BELFAIR UGA 2018 BASIN PLAN

Prepared for
Mason County Public Works

Prepared by
Herrera Environmental Consultants, Inc.

Note:
Some pages in this document have been purposely skipped or blank pages inserted so that this document will copy correctly when duplexed.

BELFAIR UGA 2018 BASIN PLAN

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INTRODUCTION

Mason County (the County) and Herrera Environmental Consultants (Herrera) are working in partnership with the Washington Department of Ecology (Ecology), Mason Conservation District, and the Hood Canal Salmon Enhancement Group (HCSEG) to develop a basin plan for the City of Belfair Urban Growth Area (UGA). The plan will provide a pathway forward for development and redevelopment of the Belfair UGA that ensures sound stormwater management and policies that are protective of the region's natural resources.

Several stormwater-related studies and planning efforts have been conducted over the past 10 years for the Belfair UGA, including the *Lower Union River Stormwater Study* (ESA 2006) and the *Belfair UGA Stormwater Management Plan* (Otak 2007a). In addition, the *Hood Canal Regional Stormwater Retrofit Project* (Herrera 2014) was completed for the entire Hood Canal watershed, including the Belfair UGA.

Expansion of the Bremerton area commercial/industrial area and recent activities, including the Washington State Department of Transportation's (WSDOT's) recent widening and safety improvements of State Route 3 (SR 3) and the planned SR 3 Freight Corridor (previously referred to as the SR 3 Bypass) as well as the new wastewater conveyance and treatment system, are expected to result in an increase in population and changes in development patterns within the Belfair UGA. This spurred the County to revisit the previous plans and develop a new basin plan. The new basin plan will help the County manage the potential impacts from future development more effectively and address existing stormwater management concerns.

Within the context of the basin plan development, the County must make decisions about the regulatory requirements that will govern future development and redevelopment projects and the necessary programs and capital projects that will be needed to help mitigate flooding and protect water quality and environmental health within the Belfair UGA. Although neither Mason County nor the UGA currently fall under the jurisdiction of Washington's National Pollutant Discharge Elimination System (NPDES) Phase II Municipal Stormwater Permit, it is also the intent of this planning process to evaluate and recommend some of the components of that permit in preparation for the County's eventual inclusion as a permittee.

Key goals of this planning process include:

- Document current conditions within the UGA and describe the current stormwater management framework.
- Predict impacts of future growth to stormwater discharge.
- Evaluate the current approach for managing stormwater against other stormwater management options and recommend changes to codes or ordinances, if needed.

- Develop and prioritize stormwater management retrofit facilities to ensure long-term protection of area resources but be sensitive to impacts on development.

- Ensure the plan is aligned with Mason County's Comprehensive Plan.

- To the extent practicable, begin building the framework for a more comprehensive stormwater program.

Predictive hydrologic models were developed at two scales to support these goals. At the site scale, modeling was employed to evaluate hydrologic implications of different stormwater management regulatory schemes applied to future development:


Drainage Issues in the Belfair Basin

- Maintain current stormwater requirements set forth in the 2005 *Stormwater Management Manual for Western Washington* (2005 SWMMWW) (Ecology 2005) and the 2008 Mason County Low Impact Development Ordinance (No. 76-08)

- Modify stormwater requirements by adopting those set forth in the 2014 SWMMWW (Ecology 2012, as amended in 2014)

At the UGA scale, modeling was employed to establish baseline hydrologic conditions basin-wide and to evaluate changes in hydrology between existing conditions and full build-out conditions that could theoretically occur within the Belfair UGA. The modeling helped identify the optimal regulatory scheme for future development, as well as existing and potential future problem areas. It also aided development of potential programs and capital projects to address those problem areas.

This plan provides information on study area characteristics, the existing stormwater management program, hydrologic modeling results, and recommendations on capital improvement program (CIP) projects and program improvements. Appendix A provides a summary of data gaps and a needs assessment, Appendices B and C provide detail on the modeling efforts, and Appendices D and E provide design concepts and details on recommended CIP projects.

PLANNING FRAMEWORK

COMPREHENSIVE PLAN

Mason County's Comprehensive Plan provides the following goal for the Belfair UGA:

"The community's vision for Belfair's future begins with a feeling for the land. Care for the land is critical to the community's economic health and long-term sustainability. For Belfair to grow and prosper, local jobs must accompany residential growth, and the economy must diversify to include industrial, professional and service, and tourist-based businesses. There must also be a more cohesive community with a more integrated, positive identity. "

While all of the goals of the Comprehensive Plan apply to the Belfair area, the following are the subset that is most relevant to this basin planning effort.

- Encourage development in urban areas where public facilities and services exist and can be provided in an efficient manner.
- Protect the environment and enhance the State's high quality of life, including air and water quality, and the availability of water.
- Protect drinking water supplies from contamination, maintain potable water in adequate supply and identify and reserve future supplies
- Discourage development activities in environmentally sensitive areas that may have a detrimental effect on public health, safety, environment, and physical integrity of the area.
- Sharing of corridors of major utilities, trails and other transportation rights-of-way is encouraged.
- Reduce regulatory barriers and allow greater flexibility in the housing development process with ensuring that future residential development carefully considers and protects natural ecosystems including wetland, streams, wildlife habitat, and fresh and marine water quality
- Ensure the involvement of citizens in the planning process and ensure coordination between communities and jurisdictions to reconcile conflicts.

REGULATORY FRAMEWORK

Several federal and state regulations and strategic planning efforts apply to the Belfair UGA's storm- and surface water program. The primary state and federal regulations that apply include:

- Federal Clean Water Act
- Federal Endangered Species Act
- State surface water quality standards (WAC 173-201A)
- Groundwater quality standards (WAC 173-200)
- Growth Management Act (RCW 36.70A.170)
- Underground Injection Control (UIC) requirements (WAC 173-218)

State and local strategic planning efforts that are instrumental for implementing the requirements of these regulations include:

- Puget Sound Partnership Action Agenda (Puget Sound Partnership 2016)
- Mason County's Comprehensive Plan (Mason County 2016)
- Union River Fecal Coliform Bacteria Total Maximum Daily Load (TMDL) plan (Ecology 2001; 2002; 2003)

NPDES refers to the part of the federal Clean Water Act that regulates discharges of wastewater or stormwater with the end goal of ensuring receiving waters meet water quality standards. In Washington, Ecology has authority for implementing the Clean Water Act and related NPDES programs through issuance of permits that detail requirements for compliance. There are five types of NPDES permits that regulate stormwater; all of them have detailed requirements related to controlling pollutant sources as well as controlling the volume and quality of stormwater discharged. The five permit types are:

- Municipal Stormwater Permit: This permit regulates discharge of stormwater from municipalities. The Phase 1 municipal permit applies to larger cities and counties, and the Phase 2 municipal permit applies to smaller cities and counties. Mason County does not currently fall under the Phase 2 permit because it does not have enough population to meet the permit criteria. WSDOT also holds its own stormwater permit, which applies to its activities along the SR 3 corridor in Belfair.
- Construction Stormwater General Permit: This permit regulates discharge of stormwater from construction sites.

- Industrial Stormwater General Permit: This permit regulates discharge of stormwater from industrial sites.

- Sand and Gravel General Permit: This permit regulates discharge of process water, stormwater, and dewatering water from sand and gravel mines.

- Boatyard General Permit: This permit regulates discharge of wastewater and stormwater from boatyards.

Although neither the County nor the Belfair UGA currently fall under the umbrella of the NPDES municipal stormwater permit, many stormwater program elements required by the NPDES permit are beneficial to consider as part of an overall program for addressing basin planning in relation to stormwater management.

Stormwater System Challenges

Mason County's Municipal Code and Stormwater Ordinances dictate allowable land uses within the UGA, prescribe or limit stormwater management techniques that may be used, and impose requirements on development. Municipal code and ordinances were used to predict future development patterns and provided reference points for testing different stormwater management scenarios. The following summarizes the most relevant codes and ordinances.

Low Impact Development (LID) Ordinance 76-08 was adopted in 2008 and applies specifically to the Belfair and Allyn UGAs. The purpose of the ordinance is to encourage use of LID techniques that, for example, minimize impervious surface, more closely mimic predevelopment hydrologic conditions through onsite control of stormwater, and encourage creation or preservation of open spaces. Mason County's LID Ordinance requires LID for new development and redevelopment sites within the Belfair UGA. The ordinance imposes a maximum impervious surface limit, prescribes the use of permeable pavement for 20 percent of all paved surfaces, prescribes bioretention facilities along 75 percent of County-owned roadways, requires infiltration of 100 percent of runoff on outwash soils, and requires reforestation of native vegetation areas. The ordinance also requires treatment of 95 percent of runoff, which exceeds Ecology's 91 percent requirement for water quality treatment (i.e., Minimum Requirement #6).

Mason County Stormwater Management Ordinance (*Ordinance 81-08*) was adopted in 2008. The first part of the ordinance adopted the minimum requirements of the 2005 SWMMWW for the Belfair and Allyn UGAs. In addition to adopting the minimum requirements of the 2005 SWMMWW (Ecology 2005), the ordinance further requires "for new development and redevelopment, no additional stormwater runoff shall be allowed from the property due to added impervious surfaces or disturbed land. The stormwater runoff from new impervious surfaces or disturbed land shall be treated and prevented from flowing off the property being developed." Again, this applies only to the UGA areas. (Note: the 2005 SWMMWW was updated in 2012 and then amended in 2014. It is referred to herein as the 2014 SWMMWW.)

Mason County Stormwater and Surface Water Utility Ordinance (Ordinance No. 80-08) was adopted in 2008. It set boundaries for a storm- and surface water utility that were to be implemented over time. Boundaries for the Belfair and Allyn UGAs were established at the time of adoption. The utility had three basic responsibilities: flood management, water quality improvement, and aquatic habitat protection. Although the utility is in place, no funding mechanism (utility fee) was adopted to support its function.

Summary of Recent Stormwater Related Efforts

A number of recent studies and plans contain information relevant to the development of the Belfair UGA basin plan. A summary of the key documents that were most informative to the development of this basin plan are summarized below.

- *Hood Canal Regional Stormwater Retrofit Project* (Herrera 2014). This report summarized an effort by a coalition of state and county agencies, tribes, and community groups to identify the most potentially beneficial stormwater retrofit opportunities throughout the Hood Canal watershed. Although the document addressed stormwater issues and solutions at the Hood Canal scale, several sites within the Belfair UGA were identified as candidate sites for stormwater retrofits. Concepts for three of these sites are currently being advanced to the preliminary design stage.

- *Hood Canal Stormwater Retrofit Infiltration Feasibility Assessment* (Aspect 2013). This report is a companion analysis to the Hood Canal Regional Stormwater Retrofit Project. This report presents the results of an assessment of the potential of infiltrating stormwater in selected portions of the Hood Canal Basin. The primary products from the report are maps of feasibility for both shallow and deep infiltration. The assessment was completed to assist in the identification, screening, and conceptual design of potential stormwater retrofit projects for selected priority areas for the entire Hood Canal Basin and includes a portion, but not all, of the Belfair UGA. *Ecology's 2016 303(d) List of Impaired Waters* (Ecology 2016) identifies water bodies that consistently exceeded one or more water quality standards. This list was used for identifying known water quality problems within the UGA and contributing watersheds.

- *Union River Watershed Fecal Coliform TMDL* (Ecology 2001, 2002, 2003; Cadmus Group 2010). The four documents related to the Union River Fecal Coliform TMDL document the bacteria problems in the river. The TMDL implementation plan (Ecology 2003) lays out the framework for addressing the problem. Belfair is the largest urban area in the basin, and stormwater from the Belfair area was cited as an important source of bacteria, based on Ecology's storm event sampling of streams in the urban area performed after release of the TMDL. WSDOT and Mason County Public Works both have responsibility for controlling and treating stormwater from roadways in the Belfair area to reduce bacteria loads. Sewering of the Belfair area was also an important part of the implementation strategy, which is also being carried out by Mason County Public Works. And, of course ongoing work by the County such as development of this stormwater management plan is an important part of the efforts to reduce pollution generated within the UGA.

- *Drainage Alternative Selection: SR 3 Belfair Area Widening and Safety Improvements* (WSDOT 2009). The WSDOT SR 3 widening project compared stormwater drainage and treatment options for the SR 3 widening project in the Belfair area. It identified feasibility, environmental costs and benefits, and economic requirements of two different drainage options. Ultimately, it recommended traditional stormwater conveyance and impoundment in stormwater ponds.

- *Hydraulic Report Supplement; SR 3 Belfair Area Widening and Safety Improvements* (WSDOT 2017a) and *SR 3/Belfair Area Widening and Safety Improvements; Summary Results of Stormwater Changes during Construction* (WSDOT 2017b). These reports document the significant changes to treatment and control of stormwater between the final designs and construction phases.

- *Belfair Urban Growth Area Stormwater Management Plan* (Otak 2007a). This provides background information about watershed characteristics and conditions, an assessment of culvert capacity, and a basic catalog of resources within the Belfair UGA. The document's primary focus and recommendations are for regional treatment facilities, although some potential site-scale retrofits were identified.

- *Belfair Urban Growth Area Stormwater Management Plan Addendum* (Otak 2007b). Due to concerns about the focus on regional treatment facilities in the original plan, an addendum was prepared that changed the focus of the plan to a decentralized approach using LID techniques and retrofitting of existing development.

- *Lower Union River Stormwater Study* (ESA 2006). In this study, modeling was used to estimate stormwater runoff originating within the Belfair UGA based on existing and future land use. Recommendations were also made related to conveyance and treatment options for future and existing land use scenarios. The report's appendix consists of older documents that characterize the watershed. Although some of the content is outdated, this report and the appendices provide a good inventory of watershed characteristics.

- *2015 WSDOT Fish Passage Performance Report* (WSDOT 2015). Although fish passage barriers reflect a physical constraint and are not directly stormwater related, sometimes stormwater projects can serve a dual purpose when improvements can be located where they will also fix the barrier. WSDOT produces an annual report to document its activities related to fish passage improvements and plans. The 2015 report indicates that there are six fish passage barriers along SR 3 within the Belfair UGA; one of these was slated for repair/construction in 2015. Two additional fish passage barriers were removed during the SR 3 road improvement work completed in 2016.

- *Stormwater Task Force (SWTF) Recommendations*. Mason County commissioners appointed a stormwater task force that met for over 2 years to consider different aspects of the County's approach to stormwater management. In 2012 they developed a series of recommendations—many of which are reflected in this plan.

