that are consistent with the intent of this Plan.	Stormwater controls will be applied that are commensurate with need and benefit.	Low	Year 1 and Low
6.1.5	Adopt LID feasibility evaluation	A plan was prepared that identifies areas of high likelihood to be feasible for LID.	Land uses can be directed to appropriate landscapes; feasibility evaluations will be standardized.	Low	Early and Moderate
6.1.6	Adopt and fund Capital Improvement Projects Plan	Flooding and construction projects program.	Systematic and prioritized infrastructure improvements.	High	Year 1 and High

6.1.1 NPDES Permit Program

The City of Bonney Lake is subject to Ecology's National Pollutant Discharge Elimination System (NPDES) General Permit for discharges from Small (Phase II) Municipal Separate Storm Sewers (MS4s) in Western Washington (Phase II NPDES Permit; Ecology 2014b). The current Phase II NPDES Permit, which regulates the City's discharge of stormwater to surface waters and groundwater, was issued on August 1, 2012; became effective on August 1, 2013; was modified January 16, 2014; and was scheduled to expire on July 31, 2018. The permit was extended 1 year to July 31, 2019 and will include additional or new provisions that should be considered in advance in the draft public comment versions. Portions of this Plan, such as the needs assessment and retrofit prioritization, are expected to address in part future permit requirements.

6.1.2 Adoption Process for Basin Planning

6.1.2.1 Stormwater Manual Requirements

The Bonney Lake Municipal Code Section 15.13.020 adopts the Pierce County Stormwater Management and Site Development Manual (Pierce County Stormwater Manual; Pierce County 2015b) as the City's guidance on stormwater BMPs to be applied to new development or redevelopment.

The Pierce County Stormwater Manual Section 2.4.7 also provides an alternative to the pre-developed duration target in Minimum Requirement 7 through application of watershed-scale evaluation. The evaluation, which must include hydrological modeling and supporting field observations, may be approved for various reasons, including the following examples:

- Establishment of a stream-specific threshold of significant bedload movement other than the assumed 50 percent of the 2-year recurrence interval peak flow.
- Adoption of zoning and land clearing ordinance restrictions that, in combination with an alternative flow control standard, maintain or reduce the naturally occurring erosive forces on the stream channel.
- The evaluation demonstrates that a predevelopment-based duration control standard is not necessary for protection, maintenance, or restoration of designated and existing beneficial uses or Clean Water Act compliance.

Bonney Lake will apply the Pierce County and Ecology processes to establish an alternative flow control requirement.

6.1.2.2 Stormwater Control Transfer Program

Ecology has provided an alternative for NPDES Phase I and Phase II Permit-holders to satisfy flow control requirements at new and redevelopment sites through an approach known as the Stormwater Control Transfer Program (Ecology 2016b). This program is intended to direct stormwater management efforts to watersheds where reducing high stream flows is more likely to contribute to maintaining or restoring state water quality criteria. Municipalities can gain approval for their programs through an Ecology Administrative Order if they meet Ecology's criteria for stormwater control transfer opportunities, watershed prioritization principles and data needs, allowable types and credit capacities of regional facilities, program tracking tools, and evaluation techniques.

Through the Stormwater Control Transfer Program, municipalities can direct stormwater control efforts such as detention facility installation or regional facility resizing from a project development project site in a lower-priority watershed to another higher priority watershed within the jurisdiction. To gain Ecology approval, permittees must first prioritize their watersheds to identify high priority watersheds that are more likely to contribute to maintaining or restoring designated and existing beneficial waterbody uses as outlined in state water quality standards. In Bonney Lake, the basins discharging to Fennel Creek are the highest priority watersheds, and those with higher impervious areas, as shown in Table 12, are a higher priority. Basins that discharge to groundwater or have stormwater management are lower priority.

6.2 Capital Plan Priorities and Schedule

The Capital Projects Plan includes 20 proposed capital projects. These projects include repair and minimization of existing flooding problem areas; new regional facilities for retrofitting and new development; and upgrades to existing facilities. The projects were ranked and prioritized according to four categories:

- Area benefitted—the number of parcels or land area served
- Need/severity—the need for the solution or project to facilitate other work and the seriousness of the problem
- Cost—low or no cost or many benefits for cost
- Opportunity—the project is ready to go, the land is owned by the City, and there are no concerns or issues with implementation

CIP 4-1 in Table 18 is an annual, on-going opportunity construction fund. CIPs 5-1 and 6-1 in Table 18 are non-construction capital elements. These projects should be initiated, when appropriate, and are not included in the prioritization.