STUDY AREA CHARACTERISTICS

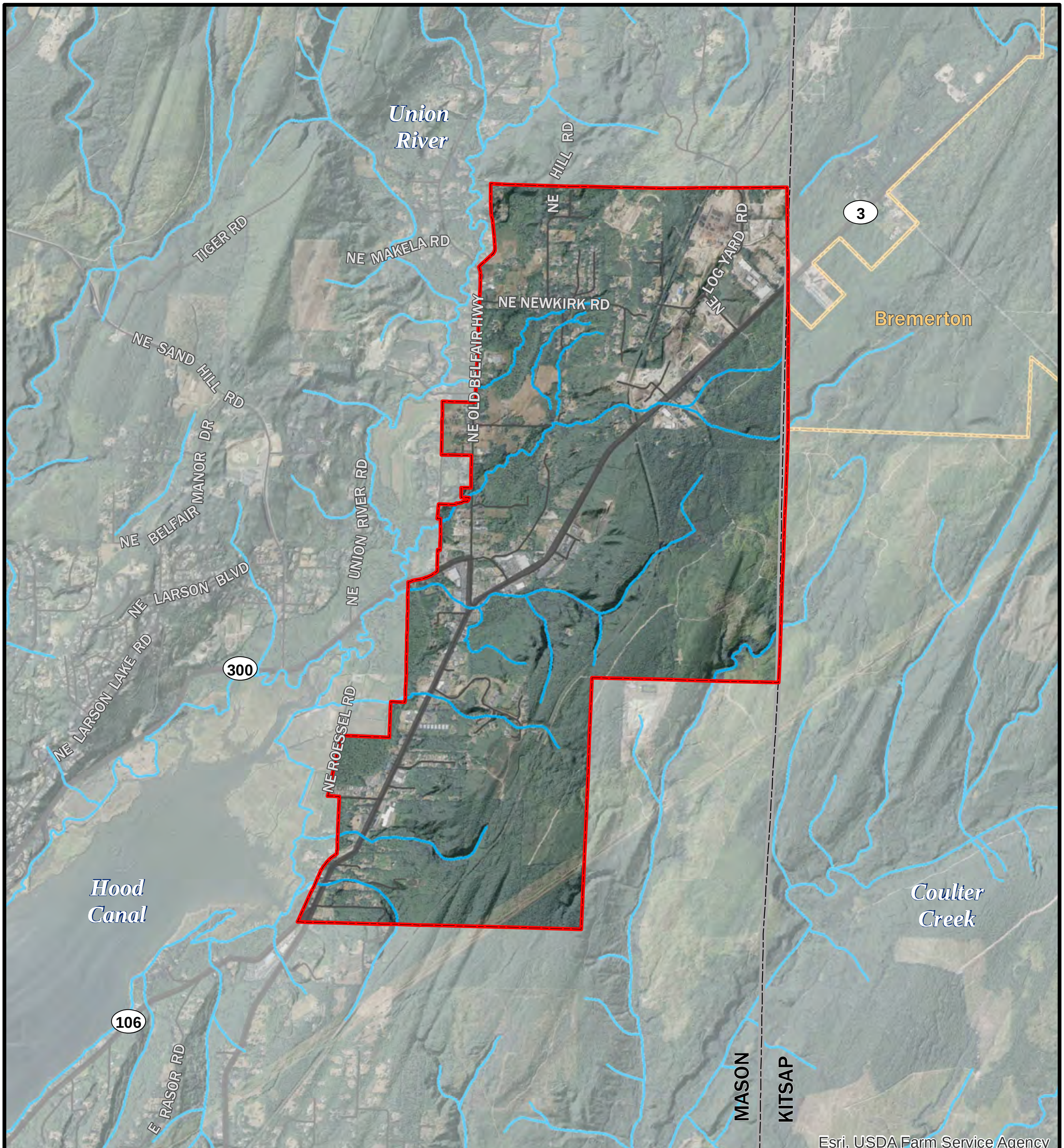
The Belfair UGA spans approximately 2,400 acres to the northeast of the eastern terminus of Hood Canal's lower arm (Figure 1). The UGA is bound on the west by the Union River, and on the east by hills that act as the watershed divide between Hood Canal and Case Inlet. SR 3 bisects the UGA. SR 3 is an important thoroughfare connecting Shelton and other South Puget Sound cities to Bremerton and Tacoma. WSDOT recently completed a construction project on portions of SR 3 in the Belfair area to improve safety and traffic flow, and these improvements also included construction of stormwater management facilities. A wastewater treatment facility was also recently constructed to address wastewater treatment needs in and around the UGA. Collectively, these infrastructure improvements will support continued residential and commercial growth in the area.

Although the majority of the UGA is undeveloped, where development has occurred it is primarily residential area with pockets of light industrial, and commercial land use. The Belfair UGA serves a population of approximately 23,000 residents, and a large number of seasonal tourists. Residential growth, tourism, and traffic volume are expected to continue increasing for the foreseeable future.

The Union River and Hood Canal are the major water bodies that lie within or adjacent to (and are affected by) the UGA (Figure 1). There are many small streams within the UGA that provide important habitat for fish and wildlife.

In the previous stormwater management plan (Otak 2007a), the UGA was separated into 19 subbasins. For the sake of consistency, the same 19 subbasins and their names/numbers are used in this report. However, the subbasins boundaries have been re-delineated using improved mapping techniques (i.e., light detection and ranging (LiDAR) imagery) resulting in different subbasin boundaries and therefore different calculated subbasin sizes. There were also some discrepancies in how the area outside of the UGA was addressed in the previous study, this also contributed to differences between this and the previous work. From a functional viewpoint, the subbasins are comparable between the plans. Figure 2 shows the 19 subbasins in the geographical context of the UGA and the region.

The following sections describe the environmental setting of the UGA, and the natural resources to be protected by implementation of this basin plan.



Legend

- Belfair UGA
- Stream or river
- Highway
- Street
- City limit
- County boundary

Figure 1.
Vicinity Map for the Belfair UGA.

N

0 1,500 3,000 6,000 Feet

HERRERA

USDA, Aerial (2015)

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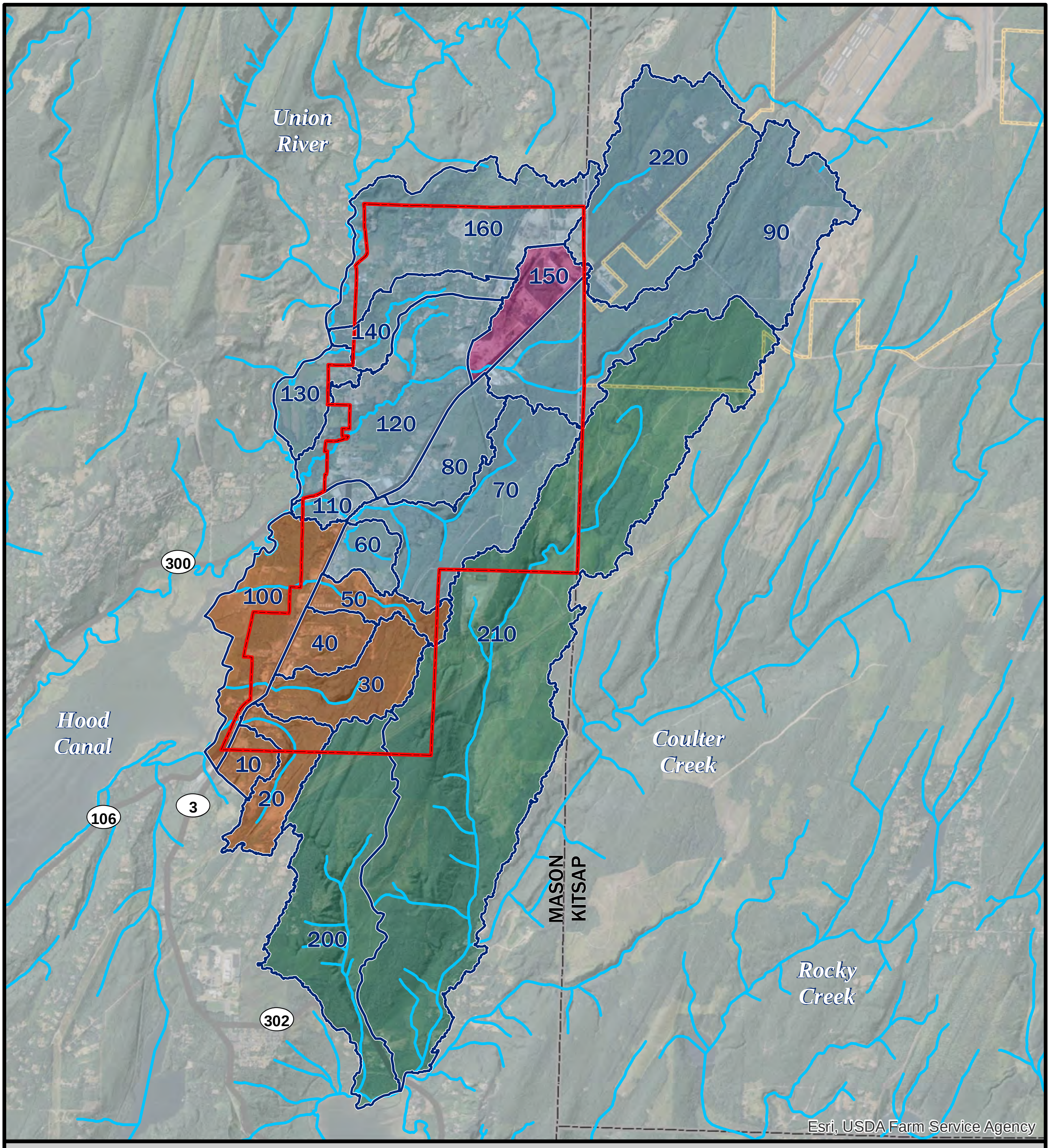

Legend

- Subbasin boundary
- Stream or river
- Belfair UGA
- Highway
- City limit
- County boundary

Receiving Water

- Union River
- Hood Canal
- Closed Depression/Union River
- Case Inlet

Figure 2.
Subbasins Within the Belfair UGA.

N

0 2,000 4,000 8,000 Feet

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ENVIRONMENTAL SETTING (TOPOGRAPHY, GEOLOGY, AND SOILS)

The majority (63 percent) of the UGA lies within the Union River watershed, although the main stem of the Union River lies just outside the UGA boundary. For the most part, the topography of the UGA slopes westward towards the Union River or south towards Hood Canal. Part of the southern portion and parts of the eastern edge of the UGA are characterized by more steeply sloping terrain, and depending on location, may slope in any direction.

The geology of the area is fairly typical of Puget Sound lowlands and is dominated by quaternary glacial deposits left behind during the more recent episodes of the Frasier glaciations. Specifically, there are regions of glacial outwash (well sorted material deposited by meltwater), alluvium (poorly sorted glacial material carried by rivers), and glacial till (poorly sorted material transported and deposited directly by the glacier). The majority of the UGA is on Vashon till, which is predominately coarse material. The western boundary of the UGA has more mixed geology consisting of Vashon recessional outwash and glacial alluvium, which are finer textured than the Vashon till. Fluvial and alluvial processes also acted to form the relatively flat floodplain and delta of the Union River and are responsible for the fine marshy sediments found there. Most of the Union River Delta is located outside the UGA boundary.

The glacial geology, and the associated deposits within the UGA are the parent material for the soils that formed within the UGA. As a result, there are specific soil types with characteristic drainage properties that form on the underlying geology. The drainage properties are broadly described by their hydrologic soil group based on how fast water infiltrates through the soil. Table 1 lists the specific drainage properties of each hydrologic soil group found within the UGA. Table 2 provides a listing of the percent of each soil group by subbasin. The hydrologic soil groups and geologic units are also mapped on Figure 3. The soils in the majority (49.6 percent) of the UGA are classified as Group A soils, which are well drained and allow for high infiltration and generate low runoff. Group B soils, which have moderate infiltration capacity comprise the next largest group (35.7 percent) within the UGA. Towards the western edge of the UGA, the soils that formed on the finer alluvial and outwash deposits are hydrologic Group C/D and B/D, are more poorly drained, and only allow for slow infiltration. Together, those groups account for approximately 14 percent of the UGA (NRCS 2016). Hydrologic soil group is an important parameter in runoff modeling calculations, and in determining appropriate stormwater control and treatment practices.

Table 1. Hydrologic Soil Group Characteristics.			
Soil Group	Infiltration Characteristic	Area Within UGA (acres)	Percent of UGA Area (percent)
A	High infiltration, low runoff, as for deep sand or loess, aggregated silts	1,152.4	49.6
B	Moderate infiltration, as for moderately coarse-textured soils such as sandy loam	829.9	35.7
C	Slow infiltration, as for fine textured soil such as clay loam, shallow sandy-loam, soils low in organic content	10.1	0.4
D	Very slow infiltration such as swelling and plastic claypan	0	0.0
A/D	Soils with drainage properties characteristic of Group A, but have a water table within 60 cm of the surface	5.2	0.2
B/D	Soils with drainage properties characteristic of Group B, but have a water table within 60 cm of the surface	108.3	4.7
C/D	Soils with drainage properties characteristic of Group C, but have a water table within 60 cm of the surface	207.4	8.9

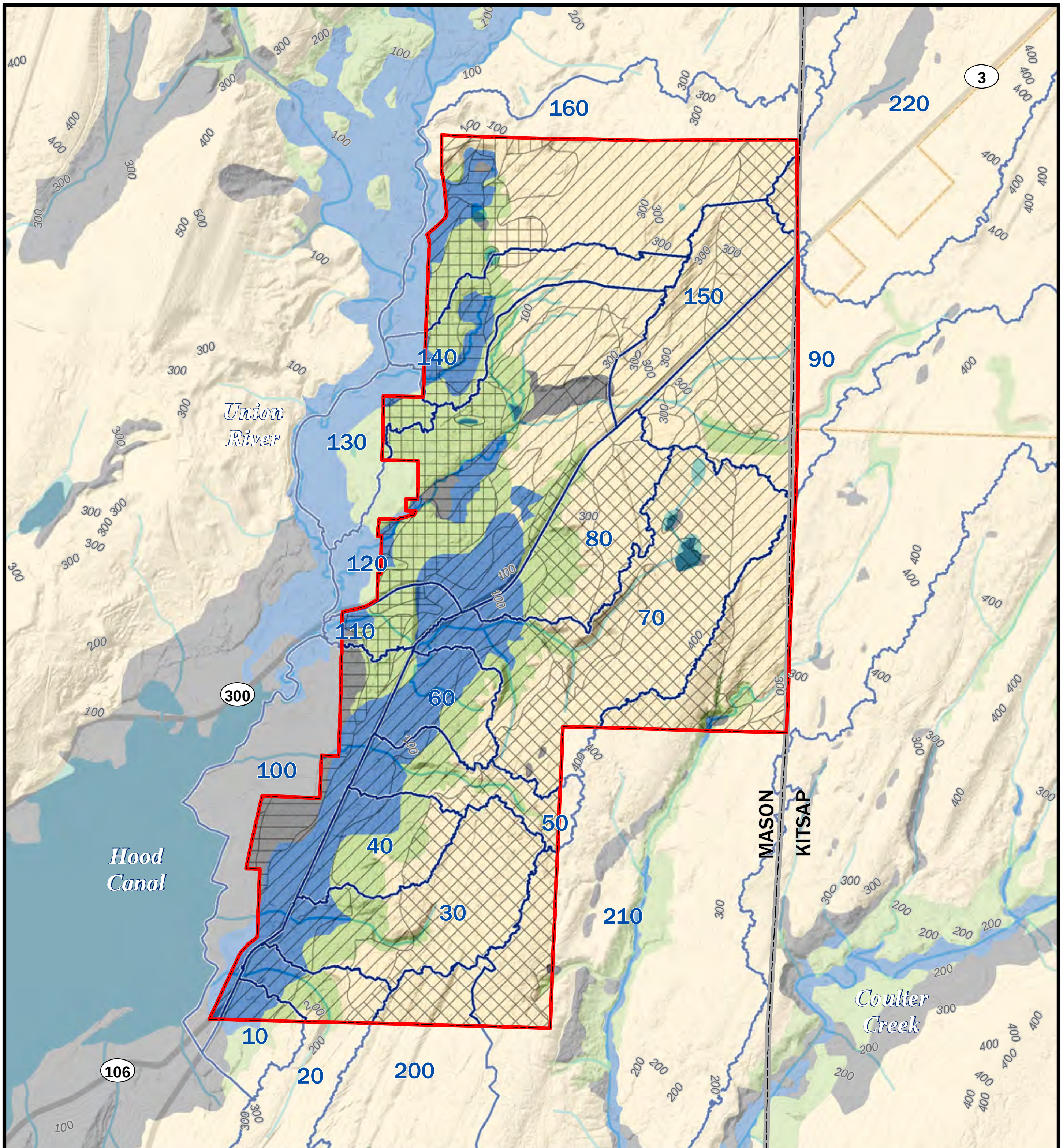
Note: Hydrologic soil group area was calculated from the NRCS Web Soil Survey Database (NRCS 2016). Hydrologic soil group was not assigned for approximately 10.4 acres (0.4 percent) of the UGA.

Table 2. Hydrologic Soil Groups for Subbasin Area Within UGA.													
	Acreage Within UGA	A		B		C		A/D		B/D		C/D	
Subbasin	Acres	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
10	15.2	15.2	100.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
20	47.6	41.4	87.0%	6.2	13.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
30	181.4	66.1	36.4%	115.3	63.6%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
40	86.4	67.4	77.8%	19.0	22.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
50	74.9	45.0	60.1%	30.0	40.1%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
60	69.8	67.2	96.3%	2.6	3.7%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
70	328.0	86.5	26.4%	236.3	72.0%	0.0	0.0%	5.2	1.6%	0.0	0.0%	0.0	0.0%
80	134.8	27.6	20.5%	107.1	79.5%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
90	151.2	64.3	42.5%	78.5	51.9%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
100	109.3	54.8	50.1%	0.0	0.0%	0.0	0.0%	0.0	0.0%	44.3	40.5%	9.5	8.7%
110	39.2	11.4	29.1%	0.5	1.3%	0.0	0.0%	0.0	0.0%	12.6	32.1%	14.6	37.2%
120	345.9	218.4	63.1%	8.4	2.4%	0.0	0.0%	0.0	0.0%	24.5	7.1%	92.6	26.8%
130	12.7	0.0	0.0%	0.9	7.1%	0.0	0.0%	0.0	0.0%	0.0	0.0%	11.6	91.3%
140	105.5	53.4	50.6%	0.4	0.4%	0.0	0.0%	0.0	0.0%	18.1	17.2%	33.5	31.8%
150	118.9	67.4	56.7%	51.5	43.3%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
160	268.4	181.6	67.7%	21.8	8.1%	10.1	3.8%	0.0	0.0%	8.8	3.3%	45.6	17.0%
200	35.9	0.0	0.0%	35.9	100.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
210	189.1	84.7	44.8%	104.3	55.2%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
220	10.7	0.0	0.0%	10.7	100.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Total	**2,325.3**	**1,152.4**	**49.6%**	**829.9**	**35.7%**	**10.1**	**0.4%**	**5.2**	**0.2%**	**108.3**	**4.7%**	**207.4**	**8.9%**

Hydrologic soil group area was calculated from the NRCS Web Soil Survey Database (NRCS 2016).

Hydrologic soil group was not assigned for approximately 10.4 acres (0.4 percent) of the UGA.

Data used for percentage area calculations came from multiple data sets. Due to discrepancies among the datasets, the percentages listed above may not be exact.



Legend

Geologic Unit
- Till (Qgic; Qgt)
- Outwash (Qga; Qgo; Qgof)
- Alluvium (Qa; Qaf)
- Other

Hydrologic Soil Groups
- A
- A/D
- B
- B/D
- C
- C/D

- Belfair UGA
- Watershed boundary
- Stream or river
- 20-foot contour
- Highway
- City limit
- County boundary

Figure 3.
Geology and Soil Hydrologic Groups in the Belfair UGA.

N

0 1,250 2,500 5,000 Feet

HERRERA

WA Division of Geology & Earth Resources, Surface Geology (2014);
NRCS, Soils (2014)

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LAND USE/LAND COVER

Land cover was mapped at the parcel scale using the 2011 National Land Cover Database (NCLD; MRLC 2011) (Figure 4). The NCLD land cover categories were combined into five main groups; residential, commercial/industrial, forest/field, agricultural, and open water.

The predominant land cover type within the UGA is mapped as forest/field (78.0 percent), residential development accounts for the next largest cover type (18 percent); while commercial/industrial and agricultural land uses occupy very little of the UGA (Table 3). The locations of residential and commercial/industrial land use of are particular relevance since they are associated with higher pollutant concentrations than forest and field, or agricultural land uses (Herrera 2011). Residential land use is predominately located along western edge of the UGA along the Old Belfair Highway, and through the center of the UGA, in the corridor along SR 3 (Figure 4). The SR 3 corridor also has the highest concentration of commercial/industrial land use. Most of the residential and commercial land use is located within subbasins that flow toward the Union River (Figure 4).

The NLCD was initially identified to provide impervious areas within the UGA. Upon examination, however, the NLCD data was deemed to be too coarse for this modeling effort and not representative of existing conditions within the UGA. As such, a new impervious cover dataset was created. Using ERDAS Imagine software, recent aerial images were used to classify existing pervious or impervious areas within the UGA.

Land cover type is closely associated with the percentage of impervious surface which, in combination with soil drainage properties, determines the amount of stormwater runoff generated by a parcel. An impervious area of 10 percent has been shown to be near the threshold at which significant declines will occur in stream health, including declines in macroinvertebrate populations and salmonid abundance (Horner et. al. 2001). As shown in Table 3 and on Figure 5, there is a wide range in percent impervious area within the UGA. Overall, most (14 of the 19 subbasins) have more than 10 percent impervious surface, and not surprisingly those that represent the core area of Belfair along the SR 3 corridor (i.e., Subbasins 100, 110, 150, and 220) have much higher impervious areas.

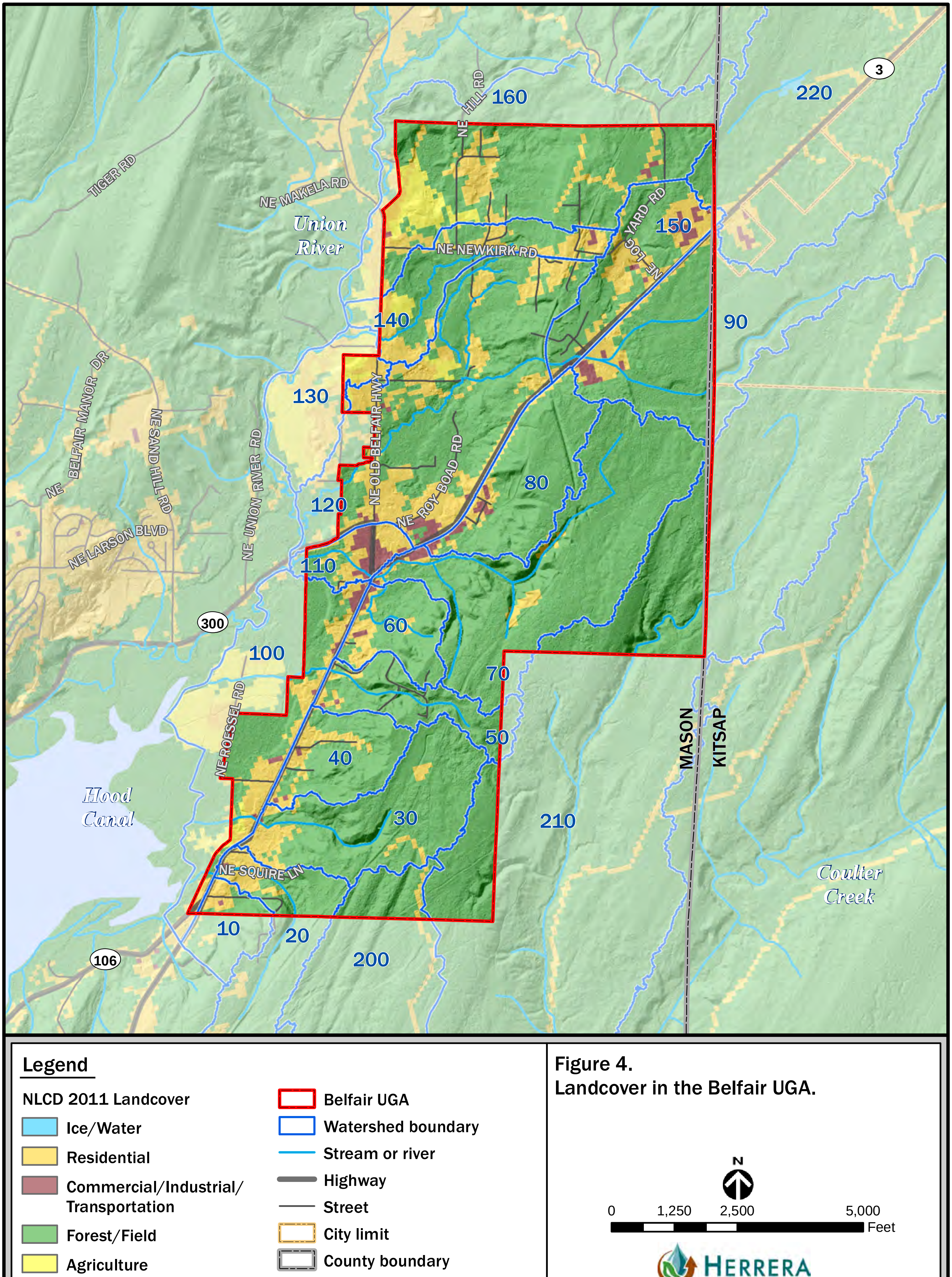

Figure 4.
Landcover in the Belfair UGA.

HERRERA

MRLC, Landcover (2014)

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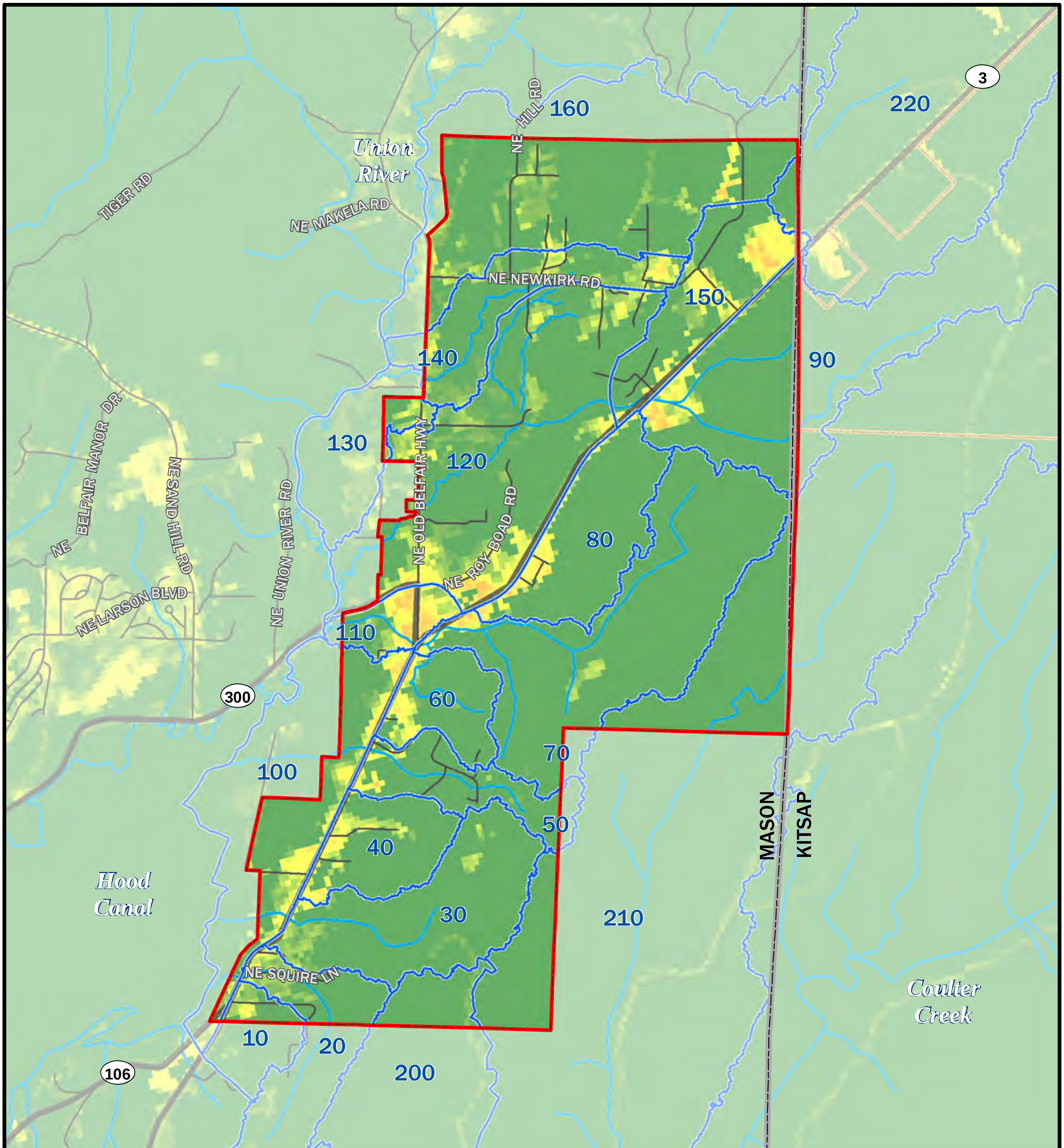
Table 3. Land Cover and Impervious Area Within the UGA.														
	Area Within UGA	**Residential**		**Commercial and Industrial**		**Forest and Field**		**Agricultural**		**Approximate Roadway Area (within UGA)**		**Impervious Area (within UGA)**	
Subbasin	**Acres**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
10	15.2	7.1	46.7%	0.2	1.3%	7.8	51.3%	0.0	0.0%	1.6	10.4%	2.0	13.2%
20	47.6	14.7	30.9%	0.8	1.7%	32.2	67.6%	0.0	0.0%	4.0	8.3%	5.9	12.4%
30	181.4	19.7	10.8%	0.2	0.1%	161.8	89.1%	0.0	0.0%	1.5	0.9%	4.0	2.2%
40	86.4	17.2	19.9%	0.7	0.8%	68.7	79.3%	0.0	0.0%	5.0	5.8%	14.1	16.3%
50	74.9	5.4	7.2%	0.4	0.5%	69.1	92.3%	0.0	0.0%	5.2	6.9%	13.3	17.8%
60	69.8	12.5	17.9%	2.1	3.0%	55.2	79.1%	0.0	0.0%	2.2	3.1%	10.1	14.5%
70	328.0	9.7	3.0%	3.5	1.1%	314.8	96.0%	0.0	0.0%	1.8	0.5%	9.2	2.8%
80	134.8	10.3	7.6%	4.5	3.3%	120.0	89.0%	0.0	0.0%	5.3	3.9%	15.5	11.5%
90	151.2	17.0	11.2%	4.1	2.7%	130.1	86.0%	0.0	0.0%	3.0	2.0%	9.8	6.5%
100	109.3	41.7	38.2%	5.0	4.6%	60.0	54.9%	2.6	2.4%	5.5	5.0%	25.5	23.3%
110	39.2	17.3	44.1%	11.9	30.4%	10.0	25.5%	0.0	0.0%	4.6	11.7%	18.8	48.0%
120	*345.9*	*111.2*	*32.1%*	*7.2*	*2.1%*	*223.1*	*64.5%*	*4.5*	*1.3%*	*18.3*	5.3%	*48.4*	*14.0%*
130	12.7	6.6	52.0%	0.0	0.0%	0.7	5.5%	5.3	41.7%	0.9	6.9%	2.4	18.9%
140	*105.5*	*37.7*	*35.7%*	*0.9*	*0.9%*	*61.3*	*58.1%*	*5.6*	*5.3%*	*5.2*	*4.9%*	*15.1*	*14.3%*
150	118.9	40.6	34.1%	8.0	6.7%	70.3	59.1%	0.0	0.0%	9.2	7.8%	55.8	46.9%
160	268.4	46.2	17.2%	1.5	0.6%	196.6	73.2%	24.1	9.0%	7.6	2.8%	46.2	17.2%
200	35.9	2.3	6.4%	0.0	0.0%	33.6	93.6%	0.0	0.0%	0.0	0.0%	0.1	0.3%
210	189.1	0.0	0.0%	0.0	0.0%	189.1	100.0%	0.0	0.0%	0.0	0.0%	2.5	1.3%
220	10.7	0.8	7.5%	0.0	0.0%	9.9	92.4%	0.0	0.0%	0.0	0.0%	4.6	43.0%
Total	**2,325.28**	**418.0**	**18.0%**	**51.0**	**2.2%**	**1,814.3**	**78.0%**	**42.1**	**1.8%**	**81.0**	**3.5%**	**303.3**	**13.1%**

Land cover was calculated from the 2011 National Land Cover Database (MRLC 2011).