Each category was ranked high/medium/low and assigned a score (High = 3, Medium = 2, Low = 1) (see Table 18).

Table 18. Capital Projects Rankings and Priority

Section Number	Project Number	Project Name	Area Benefitted	Need or Severity	Cost/Benefit	Opportunity or Constraints	Rank Total	Rank
6.2.1-1	1-1	East Hill Pothole	MED	MED	LOW	LOW	6	14
6.2.1-2	1-2	Whipple Pothole	MED	MED	LOW	LOW	6	14
6.2.1-3	1-3	200th Avenue Court E and 102nd Street E	LOW	LOW	HIGH	MED	7	10
6.2.1-4	1-4	Kelley Lake Road E and 214th Avenue E	LOW	LOW	MED	MED	6	14
6.2.1-4	1-5	The Market at Lake Tapps – SR 410	MED	HIGH	MED	HIGH	10	2
6.2.1-6	1-6	The Market at Lake Tapps – Walmart	LOW	MED	HIGH	MED	8	7
6.2.1-7	1-7	Fred Meyer at Tall Firs	LOW	LOW	HIGH	HIGH	8	7
6.2.1-8	1-8	Inlet Island – Lake Tapps	MED	MED	MED	HIGH	9	6
6.2.1-9	1-9	Simmer Property	LOW	LOW	MED	HIGH	7	10
6.2.1-10	1-10	Locust Avenue and 82nd Street E	HIGH	MED	LOW	LOW	7	10
6.2.2-1a	2-1a	Downtown Regional Storm Pond	N/A	N/A	N/A	N/A	N/A	N/A
6.2.2.1b	2-1b	Midtown Regional Pond	HIGH	HIGH	HIGH	MED	11	1
6.2.2-1c	2-1c	Eastown Regional Pond	HIGH	HIGH	HIGH	MED	11	1

(Table Continues)

Table 18. Capital Projects Rankings and Priority (Continued)

Section Number	Project Number	Project Name	Area Benefitted	Need or Severity	Cost/Benefit	Opportunity or Constraints	Rank Total	Rank
6.2.3-1	3-1	Allan York Park Subbasin Retrofit	MED	LOW	MED	HIGH	8	7
6.2.3-2	3-2	Lake Tapps Waterfront Subbasin Retrofit	MED	MED	MED	LOW	7	10
6.2.3-3a	3-3a	Lake Tapps Park/West Tapps Highway East Subbasin Retrofit, Option A	HIGH	HIGH	LOW	HIGH	10	2
6.2.3-3b	3-3b	Lake Tapps Park/West Tapps Highway East Subbasin Retrofit, Option B	HIGH	HIGH	LOW	HIGH	10	2
6.2.4-1	4-1	Water Quality Swale Retrofit Program	N/A	N/A	N/A	N/A	N/A	N/A
6.2.5-1	5-1	Fennel Creek Stream Gauge	N/A	N/A	N/A	N/A	N/A	N/A
6.2.6-1	6-1	Fennel Creek Floodplain Study	N/A	N/A	N/A	N/A	N/A	N/A

N/A means projects not ranked.

6.3 Land Use Planning Recommendations

The watershed planning effort has identified approaches to maintain stormwater and land use planning compatibility. Table 19 provides recommendations for consideration when evaluating short- and long-term land use planning or development projects.

Table 19. Land Use Planning Recommendations

Section Number	Action	Benefit	Effort and Cost	Timeline Priority
6.3.1	Direct development to Town Centers with existing or proposed regional stormwater facilities	Additional stormwater facilities are not needed; sites are shovel-ready for stormwater.	Low	Year 1 and Low
6.3.2	Adjust or maintain Town Center boundaries to remain in regional stormwater facility subbasins	Stormwater planning is focused on Town Centers and sites would have limited resource impact.	Low	Year 1 and Low
6.3.3	Define new regional stormwater facilities for concentrated new development areas or retrofit priority areas	Pre-planning for regional facilities will facilitate future preferred development locations.	High	Year 2-3 and Moderate

(Table Continues)

Table 19. Land Use Planning Recommendations (Continued)