Approximately 2.7 acres, or 0.1 percent, of the land area of the UGA is open water. This area was incorporated into the percentage calculations presented in the table above.



Legend

NLCD Percent Developed Imperviousness

100%

0%

- Belfair UGA
- Subbasin boundary
- Stream or river
- Street
- Highway
- City limit
- County boundary

Figure 5.
Impervious Surfaces in the Belfair UGA.

N

0 1,250 2,500 5,000 Feet

HERRERA

MRLC, Percent Developed Imperviousness (2011)

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SURFACE WATER RESOURCES

The primary surface water resources of concern to UGA planning are Hood Canal and the Union River, which flows into Hood Canal. Approximately 63 percent of the drainage area within the UGA flows first to the Union River and another 22 percent flows directly to Hood Canal (Table 4). This leaves only a small portion of the UGA (15 percent) that either flows toward Case Inlet or lies within a closed depression.

Union River Subbasins

The Union River is one of the more significant rivers that flow into Hood Canal and provides the largest source of water to the lower arm of the canal. The Union River Watershed is approximately 14,500 acres (Ecology 2001); but only 1,350 acres (9 percent) of the watershed lies within the Belfair UGA. The Union River is designated a class AA (extraordinary) water body according to the standards set forth in WAC 173-201-045.

Monitoring at several sites in the Union River between 1990 and 1998 indicated that fecal coliform frequently exceeded state water quality standards. Subsequently, Ecology conducted a TMDL study to confirm the findings, and determine load reductions for specific river reaches that would be needed to meet the water quality standards. A 22 to 38 percent reduction in fecal coliform is required in the river segment adjacent to the UGA to meet the water quality standard. High bacteria loads that occur during the fall and winter indicated that stormwater runoff from urban impervious surfaces and agricultural land were likely significant contributors to the bacteria problem (Ecology 2001). Although many changes have occurred in the watershed since the TMDL, including constructing a wastewater treatment facility, subsequent monitoring has indicated that there has not been a meaningful change in bacteria concentrations and the river continues to be listed as impaired due to high bacteria concentrations.

Table 4. Subbasins and Water Resources of the Belfair UGA.										
Subbasin	Water Course Name	Final Receiving Water	Total Subbasin Area		Area Within UGA		Upstream of UGA		Downstream of UGA	
			Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
60	Mindy Creek	Union River	69.8	1.2%	69.8	3.0%	0	0.0%	0	0.0%
70	Belfair Creek	Union River	337.0	5.6%	328.0	14.1%	9.0	2.7%	0	0.0%
80	Unnamed Drainage	Union River	134.8	2.2%	134.8	5.8%	0	0.0%	0	0.0%
90	Unnamed Drainage	Union River	636.8	10.6%	151.2	6.5%	485.5	76.2%	0	0.0%
110	Belfair Creek	Union River	42.4	0.7%	39.2	1.7%	0	0.0%	3.3	7.8%
120	Irene Creek	Union River	*389.0*	6.5%	*345.9*	14.9%	0	0.0%	43.1	11.1%
130	Unnamed Drainage	Union River	97.2	1.6%	12.7	0.5%	0	0.0%	84.5	86.9%
140	Viola Creek	Union River	*114.5*	1.9%	*105.5*	4.5%	0	0.0%	8.9	7.8%
160	Unnamed Drainage	Union River	440.3	7.3%	268.4	11.5%	125.4	28.5%	46.5	10.6%
220	Unnamed Drainage/ Lider Lake	Union River	516.8	8.6%	10.7	0.5%	0	0.0%	506.0	97.9%
10	Unnamed Drainage Course	Hood Canal	51.1	0.9%	15.2	0.7%	35.9	70.3%	0	0.0%
20	Alder Creek	Hood Canal	134.0	2.2%	47.6	2.0%	86.4	64.5%	0	0.0%
30	Sweetwater Creek	Hood Canal	181.6	3.0%	181.6	7.8%	0	0.0%	0	0.0%
40	Unnamed Drainage	Hood Canal	86.6	1.4%	86.6	3.7%	0	0.0%	0	0.0%
50	Romance Hill Drainage	Hood Canal	83.4	1.4%	74.9	3.2%	8.5	10.2%	0	0.0%
100	Creek/Wetland	Hood Canal	263.9	4.4%	109.3	4.7%	0	0.0%	154.7	58.6%
150	Unnamed Drainage	Closed Depression	120.0	2.0%	118.9	5.1%	1.2	1.0%	0.0	0.0%
200	Unnamed Drainage/ Coulter Creek	Case Inlet	514.0	8.6%	35.9	1.5%	0	0.0%	478.1	93.0%
210	Unnamed Drainage/ Coulter Creek	Case Inlet	1,792.0	29.8%	189.1	8.1%	497.3	27.8%	1,105.6	61.7%
Total			**6,005.2**	**100.0%**	**2,325.3**	**38.7%**	**1,261.4**	**21.0%**	**2,418.5**	**40.3%**

As shown in Table 5 and Figure 6, waters in and directly adjacent to the Belfair UGA have bacteria, dissolved oxygen, and temperature levels that exceed the state water quality standard.

Table 5. Water Bodies Listed as Impaired in the 2016 Water Quality Assessment in or Adjacent to the Belfair UGA.

Water Body	Parameter	Category
Belfair Creek	Bacteria	4A
Union River	Bacteria	4A
Union River	Dissolved oxygen and temperature	5

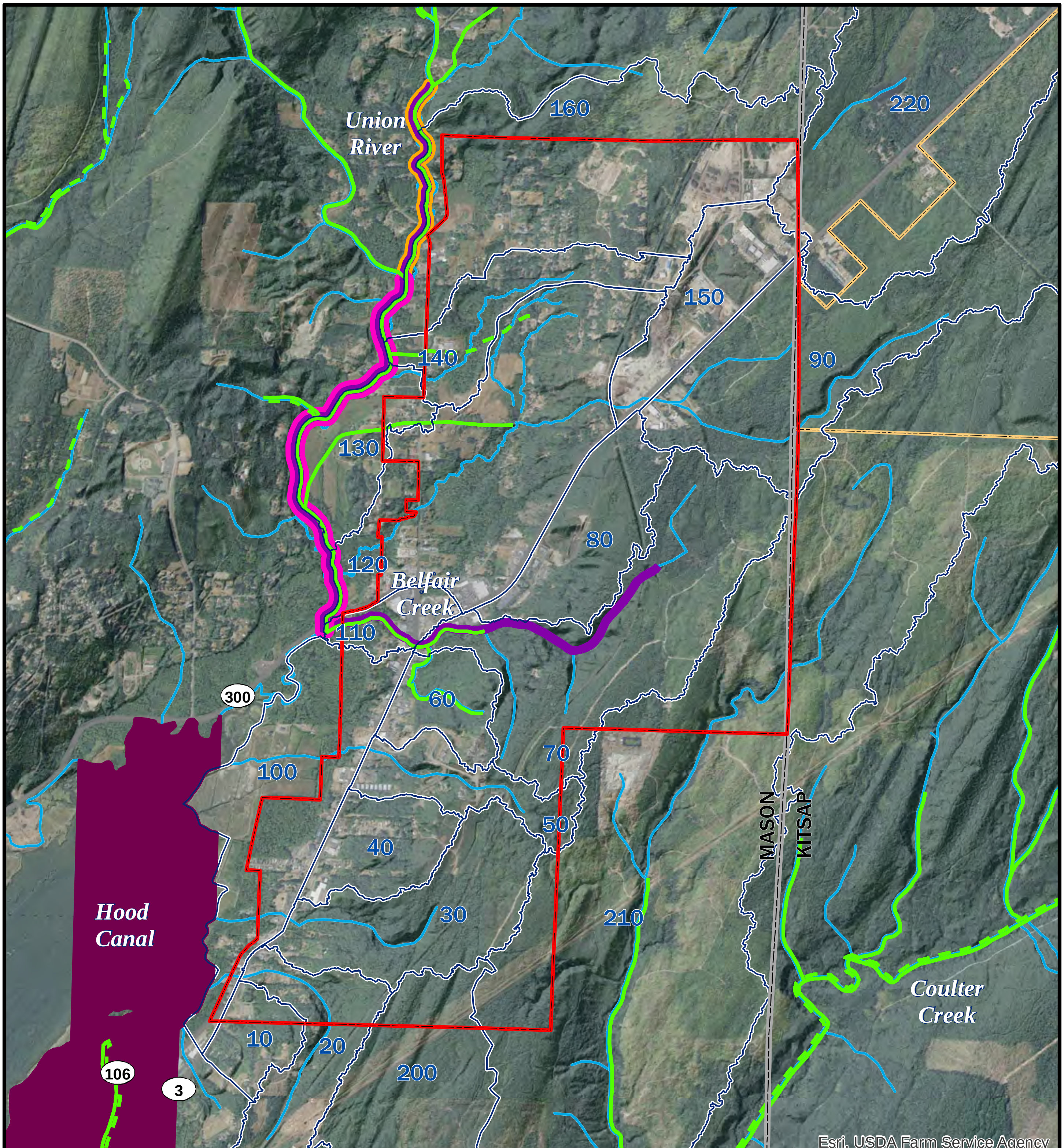
Note: Category 4A = These water bodies have an approved plan in place for improving water quality that is actively being implemented.

Category 5 = Polluted waters that require a TMDL or other water quality improvement (WQI) project. Traditionally known as the 303(d) list.

High peak flows during winter months are also a concern for the Union River since they coincide with redd formation in the stream channels. There are frequent cases when salmon redds are washed out during storm events (Julian Sammons, Hood Canal Salmon Enhancement Group, personal communication, September 14, 2015).

Within the Belfair UGA there are four named stream systems, that discharge to the Union River and for which their watersheds are entirely or almost entirely within the UGA. These include; Irene, Belfair, Mindy, and Viola Creeks, which together represent 61 percent of the drainage area for the Union River that is within the UGA. Small, unnamed drainage courses comprise the rest of the Union River portion of the UGA. There is a small closed depression that receives water from Subbasin 150. Although this is within the Union River watershed, it does not discharge surface water to the Union River, though there is likely a groundwater connection.

In terms of drainage subbasins, while only 10 of the 19 subbasins within the UGA flow toward to the Union River, these subbasins represents approximately 63 percent of the total UGA land area. Most of these subbasins are located to the west of SR 3 and slope gently to the southwest. A notable exception is Subbasin 220 which flows northward to Lider Lake, which discharges to the Northeast Fork of the Union river, which joins the mainstem Union River upstream of the UGA.



Legend

- Documented fish presence
- Presumed fish presence

Water Quality Assessment - 305(b)

- Bacteria, Category 4A
- Bacteria, Category 5
- Dissolved Oxygen, Category 5
- Temperature, Category 5
- Belfair UGA
- Watershed boundary
- Stream or river
- Highway
- City limit
- County boundary

Figure 6.
Water Quality Impairments and Fish Presence in Belfair UGA Streams.

N

0 1,250 2,500 5,000 Feet

HERRERA

WA Dept. of Health, WPA (2015)

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Hood Canal Subbasins

Hood Canal is the westernmost fjord of Puget Sound, and is an important natural, economic, and cultural resource for the region. Hood Canal experiences poor water circulation as a result of a series of glacial sills that prevent water exchange despite its proximity to the Pacific Ocean and large tidal influence. Consequently, Hood Canal suffers from periodic water quality problems, most notably, low dissolved oxygen levels, but high bacteria concentrations, warm temperature, and toxics in sediments are also identified problems. Because of the poor circulation, relatively shallow water depth (<40 meters), and its distance from its mouth in the Strait of Juan de Fuca, the lower arm of Hood Canal (the east west trending portion that spans between Union and its terminus at Lynch Cove), may be more susceptible to land based pollutant inputs than other areas of Puget Sound. In the lower arm of Hood Canal, there are several segments (termed assessment units in Ecology's database) that do not meet water quality standards for the above listed problems. Six subbasins within the Belfair UGA drain directly to Hood canal, rather than the Union River or Case Inlet. The subbasins are located to the west of SR 3 towards the southern end of the UGA. The area covered by these subbasins within the UGA represents approximately 22 percent of the total area of the UGA. The area within the UGA for each subbasin ranges from approximately 15 to 182 acres. The two largest Subbasins 30 and 100; (Sweetwater Creek and an unnamed Wetland, respectively) have contributing drainage areas within the UGA between approximately 109 and 182 acres. Collectively, these two subbasins represent over 50 percent of the Hood Canal drainage area within the UGA.

Case Inlet Subbasins

Subbasins 200 and 210 flow to Coulter Creek which discharges to Case Inlet. Only 7 to 11 percent of the land (representing 36 and 189 acres, respectively) within these two large subbasins lies within the UGA.

Water Quality Monitoring

Most of the water quality monitoring in the Belfair UGA conducted during the past decade is related to the Union River Fecal Coliform Bacteria TMDL. Frequent and regular bacteria monitoring occurred at sites on the Lower Union River and at the mouth of Belfair creek. Ecology operates one, long-term monitoring station in the lower Union River where monthly sampling for conventional water quality parameters (e.g., temperature, conductivity, bacteria, dissolved and total nutrients) is occasionally conducted for year-long periods as part of Ecology's ambient monitoring program. This site was monitored in 1998 and 2008.

For many years Mason County has implemented a Pollutant Identification and Correction (PIC) program. The program primarily focuses on testing and identifying fecal coliform sources. Most of the fecal sampling occurs along the shoreline of Hood Canal. Several of the sampling sites are adjacent to the Belfair UGA. The PIC program also maintains ambient water quality monitoring stations to track long term trends in a range of water quality constituents. However, none of these stations are located within the Belfair UGA. Downstream sites, particularly along the shoreline of Hood Canal below Subbasins 10 through 50, and Subbasin 100 may reflect conditions in the UGA.

Three recent studies for which water quality samples were collected within the Belfair UGA were identified through an online search of Ecology's Environmental Information Management (EIM) database.

- Surface water samples were collected from 7 locations along Sweetwater Creek in 2006 as part of the Pacific Northwest Salmon Center Brownfields Cleanup study Surface water samples were analyzed for total metals only and no water quality criteria were exceeded;

- Ten locations located in the commercial center of Belfair were monitored between 2008 and 2011 as part of Mason County's Stormwater Management Program. Samples were analyzed for conventional parameters such as temperature and dissolved oxygen, metals, and semivolatile organic compounds (SVOCs). Exceedances of water quality criteria for temperature, dissolved oxygen, pH, fecal coliform, lead, zinc, and 2,4,6-trichlorophenol were measured at one or more of the sample locations;

- One location on a tributary to Hood Canal was sampled monthly in 2015 as part of the Regional Stormwater Monitoring Program (RSMP) small stream status and trends monitoring. Samples were analyzed for conventional parameters, metals, and SVOCs. A summary of the water quality data collected for this study is presented in Table 6. As shown in the table, no State water quality standards were exceeded. This site is not within the UGA.

Table 6. Water Quality Results for the 2015 RSMP Monitoring Station Located Within the UGA.

Water Quality Parameter	Number of Samples	Number of Detections	Reporting Limit	Range	Average	Water Quality Criteria
Temperature (°C)	15	15	NA	7.3–12.47	10.3	Shall not exceed 17.5[a]
Dissolved oxygen (mg/L)	15	15	NA	10.53–12.13	11.1	Shall exceed 8.0[a.]
pH (standard units)	15	15	NA	6.81–7.92	7.64	Shall be within the range of 6.5 to 8.5[a]
Fecal coliform (CFU/100 mL)	13	8	1–4	ND–260	5.9[c]	Shall be less than 100[a]
Total nitrogen (mg/L)	13	13	0.025	0.346–1.4	0.604	NA
Total phosphorus (mg/L)	13	13	0.005	0.027–0.30	0.057	NA
Arsenic, dissolved (µg/L)	13	13	0.2	0.44–0.97	0.68	360[a]

Table 6 (continued). Water Quality Results for the 2015 RSMP Monitoring Station Located Within the UGA.						
Water Quality Parameter	Number of Samples	Number of Detections	Reporting Limit	Range	Average	Water Quality Criteria
Cadmium, dissolved (µg/L)	13	0	0.2	ND	ND	1.60[a,d]
Chromium, dissolved (µg/L)	13	13	0.5	1–1.35	1.22	291[a,d]
Lead, dissolved (µg/L)	13	0	0.1	ND	ND	27.5[a,d]
Zinc, dissolved (µg/L)	13	0	5	ND	ND	59.4[a,d]

[a] Aquatic Life Criteria in Freshwater (WAC 173-201a) for Salmonid Spawning, Rearing, and Migration.

[c] Geometric mean.

[d] Criteria calculated based on average hardness value of 46.1 mg/L.

°C degrees Celsius.

µg/L micrograms per liter.

mg/L milligrams per liter.

NA not applicable.

ND not detected above laboratory reporting limit.

One sediment sample was also collected from the RSMP study site in summer of 2015. The sample was analyzed for metals, SVOCs, herbicides, polybrominated diphenyl ether (PBDE) congeners, and polychlorinated biphenyl (PCB) congeners. Metals results are summarized in Table 7. As shown, none of the metals were detected at levels of concern. In terms of organic constituents, one herbicide (dichlobenil), one SVOC (retene), and several PBDE and PCB congeners were detected above reporting limits; however there are no freshwater sediment criteria for these compounds.

Table 7. Sediment Sampling Results from the 2015 RSMP Monitoring Station Located Within the Belfair UGA.				
			Sediment Management Standards[a]	
Sediment Quality Parameter	Units	2015 Sediment Result	SCO	CSL
Arsenic	mg/kg	3.95	14	120
Cadmium	mg/kg	0.12	2.1	5.4
Chromium	mg/kg	51.4	72	88
Copper	mg/kg	14.5	400	1200
Lead	mg/kg	5.25	360	>1300
Silver	mg/kg	0.1 U	0.57	1.7
Zinc	mg/kg	45.8	3200	>4200

[a] Sediment Management Standards Freshwater Sediment Criteria (WAC 173-204).

CSL = Cleanup Screening Level

mg/kg = milligrams per kilogram.

SCO = Sediment Cleanup Objective.

U = Not detected above the laboratory reporting limit.

Critical Areas

Critical areas are designated to prevent harm to the community from natural hazards and to protect natural resources. Generally speaking, natural hazards are geologically hazardous areas (e.g., steep slopes) and areas at risk for flooding. Natural resources include certain streams, wetlands, fish and wildlife habitat conservation areas, and critical aquifer recharge areas. There was no single data source (i.e., critical areas database) that details all of the critical areas within the UGA, rather critical areas were described in GIS datasets provided by Mason County, or in the case of hillslope hazards were inferred based on LiDAR.

Groundwater Resources

Groundwater resources are an important consideration for stormwater planning efforts, since many stormwater management strategies (e.g., those relying on underground injection or infiltration) have the potential to influence groundwater quality. Most Belfair residents get their drinking water either from municipal, private, or community wells, and it is critical to protect these sources from potential degradation.

Low lying areas along the Union River in the northwest side of the UGA have been designated as Critical Aquifer Recharge Area (CARA); CARAs are areas that are considered critical for recharging aquifers used for potable water sources. The CARA along the Union river spans much of the urbanized portion of Belfair
(Figure 7).

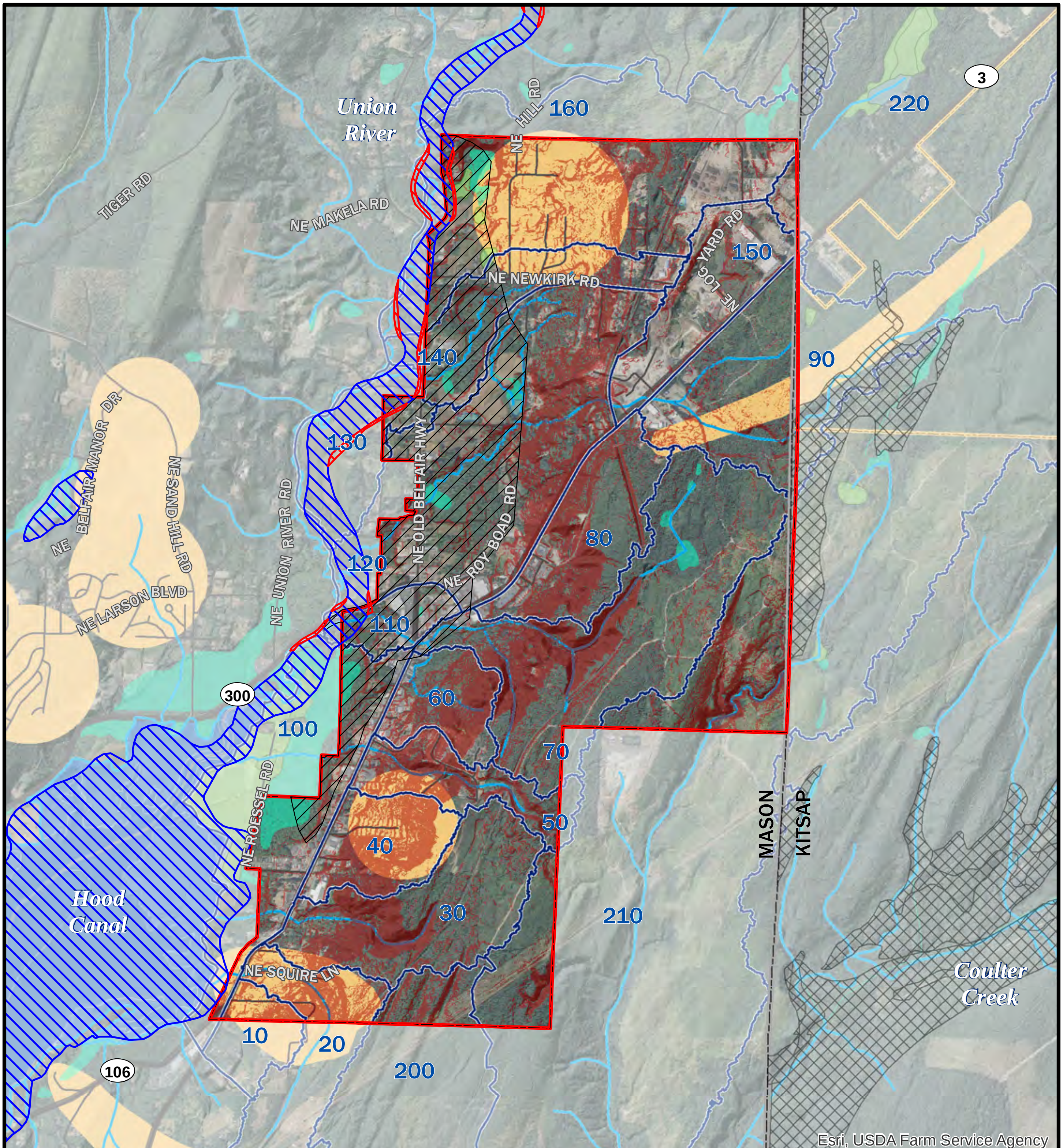
There are also fourteen public water supply wells in the UGA that have designated wellhead protection zones as shown in Figure 7. (Note: The 14 wellhead protection zones are not all visible in the figure either because their zones overlap or because they are too small to be depicted at this scale.)

Between the CARAs and WHPAs a large portion of the UGA is within an area where groundwater resources are important and should be protected.

Wetlands, Riparian Buffers, and Salmon Bearing Streams

Wetlands and stream buffers are important to preserve because of the habitat and other ecological functions they provide. From a basin planning perspective they are important because they can limit the areas that can be developed; and can affect other development logistics such as setbacks.

While there are numerous wetlands throughout the UGA (Figure 7), they represent less than 2 percent of the total land area (Table 8). The largest wetland is approximately 18 acres and is located in Subbasin 100 adjacent to Hood Canal and the UGA Boundary. There are also several small wetlands scattered throughout the northern half of the UGA along the western edges of Subbasins 110, 120, 140, and 150. These wetlands range from 0.5 to 12 acres in size.



Legend

- Critical Aquifer Recharge Area
- Category II (CARA) (Kitsap Co)
- Hillslope hazard >15% slope
- Wellhead Protection Area
- NWI Wetlands (USFWS)
  - Estuarine and Marine Wetland
  - Freshwater Emergent Wetland
  - Freshwater Forested/Shrub Wetland
  - Freshwater Pond
- Belfair UGA
- Watershed boundary
- City limit
- County boundary
- Stream or river
- Highway
- Street
- FEMA 100-year floodplain
- FEMA 500-year floodplain

Figure 7.
Critical Areas in the Belfair UGA.

N

0 1,250 2,500 5,000 Feet

HERRERA

WA Dept. of Health, WPA (2015)

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Table 8. Critical Areas Within the Belfair UGA.											
	Total Area Within UGA	**Wetlands**		**WHPAs[a]**		**CARAs**		**>15 Percent Slope**		**FEMA Flood Hazard Area**	
Subbasin	**Acres**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
10	15.2	0.0	0.0%	15.2	100.0%	0.0	0.0%	8.4	55.1%		
20	47.6	0.0	0.0%	44.2	92.9%	0.0	0.0%	27.2	57.1%		
30	181.6	0.0	0.0%	7.5	4.1%	0.0	0.0%	78.5	43.2%		
40	86.6	0.0	0.0%	54.6	63.0%	0.0	0.0%	51.9	59.9%		
50	74.9	0.0	0.0%	37.5	50.1%	0.0	0.0%	44.3	59.2%		
60	69.8	0.0	0.0%	11.6	16.6%	0.4	0.6%	41.6	59.6%		
70	328.0	5.8	1.8%	8.4	2.6%	6.3	1.9%	112.8	34.4%		
80	134.8	0.0	0.0%	9.5	7.0%	0.0	0.0%	63.6	47.2%		
90	151.2	0.0	0.0%	116.0	76.7%	0.0	0.0%	29.7	19.6%		
100	109.3	18.2	16.7%	22.3	20.4%	44.6	40.8%	22.7	20.7%	10.5	9.6%
110	39.2	0.5	1.3%	0.0	0.0%	39.2	100.0%	5.3	13.4%	0.1	0.3%
120	***345.9***	7.3	2.1%	**89.5**	25.9%	172.2	49.8%	125.2	36.2%		
130	12.7	0.0	0.0%	0.4	3.1%	12.7	100.0%	0.7	5.7%		
140	***105.5***	2.0	1.9%	**90.2**	85.5%	55.0	52.1%	24.2	23.0%		
150	118.9	0.0	0.0%	110.9	93.3%	0.0	0.0%	32.2	27.1%		
160	268.4	12.0	4.5%	167.2	62.3%	57.4	21.4%	78.2	29.1%	13.8	5.1%
200	35.9	0.0	0.0%	0.1	0.3%	0.0	0.0%	15.6	43.6%		
210	189.1	0.0	0.0%	0.0	0.0%	0.0	0.0%	67.3	35.6%		
220	10.7	0.0	0.0%	5.8	54.2%	0.0	0.0%	1.4	13.4%		
Total	**2,325.3**	**45.8**	**2.0%**	**790.9**	**34.0%**	**387.8**	**16.7%**	**830.8**	**35.7%**	**24.4**	**1%**

[a] WHPA area represents the land surface area covered by the 5-year WHPA or the assigned WHPA.

Stream buffers are the protected corridors along streams set aside to preserve habitat, prevent erosion, and minimize other impacts to streams. Certain development may be conditionally allowed within or near stream buffers but only on a limited basis. In Mason County, regulated stream buffer widths vary from 50 to 150 feet, depending upon the stream type (Mason County Municipal Code Chapter 21.64). These buffers have not yet been mapped by the County, however some gross level assumptions were made to approximate stream buffers for modeling purposes for this plan. (Stream buffers are not depicted on Figure 7 because they are too narrow to be visible.)

The WDNR surveys and catalogs streams based on the presence of salmonids. Within the UGA there are three streams with documented fish presence (Washington Department of Fish and Wildlife (WDFW) 2017). Together these provide approximately 9,500 feet (approximately 1.17 miles) of fish habitat within the UGA. These stream segments are shown on Figure 6 and are described further below.

Belfair Creek is used by coho, summer chum, and fall chum for rearing and holding (WDFW 2017). Belfair Creek has four culverts all of which have fish passage concerns. The first three are considered partial blocks to fish passage and the last culvert is identified as a total block to fish access (WDFW 2017). Salmonid use is limited to the lower approximately 0.17 miles of Belfair Creek, ending approximately 500 feet downstream of the first partial barrier.

There are two unnamed streams in the UGA that support salmonids; both are tributaries to the Union River. These streams are those associated with Subbasins 130 and 140 (Figure 6). The stream associated with Subbasin 130 is used by coho and winter steelhead for rearing and holding (WDFW 2017). There are no known blockages to fish passage in this stream, and fish utilize approximately 0.88 miles of the stream (WDFW 2017). The unnamed stream associated with Subbasin 140 is used by coho salmon for rearing. Presence of coho is only presumed east of Old Belfair Highway which represents 0.12 miles of stream. There are no fish passage barriers documented on this system.

Geologic and Flood Hazard Areas

Natural hazards are defined in the Mason County Resource Ordinance (MC 17.01). The most pertinent natural hazards affecting stormwater planning and development potential within the Belfair UGA are landslide hazard and flooding. There are a number of criteria, based on Mason County's Critical Areas Ordinance (lIST), that qualify an area as a landslide hazard, however these areas have not been delineated and mapped by the County. For the purpose of modeling future development, the defining characteristic for landslide hazard areas was hillslopes with grades in excess of 15 percent. Hillslope was calculated and mapped for the UGA using 2005 LiDAR data with a pixel resolution of 6 feet. Hillslope hazard areas and flood hazard areas (as mapped by FEMA) are depicted on Figure 7.

Most of the hillslope hazard areas are in the southern portion of the UGA (Figure 7). Subbasins 10 through 80, 120, 200, and 210, have more than 30 percent of their land area classified as hillslope hazard areas (Table 8). Several of those subbasins have more than 50 percent of their land area classified as hillslope hazard areas. Hillslope hazard areas are important from a planning perspective because the development potential of these areas is limited. They are also important for stormwater planning because of concerns associated with infiltrating stormwater near steep slopes and inadvertently contributing to landslide hazards.

Flooding risks were determined from FEMA 100-year flood maps, and reports from County staff. There are only two very small areas of the UGA within the FEMA 100-year floodplain, located in Subbasins 100 and 160 (Figure 7).