Section Number	Action	Benefit	Effort and Cost	Timeline Priority
6.3.4	Evaluate and plan to modify existing facilities to accommodate new development and infill	The land and infrastructure investment is already made and can be optimized for additional benefits.	Moderate	Year 2-3 and Moderate
6.3.5	Direct and encourage development to lands with suitable conditions for LID	Land in LID feasibility areas has lower risk for stormwater impacts.	Low	Year 1 and Low
6.3.6	Modify existing facilities to accommodate new development and infill	The land and infrastructure investment is already made and can be optimized for additional benefits.	Moderate	Year 2-3 and Low
6.3.7	Direct new development, redevelopment, and infill to land with existing controls	The land and infrastructure investment is already made and can be optimized for additional benefits.	Low	Year 1 and Low

6.4 Stormwater Retrofitting Plan

Section 4 describes approaches to selecting and prioritizing proactive retrofitting and retrofitting by redevelopment. Table 20 summarizes the findings and recommendation for this Plan element.

Table 20. Stormwater Retrofitting Plan Recommendations

Section Number	Action	Benefit	Effort and Cost	Timeline Priority
6.4.1	Encourage development to areas well-suited to LID	Land in LID feasibility areas has lower risk for stormwater impacts.	Low	Year 1 and Low
6.4.2	Establish development size thresholds that require stormwater retrofitting when feasible	This will facilitate retrofitting by redevelopment, although it can deincentivize redevelopment and infill if over-reaching.	Moderate	Year 1 and Moderate
6.4.3	Provide incentives for redevelopment and proactive stormwater retrofitting	Encourages opportunistic retrofitting.	Moderate	Year 2-3 and Moderate
6.4.4	Prepare a road system stormwater retrofitting priority plan	A majority of the stormwater impacts in the Fennel Creek watershed are due to roads.	High	Year 1 and High
6.4.5	Prepare an opportunity fund and policies to add stormwater retrofitting to City projects when feasible	Be prepared for retrofitting when opportunities arise.	Moderate	Year 2-3 and High

(Table Continues)

Table 20. Stormwater Retrofitting Plan Recommendations (Continued)

Section Number	Action	Benefit	Effort and Cost	Timeline Priority
6.4.6	Adopt flow control retrofitting only in those subbasins where there is a benefit to a receiving water	Reserve resources for areas where it will provide more benefits.	Low	Year 1 and Low
6.4.7	Use Fennel Creek retrofit plan priorities to seek grants for retrofitting projects	Reduces the burden on City resources and provides an orderly approach to retrofitting priorities.	Very High	Year 4-5

6.5 Next Steps and Future Actions

Additional data needs that could not be addressed in the time frame of the Plan are listed below for consideration during the project implementation phase. Table 21 lists proposals for ongoing plan development.

Table 21. Additional Basin Planning Activities

Section Number	Action	Effort and Cost	Timeline Priority
6.5.1	Install and operate flow recorder in Fennel Creek to provide future hydrologic model calibration	Moderate	Year 1 and High
6.5.2	Add a stream restoration capital project to Fennel Creek	High	Year 2-3 and Moderate
6.5.3	Install lake level recorders in Lake Bonney, Lake Debra Jane, and East Pothole	Moderate	Year 1 and Moderate
6.5.4	Consider implementing a regional groundwater evaluation to develop a greater understanding of the regional groundwater system	High	Year 4-5 and Low
6.5.5	Conduct an evaluation of lake water quality in the city to determine if broader lake quality protection plans are warranted	High	Year 2-3 and Moderate
6.5.6	Consider additional BIBI monitoring sites: one upstream in Fennel Creek, and on the Fennel Creek tributaries from the lakes	Moderate	Year 1 and Low
6.5.7	A Floodplain Study to be conducted on the Upper Fennel Creek watershed to determine the floodplain limits to aid in the application of appropriate floodplain management practices.	Moderate	Year 2-3 and Moderate

6.6 Summary Implementation Plan

The Basin Plan Program elements have been summarized in an implementation schedule in order of anticipated priority and timeline in Table 22. This is recommended for planning purposes to determine the relative costs and effort levels that may need to be applied. It is anticipated that some elements may be moved up the list because of changing needs or opportunities that arise and may need to be delayed over a longer time frame due to lack of available resources.