EXISTING STORMWATER INFRASTRUCTURE

The stormwater conveyance network within the UGA consists primarily of open ditches and swales with associated culverts and catch basins. There are also a few stormwater treatment facilities owned by the County, WSDOT, and private entities.

Existing Forested Wetland in the Belfair Basin

County- Owned Facilities

The County maintains a network of culverts, catch basins and open-ditch systems that are used for stormwater conveyance. The County also maintains two detention ponds in the area that are privately owned. Most of the County's stormwater system has not been surveyed and information such as invert elevations for culverts and ditch cross sectional area is almost entirely missing. These data are important for evaluating drainage capacity and flooding potential.

A general categorization of known stormwater structures is provided in Table 9. This table is provided as a means of illustrating the relative size and complexity of the system that is managed. It should not be considered to be highly accurate because the inventory is incomplete and because this information changes fairly often.

Table 9. Stormwater Infrastructure in Belfair UGA.[a]

Device Type	Total	County	WSDOT	Private
Catch Basins	35	29	0	6
Culverts	23	Unknown	Unknown	Unknown
Catch Basin Culverts	32	Unknown	Unknown	Unknown
Outfalls	6	Unknown	Unknown	Unknown
Detention Facilities	5	0	3	2
Detention/Wetland			4	
Wetland			1	
Oil/water separator			1	
Regional Facilities	1	0	0	1[b]

[a] Based on GIS data obtained from Mason County in September 2015.

[b] Hood Canal Salmon Enhancement Group maintains a regional stormwater facility at the Northwest Pacific Salmon Center WSDOT Facilities.

The widening and safety improvements of SR 3 resulted in construction of 6 stormwater facilities; an oil/water separator at one site, detention ponds with modular wetland treatment vaults were built at three sites, a modular wetland system, and a detention pond with a downstream wetland system. Due primarily to high groundwater conditions and lack of available land for increasing the size of these systems, there were significant changes between the design and construction phases of the project in terms of how stormwater is handled. The design included runoff control of 100 percent of the new impervious area but ultimately this was reduced to 76 percent due to the problems described.

In addition to the direct stormwater improvements that occurred as part of WSDOT's work, WSDOT identified a number of connections to their system from private property. This is a common issue with existing stormwater systems and typically neither the property owner or WSDOT knows of these connections until projects such as this are completed. In this case, the owners were notified about these connections and WSDOT replumbed most of them, removing the connection. This activity also served as a reminder to about their responsibilities for treating stormwater and cleaning and maintenance of their system. Thus, an important indirect benefit of the SR 3 project was the removal of, and improvements to, a number of private connections.

When WSDOT builds the SR 3 Freight Corridor, additional stormwater facilities will be built; as yet the location and types are unknown. WSDOT facilities including culverts and detention ponds are documented in the WSDOT stormwater features inventory database.

Private Facilities

There is no existing inventory or database for private stormwater facilities in the UGA. According to a previous study (ESA 2006), there were approximately 20 businesses, or groups of business that maintain onsite stormwater detention and treatment, but most older developments are believed to release their water untreated (Otak, 2007a No more recent or verifiable information is available for private facilities.

Stormwater Infrastructure Challenges

A regional treatment facility was recently built at the Pacific Northwest Salmon Center (PNSC) near the mouth of the Union River. This facility is capable of retaining 13 acre-feet of stormwater; this capacity is not currently being used (Mendy Harlow, Executive Director, Hood Canal Salmon Enhancement Group, personal communication, November 2015).

HYDROLOGIC MODELING

As part of the basin plan development, hydrologic modeling was used to help inform recommendations about the regulatory requirements that will govern future development projects and about the necessary programs and capital projects to help mitigate flooding and protect water quality and environmental health in the Belfair UGA. Various hydrologic modeling analyses were used to support these recommendations. A detailed presentation of these modeling analyses can be found in the *Modeling Report for the Belfair UGA Stormwater Basin Plan* in Appendix C.

Modeling was completed at two scales. At the site scale, modeling was employed to evaluate hydrologic implications of different stormwater management regulatory schemes. At the UGA scale, modeling was employed to establish baseline hydrologic conditions basin-wide and to identify potential future development-related problem areas. The UGA-scale modeling was used to guide the development of capital projects and programmatic recommendations as described later in the CIP Project Development and Prioritization and Stormwater Program Recommendations sections.

A summary of these analyses and the results are presented below.

SITE-SCALE REGULATORY EVALUATION

The site-scale modeling was carried out to investigate the merits and hydrologic implications of two regulatory schemes applied to development in the Belfair UGA. The two regulatory schemes were to:

- Maintain current stormwater management requirements set forth in the *2005 Stormwater Management Manual for Western Washington* (SWMMWW) (Ecology 2005) and the 2008 Mason County Low Impact Development (LID) Ordinance (No. 76-08)

- Modify stormwater management requirements by adopting those set forth in the 2014 SWMMWW (Ecology 2012 as amended in 2014)

To evaluate and compare site-scale regulatory schemes, modeling scenarios were developed based on a hypothetical new, small, commercial development. Multiple scenarios were developed that considered the impact that specific soil types (outwash and till) have on managing stormwater on the hypothetical small commercial development. In total, the analysis included four scenarios based on the two manuals (2005 and 2014) and the two soil types.

This analysis looked at the size, performance, and cost difference for managing stormwater using an infiltration facility under both regulatory systems. As a result, facilities designed under the two regulatory schemes perform similarly when meeting all minimum requirements, which includes flow control. Considering the Mason County LID requirements, LID facility sizes do not decrease with better infiltration and filtration rates. Therefore, in scenarios with good draining soils, the current Mason County stormwater requirements result in larger design of facilities. Given this and the lack of flexibility inherent in selecting LID BMPs under current regulatory scheme, it was recommended that Mason County consider adopting the 2014 SWMMWW (Ecology 2012 as amended in 2014).

UGA-Scale Evaluation

As previously noted, the UGA-scale modeling was performed to aid in the identification of existing and potential future problem areas, which in turn were used in the basin planning effort to inform development of potential programs and capital projects to address problem areas. To complete the modeling, the Belfair UGA was delineated into 19 drainage subbasins; some of which extend beyond the UGA boundary. These were the same subbasins identified in previous work (Otak 2007a) but modified based upon more recent LiDAR data.

Example LID BMP

Existing Conditions Modeling

For the existing conditions modeling, existing land use, impervious area, soil types, and slope were estimated or developed from various sources. A breakdown of land cover across the 19 subbasins is presented below in Table 10. Note that the subbasins include area outside of the UGA.

The average impervious area across the subbasins is 6.9 percent. As shown in Figure 5, most of the developed portions of the UGA are oriented along State Route (SR) 3, which generally runs north and south through the area. This includes Subbasin 110 (44 percent impervious), which is dominated by commercial land-use and is considered “downtown” Belfair, and Subbasin 150 (47 percent impervious), which is dominated by several landscaping supply yards north of downtown.

Existing conditions peak flows, runoff volumes, and flow durations were modeled to provide a baseline for comparison with future conditions. A predeveloped forested condition was also modeled to provide reference to the regulatory target for flow durations.

Table 10. Existing Land Cover by Soil Type for each Subbasin and Calculated Total Impervious Area.									
Subbasin	Forest on Till (acres)	Pasture on Till (acres)	Lawn on Till (acres)	Forest on Outwash (acres)	Pasture on Outwash (acres)	Lawn on Outwash (acres)	Pervious (acres) [%]	Impervious (acres) [%]	Total Area (acres)
10	–	–	–	38	–	8	46 [90%]	5 [10%]	51
20	–	–	–	104	–	19	123 [92%]	10 [8%]	133
30	–	–	–	160	–	17	177 [98%]	4 [2%]	181
40	–	–	–	64	–	8	72 [84%]	14 [16%]	86
50	–	–	–	68	–	2	70 [84%]	13 [16%]	83
60	–	–	–	52	–	8	60 [86%]	10 [14%]	70
70	5	–	–	315	–	8	328 [97%]	9 [3%]	337
80	–	–	–	114	–	6	120 [89%]	15 [11%]	135
90	15	–	1	567	–	26	609 [98%]	14 [2%]	623
100	109	39	16	25	5	25	219 [84%]	43 [16%]	262
110	9	–	8	3	–	4	24 [56%]	19 [44%]	43
120	82	4	46	126	1	38	297 [86%]	48 [14%]	345
130	6	17	23	8	29	10	93 [95%]	5 [5%]	98
140	29	4	15	57	3	27	135 [87%]	21 [13%]	156
150	–	–	–	41	–	23	64 [53%]	56 [47%]	120
160	75	18	9	234	9	43	388 [88%]	53 [12%]	441
200	22	–	3	454	–	24	503 [98%]	10 [2%]	513
210	62	–	3	1,639	–	49	1,753 [98%]	38 [2%]	1,791
220	4	–	–	424	–	32	460 [95%]	25 [5%]	485

Note: Subbasin areas exclude land use designated as wetland and gravel pit accounting for approximately 45 acres.

Future Conditions Modeling

Future build-out conditions were developed from a buildable lands inventory. This inventory was created from existing map layers of UGA zoning and statewide land use and then modified by applying buffers and constraints associated with “undevelopable lands” identified through a review of County codes. The undevelopable lands dataset included FEMA floodplain area, National Wetland Inventory (NWI) wetlands, riparian buffers (i.e., 150 feet from fish-bearing streams or shorelines of the state, 100 feet from non-fish-bearing streams or streams typed as "other" or with no type), slopes greater than 15 percent derived from LiDAR (cleaned up to remove small pixelated areas less than 1,000 sf), and other parcels excluded from future development identified by Mason County. All of these areas are excluded from build-out consideration (964 acres of area in total). (Note: Areas identified as undevelopable have a low likelihood of development; however, individual parcel review would need to be conducted to make an actual determination of developability at a parcel scale.)

Future build-out conditions were defined for each subbasin by omitting the undevelopable lands and assuming full utilization of existing zoning and densities for the remaining land area that is not currently developed. To determine the conditions associated with full utilization, a typical impervious cover breakdown for each zoning type was determined from existing conditions. The predicted future new land cover for each subbasin was added to the existing land cover to create future build-out conditions.

Future conditions peak flows, runoff volumes, and flow durations were modeled and compared to both existing conditions and a predeveloped forested condition. Predictably, the highest runoff volumes and peak flow were observed in subbasins with significant development within the UGA due to increased impervious land cover and decreased forest and pasture land covers. Future development and redevelopment is projected to occur more densely along the SR 3 corridor and around the junction of SR 300 and SR 3.

Drainage from Impervious Surface

While much of the future development will require stormwater treatment and peak flow control, some development areas will not meet the triggers for management under the existing stormwater management regulations. The majority of subbasins will see a net decrease in peak flows and flow durations due to redevelopment requirements, however two basins are projected to see an increase in flows over existing conditions. These two basins are estimated to see an increase in impervious cover of approximately 500-percent, indicating that small parcels that do not trigger flow management make a meaningful impact on flow within the basin. However, the magnitude of peak flow increases and flow exceedances predicted in these basins is small when framed against the large amount of impervious cover added. See exceedance plots in the *Modeling Report for the Belfair UGA Stormwater Basin Plan* in Appendix C.

CIP PROJECT DEVELOPMENT AND PRIORITIZATION

The County's stormwater CIP encompasses capital projects that can be completed proactively outside of the development/redevelopment process to improve water quality, aquatic habitat, and environmental health within the Belfair UGA. One of the significant outputs from this plan is a list of CIP projects that could address existing drainage problems and/or prepare for future predicted increases in discharge in the Belfair UGA.

The approach for development of the CIP project list was to identify the issues associated with stormwater runoff in the UGA, develop potential capital solutions to these issues, and prioritize them according to need and benefit. Following this step, conceptual designs were developed for a subset of prioritized projects. Each of these steps is summarized in Figure 8 and outlined in more detail in the following sections.

IDENTIFY STORMWATER ISSUES

The primary issues within the UGA related to stormwater runoff include: water quality impacts, aquatic habitat impacts, and flooding. Each is described in more detail below. Figure 9 depicts locations of key stormwater issues.

Temporary Solution to Drainage Problem

- **Water Quality Impacts –** Much of the development within the Belfair UGA is lacking or has inadequate stormwater treatment. Sediment, nutrients, trace metals, petroleum hydrocarbons, bacteria, and organic chemicals are common pollutants found in stormwater runoff and these are expected to be found in higher concentrations in stormwater runoff from the more developed portions of the UGA. As previously noted, the Union River has a TMDL for bacteria and is on the 303(d) list for temperature and dissolved oxygen. Stormwater from the Belfair area has been cited as an important source for these impairments.

  While stormwater management ordinances and regulations will maintain or improve stormwater runoff quality from new development or substantive redevelopment, these will not help improve existing development related stormwater issues. As such, stormwater treatment retrofits that address impacts from existing development are recommended.

As noted in the Modeling Report (Appendix C), there was insufficient data to support water quality modeling within the Belfair UGA. So, hydrologic modeling was used as a surrogate to help identify those subbasins where water quality issues are expected to be the most problematic; that is, it assumed that those subbasins where there is more impervious surface and more intense land use and which therefore experience increased flow are likely to be those with more water quality issues. Subbasins 60, 100, 110, 130, 140, and 150 are recommended as the focus areas for CIP projects since these basins currently experience the highest peak flows and runoff volumes normalized by basin area.

- **Aquatic Habitat Impacts –** Baseline habitat data are not available for the streams in the Belfair UGA. The primary known aquatic habitat impacts in the UGA are related to fish passage barriers. As described previously, WDFW developed a state-wide inventory of fish passage barriers. WSDOT and Mason County have also surveyed fish passage barriers within their jurisdictions.
- **Flooding –** As noted in the previous Stormwater Management Plan (Otak 2007a), there are no identified existing major flooding or hydraulic capacity problems within the Belfair UGA. Minor, localized flooding issues identified in the previous plan have largely been addressed as part of the recently completed SR 3 improvements.

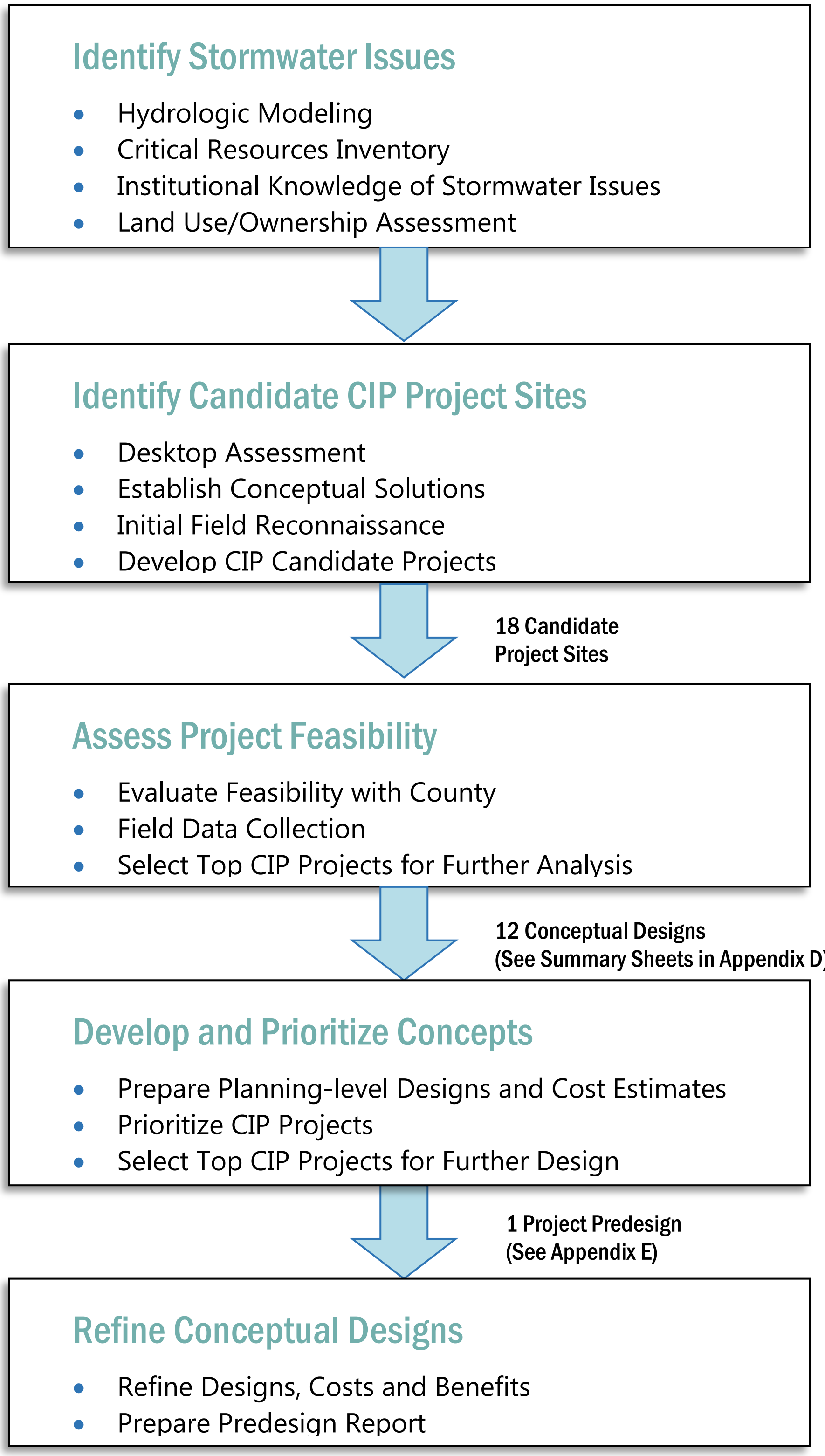
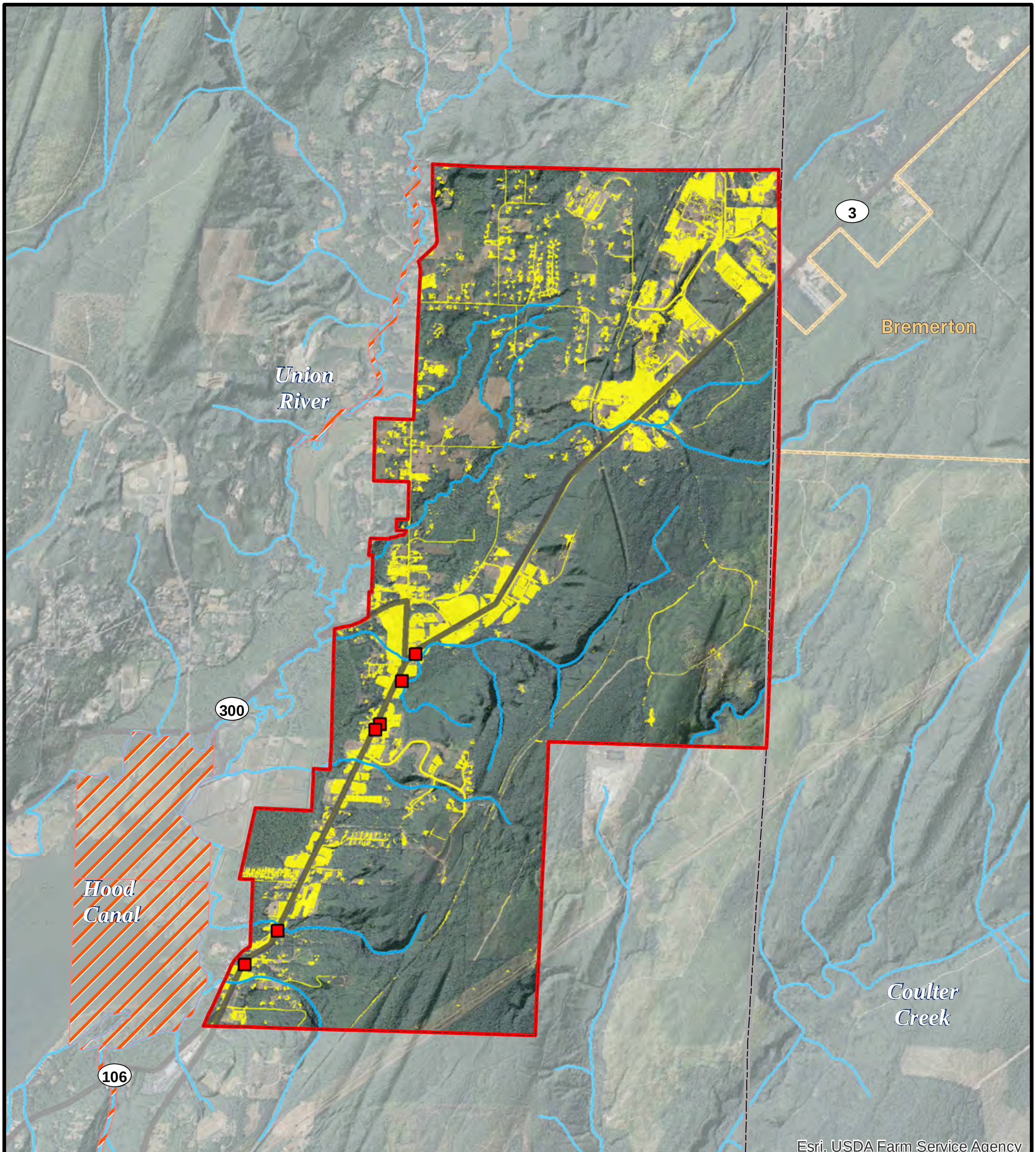


Figure 8. Process for Identifying and Prioritizing Stormwater CIP Projects.



Legend

- Impervious cover
- Water Quality Assessment 303(d) waterbody
- WSDOT Fish barrier project
- Belfair UGA
- County boundary
- City limit
- Stream or river
- Highway

Figure 9.
Key Stormwater Issues.

N

0 1,250 2,500 5,000 Feet

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IDENTIFY CANDIDATE CIP PROJECT SITES

Candidate CIP projects were identified by several means. A few projects were conceived by the County during previous planning exercises or were modified from previously conceived projects from the 2007 Stormwater Management Plan (Otak 2007a and b). Most of the projects were identified as part of this plan development process through a desktop assessment followed by field reconnaissance.

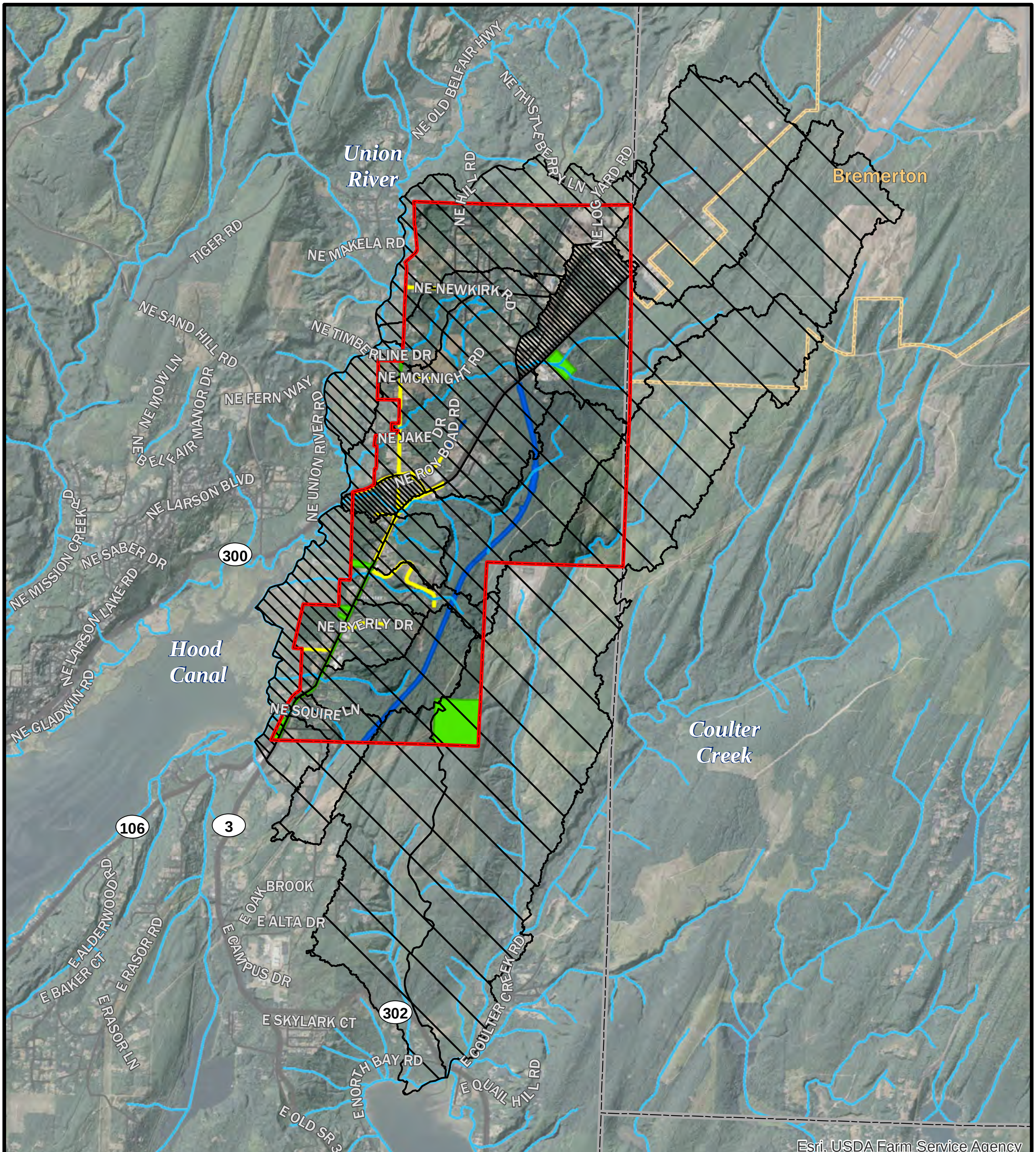
The desktop assessment was performed to gain an understanding of the physical characteristics of the UGA that affect stormwater CIP project feasibility and to identify specific project opportunity areas. The desktop assessment entailed overlaying the locations of stormwater issues (as described in the previous section of this Plan) with various inventories of critical resources and parcel data identifying public land ownership. A list of the data layers included in this overlay is presented in Table 11 and a map of the overlay is presented in Figure 10.

Table 11. Data Used to Identify Project Opportunity Areas.

Category	Dataset	Source
Base Data	UGA boundary	Mason County
	Parcel boundaries	Mason County
Utilities	Catch basins, culverts, outfalls, and detention ponds	Mason County
Stormwater and Water Quality	2012 303(d) listed water bodies	Ecology
	TMDL boundaries	Ecology
	Potential retrofit sites	Herrera
	Areas of concern	Mason County
Hydrology	Hydrologic modeling results	Herrera
Environmental	Fish passage barriers	WDFW, WSDOT, and Mason County
	Deep and shallow infiltration potential	Aspect Consulting

This overlay map helped direct the initial field reconnaissance, which took place in October 2016. In general, the field effort was focused primarily on priority subbasins identified from the hydrologic modeling exercise (i.e., those basins predicted to have higher runoff in the future and therefore potentially more flow and water quality problems) and on publicly controlled (i.e., County, State, and Federal) properties and transportation rights-of-way; though some potential projects were considered on private property where opportunities were identified from the desktop assessment or observed in the field.

The suite of conceptual solutions considered during the initial field effort depended on the specific basin issues being evaluated. For projects that addressed water quality impacts, decentralized LID techniques and retrofitting of existing development was preferred over regional treatment facilities. This is consistent with the approach used in the amendment to the 2007 Stormwater Management Plan (Otak 2007b). A variety of LID retrofits were considered, including but not limited to, bioretention/infiltration, bioswales, and permeable pavement. For projects that addressed aquatic habitat impacts, a number of conceptual solutions were considered, including stream restoration, stream daylighting, fish passage enhancement, and habitat preservation among others. For flooding-related projects, storage solutions and conveyance upgrades were the primary project types evaluated.



Legend

Public parcels within UGA
- County
- State
- Federal

Existing 25-yr normalized by acre
- < 0.125 cfs
- 0.125 - 0.250 cfs
- 0.250 - 0.375 cfs
- > 0.375 cfs

- Belfair UGA
- County boundary
- City limit
- Stream or river
- Highway

Figure 10.
Potential Project Opportunity Areas.

N

0 2,000 4,000 8,000 Feet

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The initial field evaluation was conducted to identify specific projects and to conduct a preliminary assessment of feasibility and constructability. The following considerations were used in the assessment of project feasibility:

- Opportunity for water quality or flow control improvement,
- Absence of existing stormwater treatment or lack of effective stormwater treatment,
- Sufficient space available for retrofits given appropriate setbacks,
- Existing grading and surface drainage patterns to promote gravity flow to potential retrofit locations (with minor modification),
- Drainage infrastructure to route stormwater runoff to and around the retrofit can be reasonably modified,
- Lack of conflicts with other visible infrastructure or utilities,
- Limited long-term impact to existing uses (e.g., parking, pedestrian uses), and
- Minimal short-term impacts to the environment from construction.

A total of 18 candidate projects were identified during the desktop assessment and the initial field reconnaissance process. These projects and the process to further vet them is summarized in the next section.

Assess Project Feasibility

Further refinement of the preliminary project list was performed following consultation with the County and other stakeholders and a more intensive field reconnaissance visit in November 2016. From this effort, the list of 18 projects was reduced to 12. Projects were eliminated from further considerations for several reasons, including conflict with future development or construction plans, incompatibility with County priorities, and the presence or potential presence of legacy site contamination. Table 12 provides a summary of the 18 preliminary projects including the project type, a project narrative, and a rationale for elimination or retention of the project. A map of the retained and eliminated CIP project locations is provided in Figure 11.