Table 22. Summary Plan Implementation Time Line

First Steps	Item No.	Title	Priority	Comment
First Priority: Implement at initiation				
	6.1.1	Adopt basin plan	High	
	6.1.3	Adopt subbasin-specific standards	High	
	6.1.5	Adopt LID feasibility evaluation	Moderate	
Year one	6.4.4	Prepare a road system stormwater retrofitting priority plan	High	
	6.5.1	Install and operate flow recorder in Fennel Creek to provide future hydrologic model calibration	High	
	6.1.2	Obtain Ecology approval for adopted basin plan	Moderate	
	6.4.2	Establish development size thresholds that require stormwater retrofitting when feasible	Moderate	
	6.5.3	Install lake level recorders in Lake Bonney, Lake Debra Jane, and East Pothole	Moderate	
	6.1.4	Adopt redevelopment retrofitting standards	Low	
	6.3.1	Direct development to Town Centers with existing or proposed regional stormwater facilities	Low	
	6.3.2	Adjust or maintain Town Center boundaries to remain in regional stormwater facility subbasins	Low	
	6.3.5	Direct and encourage development to lands with suitable conditions for LID	Low	
	6.3.7	Direct new development, redevelopment, and infill to land with existing controls	Low	
	6.4.1	Encourage development to areas well-suited to LID	Low	
	6.4.6	Adopt flow control retrofitting only in those subbasins where there is a benefit to a receiving water	Low	

(Table Continues)

Table 22. Summary Plan Implementation Time Line (Continued)

First Steps	Item No.	Title	Priority	Comment
Year 2-3	6.2.2.1b	Midtown Regional Pond	High	Year 1 of CIP, rank 1st
	6.2.2-1c	Eastown Regional Pond	High	Year 1 of CIP, rank 1st
	6.2.1-5	The Market at Lake Tapps – SR 410	High	Year 1 of CIP, rank 2nd
	6.2.3-3a or 3b	Lake Tapps Park/West Tapps Highway East Subbasin Retrofit, Option A or B	High	Year 1 of CIP, rank 2nd
	6.4.5	Prepare an opportunity fund and policies to add stormwater retrofitting to City projects when feasible	High	
	6.2.1-8	Inlet Island – Lake Tapps	Moderate	Year 2 of CIP
	6.2.2-1a	Downtown Regional Storm Pond	Moderate	Year 2 of CIP
	6.2.1-6	The Market at Lake Tapps – Walmart	Moderate	Year 2 of CIP
	6.2.3-1	Allan Yorke Park Subbasin Retrofit	Moderate	Year 2 of CIP
	6.3.3	Define new regional stormwater facilities for concentrated new development areas or retrofit priority areas	Moderate	
	6.3.4	Evaluate and plan to modify existing facilities to accommodate new development and infill	Moderate	
	6.3.6	Modify existing facilities to accommodate new development and infill	Moderate	
	6.4.3	Provide incentives for redevelopment and proactive stormwater retrofitting	Moderate	
	6.5.2	Add a stream restoration capital project to Fennel Creek	Moderate	
	6.5.5	Conduct an evaluation of lake water quality in the city to determine if broader lake quality protection plans are warranted	Moderate	
	6.5.7	A Floodplain Study to be conducted on the Upper Fennel Creek watershed to determine the floodplain limits to aid in the application of appropriate floodplain management practices.	Moderate	
Year 4-5	6.2.1-3	200th Avenue Court E and 102nd Street E	High	Year 3 of CIP
	6.2.1-4	Kelley Lake Road E and 214th Avenue E	High	Year 3 of CIP
	6.2.1-7	Fred Meyer at Tall Firs	High	Year 3 of CIP
	6.2.1-9	Simmer Property	High	Year 3 of CIP
	6.2.1-10	Locust Avenue and 82nd Street E	High	Year 3 of CIP
	6.2.3-2	Lake Tapps Waterfront Subbasin Retrofit	High	Year 3 of CIP
	6.2.1-1	East Hill Pothole	Moderate	Year 4 of CIP
	6.2.1-2	Whipple Pothole	Moderate	Year 4 of CIP
	6.5.4	Consider implementing a regional groundwater evaluation to develop a greater understanding of the regional groundwater system	Low	
	6.4.7	Use Fennel Creek retrofit plan priorities to seek grants for retrofitting projects	Low	

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Appendix A

Project Kickoff Sessions

Appendix B

Public Workshops and Peer Reviewer Input

Appendix C

Stream and Riparian Corridor Assessment

Appendix D

Lake Stage Elevations Data

Appendix E

Stormwater Control Facilities Detail

Appendix F

Model Land Use Analysis and Model Inputs

Appendix G

LID Feasibility Analysis

Appendix H

Capital Projects Project Sheets