Table 12. Summary of Preliminary CIP Projects.			
ID	**Category**	**Project Summary**	**Status**
1	Fish passage improvement	**Viola Creek Fish Passage Improvements –** Viola Creek is a salmon bearing stream and the culvert beneath the road is a fish passage barrier according to HCSEG. Conduct a fish passage improvement investigation for Viola Creek. Coordinate with WDFW and HCSEG to develop options and costs for passage improvement. *Note: More recent information from Mason County suggests this culvert may not be a fish barrier. Additional investigation is pending and this project will be updated as necessary.*	Retain
2	Fish passage improvement	**Irene Creek Fish Passage Improvements –** Irene Creek is a salmon bearing stream and the culvert beneath the road is a fish passage barrier according to HCSEG. Conduct a fish passage improvement investigation for Irene Creek. Coordinate with WDFW and HCSEG to develop options and costs for passage improvement. *Note: More recent information from Mason County suggests this culvert may not be a fish barrier. Additional investigation is pending and this project will be updated as necessary.*	Retain
3	Fish passage improvement	**Belfair Creek Fish Passage Improvements –** Belfair Creek is a salmon bearing stream and the culvert beneath the road is a fish passage barrier according to HCSEG. Conduct a fish passage improvement study for Belfair Creek from the east side of SR 3 to the existing active stream west of the commercial area. The study would include an alternatives analysis for stream location, accommodation of existing commercial uses, and preparation of preliminary plans. Coordinate with WDFW and HCSEG to develop options and costs for passage improvement. This project was previously identified in the 2007 Stormwater Management Plan (Otak 2007a; Otak 2007b).	Retain
4	Aquatic habitat improvement	**Sweetwater Creek Stream and Wetland Restoration –** This project is associated with plans for a new community park along Sweetwater Creek that is being spearheaded by HCSEG. Conceptual plans call for the restoration of Sweetwater Creek and associated riparian wetlands, restoration of a historic water wheel and removal of a fish passage barrier, and a new accessible trail with interpretive signage.	Retain
5	Stream daylighting	**Unnamed Stream Daylighting Study –** County is interested in daylighting the downgradient pipe that flows through private property fronted on Old Belfair Highway. Conduct a daylighting and habitat enhancement study to determine feasibility, and develop options and costs.	Eliminate
6	Bioretention retrofit	**Old Belfair Highway Sidewalk Retrofit –** Ditch in ROW of Old Belfair Highway (west side) could be enhanced to improve water quality (e.g., bioretention). County planning future sidewalk improvement that could be leveraged with this retrofit.	Retain
7	Bioretention retrofit	**William Hunter Park Bioretention (West) –** Runoff from Clifton Lane flows west along the curb and gutter adjacent to William (Bill) Hunter park in downtown Belfair. Two catch basins in Clifton Lane capture this runoff and convey it untreated to the municipal stormwater system, which eventually discharges to the Union River. Through simple pipe modifications and curb cuts, the runoff directed to these catch basins would be routed to a new bioretention facility at the lower or western end of the park. This bioretention facility would be sited in existing green space adjacent to an existing small plaza and sculpture near the intersection of Clifton Lane and State Route 300. One catch basin and the existing connecting pipe would be decommissioned. Signage could be installed to provide education and information on the facility for the public.	Retain

Table 12 (continued). Summary of Preliminary CIP Projects.			
ID	**Category**	**Project Summary**	**Status**
8	Bioretention retrofit	**Roy Boad Road Bioretention –** Piped runoff from the Safeway development and Roy Boad Road converge at a catch basin located within a grassy area north of the Roy Boad Road and Clifton Lane intersection within the County ROW. Some overland runoff from Roy Boad Road and Clifton Lane is also directed to this area. This combination of public and private runoff is collectively conveyed to a private stormwater pond to the north. This pond appears to provide flow control, but offers limited water quality improvement. This project would create a large bioretention facility where these flows converge in the ROW to improve water quality upstream of the pond. To intercept piped flow, the facility would need to be 6 to 7 feet deep. A combination of low walls, ornamental fencing, vegetation, and stepped terraces would be used to avoid safety concerns related to public access and to create an aesthetically pleasing facility in this highly visible location.	Retain
9	Regional BMP	**Public/Private Regional Facility –** Empty commercial parcel for sale in northwest corner of Safeway development parking lot. Opportunity for large regional facility to manage runoff from parking lot and potentially from Clifton Road. Property acquisition would be needed.	Eliminate, County wants to avoid use of developable property for stormwater control.
10	Wetland/ landscape preservation and enhancement	**William Hunter Park Expansion –** A forested wetland covers the southern portion of William (Bill) Hunter park and an adjacent commercial parcel that is mostly undeveloped and currently for sale. The wetland appears to have marginal functionality and would be threatened by any new development on the commercial parcel south of the park. This project entails acquiring the commercial property to expand the park and to preserve the wetland and surrounding landscape, including mature trees. Wetland enhancement work would be conducted to improve wetland function and aesthetics. This could include trash and invasive species removal, native wetland vegetation planting, and targeted regrading if necessary. A boardwalk and interpretive signage could be considered to provide safe public pedestrian access and educational opportunities. The existing dilapidated residential structure on the western edge of the property would be demolished and the footprint would be incorporated into the expanded park landscape.	Retain
11	Bioretention retrofit	**William Hunter Park Bioretention (East) –** Runoff from Clifton Lane flows northwest along the curb and gutter west of the Safeway development in downtown Belfair. Several catch basins in Clifton Lane capture this runoff on the west side and convey it to municipal stormwater pipes on the east side of the road. This runoff is untreated and eventually discharges to the Union River. This project would decommission one of the downgradient catch basins and redirect the runoff to a new bioretention facility at the upper or eastern end of William Hunter park. This bioretention facility would be sited in existing green space near a picnic area. Signage could be installed to provide education and information on the facility for the public.	Retain

Table 12 (continued). Summary of Preliminary CIP Projects.			
ID	**Category**	**Project Summary**	**Status**
12	BMP Retrofit	**Safeway BMP Retrofit –** Retrofit existing linear BMP behind Safeway development shops. Currently overgrown with blackberries and other invasives. BMP could also be configured to manage road.	Eliminate, BMP was retrofitted within past 5 years to dewater groundwater directly to wetland. Needs maintenance, not capital project.
13	Bioretention retrofit	**SR 3 Linear Bioretention Retrofit –** Long bare bed in ROW on north side of SR 3 adjacent to Safeway development. Bed is currently devoid of vegetation. Could be retrofitted with bioswale or linear bioretention.	Eliminate, incompatible with SR 3 widening.
14	Bioretention retrofit	**SR 300 Bioretention Retrofit (South Shell) –** Small vegetated area with existing ditch between stormwater pipes, adjacent to Shell gas station entrance on east side of SR 300. Opportunity to retrofit with bioretention. Origin of flow unclear.	Eliminate, history of contaminated soils associated with this site.
15	Multiple LID opportunities	**Belfair Elementary LID –** Multiple opportunities to capture roof, driveway, and parking lot runoff via bioretention, permeable pavement, and other LID techniques	Eliminate, retrofit projects already completed/planned for the school.
16	Bioretention retrofit	**SR 300 Linear Bioretention Retrofit (North QFC) –** Runoff from SR 300 flows west along the curb and gutter to the north of the QFC development in downtown Belfair. Two catch basins between parking lot entrances capture runoff from SR 300 and convey it untreated to the municipal stormwater system, which eventually discharges to the Union River. Through simple catch basin modifications and curb cuts, the runoff directed to these catch basins would be routed to a new linear bioretention facility installed within the right-of-way north of the QFC development. One catch basin would be decommissioned. Potential utility conflicts (fire hydrant, utility pole) should be investigated before moving into further design. Multiple bioretention cells are proposed to work around utility conflicts.	Retain
17	Ditch retrofit	**SR 300 Ditch Improvement –** A ditch on the east side of SR 300 ROW adjacent to Belfair House Apartments is overgrown, full of organic debris, and overflowing onto the road shoulder. The ditch is located between the road and a berm that holds back a stormwater facility on the Belfair House Apartments property. Seepage of groundwater or wetland water through the berm was observed flowing into the ditch. With this project, the ditch would be enlarged slightly and revegetated to improve capacity and water quality. Seepage through the berm would be investigated further and remediated as needed.	Retain

Table 12 (continued). Summary of Preliminary CIP Projects.			
ID	**Category**	**Project Summary**	**Status**
18	Bioretention retrofit	**SR 300 Linear Bioretention Retrofit (East QFC) –** A poorly placed surface inlet is located in the middle of the curb lane of SR 300 in front of the QFC development. As a result, ponding/flooding routinely occurs at the adjacent driveway entrance to the QFC parking lot. In addition, runoff from SR 300 further downgradient from this point is collected from both sides of the street and conveyed untreated to the Union River. This project would decommission the misplaced surface inlet and route flow intended for this inlet, along with two additional downgradient catch basins, to a series of long linear bioretention facilities in the SR 300 ROW in front of the QFC development. The ROW is sparsely vegetated with low quality shrubs and some mature trees. A larger bioretention facility would also be placed at the point where runoff collected from both sides of SR 300 converge (southeast corner of QFC parking lot).	Retain

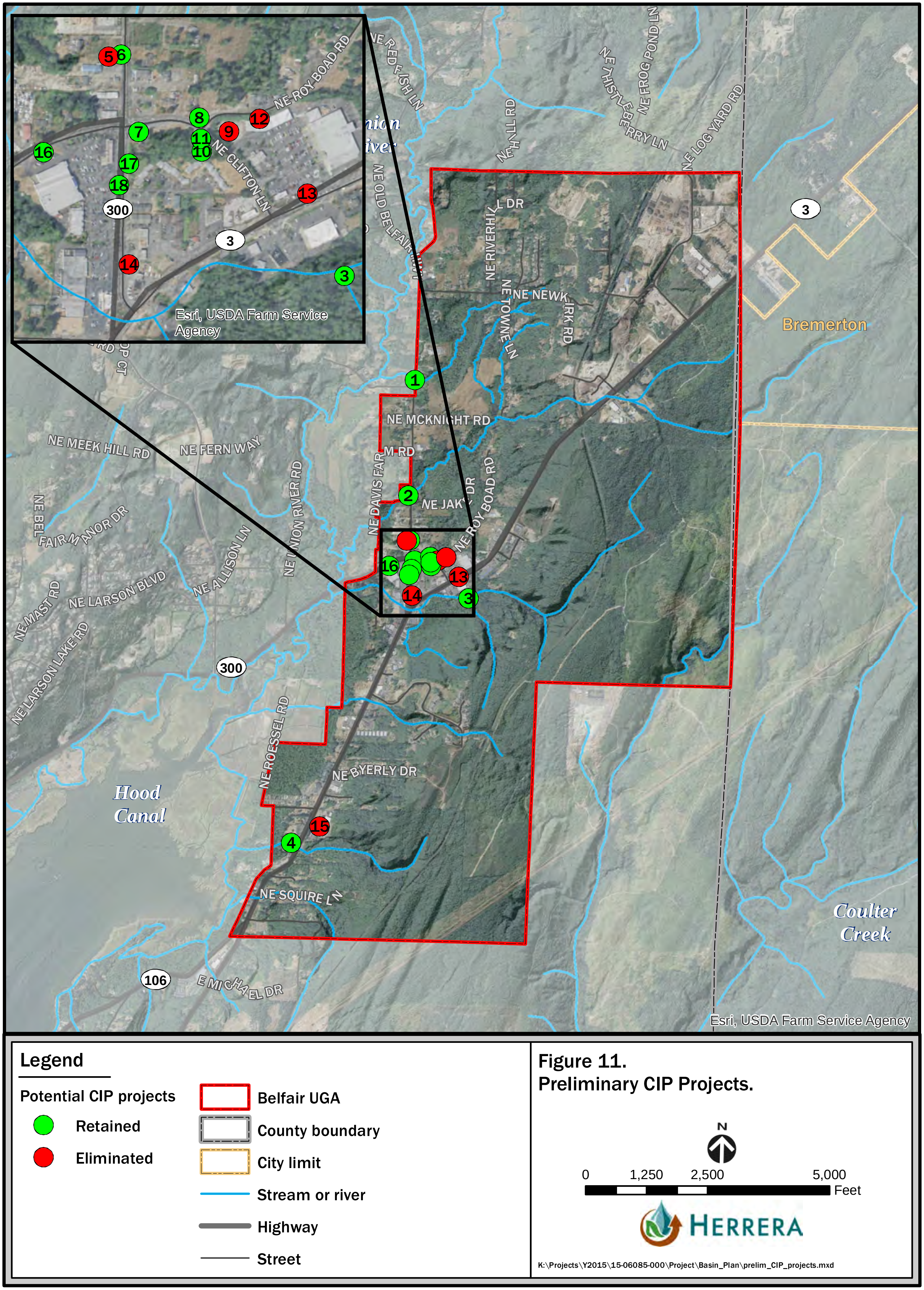

Figure 11.
Preliminary CIP Projects.

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DEVELOP AND PRIORITIZE CONCEPTS

Conceptual designs were subsequently developed for the 12 CIP projects that were retained following the project feasibility assessment. These concept designs are provided in the project summary sheets in Appendix D. The summary sheets include a project narrative summary, a map and concept sketch, and existing conditions photos.

Example Bioretention Design

Following concept development, the 12 CIP projects were evaluated and ranked based on a set of qualitative prioritization metrics. The intent of this effort was to identify the highest priority projects to implement that would most effectively meet overall plan objectives. Each qualitative metric for each of the CIP projects received a rating of “High,” “Medium,” “Low,” or “None” related to how well the project satisfies the metric. These ratings were converted to a score of 0 to 3. Higher scores suggest that the project more effectively satisfied the metric (i.e., rating of “High” is equal to a score of 3). The qualitative metric scores were weighted in terms of importance and then combined to determine an overall project priority score (scale from 0 to 100). Higher scores reflect higher priority projects.

Table 13 presents a summary of the prioritization scheme, including metrics, metric weight, and rating scores. Table 14 provides the results of the project prioritization.

Table 13. Prioritization Scheme Summary.

Category	Category Weight (percent)	Metric	Metric Weight (percent)	Notes	Rating Category	Rating Score
Impaired Infrastructure	20%	Addresses Existing Infrastructure Issue or Deficiency	20%	Based on drainage, fish passage, or other issues identified by County or observed in field.	YES	3
					NO	0
Stormwater	40%	Improves Water Quality	20%	Anticipated water quality improvements. Based on impervious surface type (pollutant generation) and treatment effectiveness.	HIGH	3
					MED	2
					LOW	1
					NONE	0
		Reduces Water Quantity	20%	Anticipated water quantity improvements and peak flow attenuation.	HIGH	3
					MED	2
					LOW	1
					NONE	0
Ecological	20%	Habitat Creation/ Rehabilitation	20%	Creates or enhances aquatic and/or terrestrial habitat.	HIGH	3
					MED	2
					LOW	1
					NONE	0
Education and Community	20%	High Visibility	10%	Highly traveled areas, where there are opportunities for public education.	HIGH	3
					MED	2
					LOW	1
					NONE	0
		Enhances Public Space	10%	Improves public space and community identity.	HIGH	3
					MED	2
					LOW	1
					NONE	0

Table 14. Project Prioritization.										
					Impaired Infrastructure	Stormwater		Ecological	Education and Community	
					Infrastructure – Addresses Existing Infrastructure Issues	Improves Water Quality	Improves Water Quantity	Ecological – Habitat Creation/ Rehabilitation	High Visibility	Enhances Public Space
Rank	**Project ID**	**Project Name**	**Estimated Project Cost**	**Total Score**	**20%**	**20%**	**20%**	**20%**	**10%**	**10%**
1	18	SR 300 Linear Bioretention Retrofit (East QFC)	$309,000	67	YES	HIGH	LOW	LOW	MED	MED
2	4	Sweetwater Creek Stream and Wetland Restoration	Data Requested	57	YES	MED	NONE	HIGH	LOW	NONE
3T	7	William Hunter Park Bioretention (West)	$54,000	50	NO	HIGH	LOW	LOW	HIGH	MED
3T	8	Roy Boad Road Bioretention	$535,000	50	NO	HIGH	LOW	LOW	HIGH	MED
3T	11	William Hunter Park Bioretention (East)	$42,000	50	NO	HIGH	LOW	LOW	HIGH	MED
6T	6	Old Belfair Highway Sidewalk Retrofit	$60,000	47	NO	HIGH	LOW	LOW	MED	MED
6T	10	William Hunter Park Expansion	$311,000	47	NO	LOW	NONE	HIGH	HIGH	HIGH
6T	16	SR 300 Linear Bioretention Retrofit (North QFC)	$36,000	47	NO	HIGH	LOW	LOW	MED	MED
6T	17	SR 300 Ditch Improvement	$49,000	47	YES	LOW	LOW	LOW	LOW	LOW
10T	1	Viola Creek Fish Passage Improvement	$50,000	43	YES	NONE	NONE	HIGH	LOW	NONE
10T	2	Irene Creek Fish Passage Improvement	$50,000	43	YES	NONE	NONE	HIGH	LOW	NONE
10T	3	Belfair Creek Fish Passage Improvement	$50,000	43	YES	NONE	NONE	HIGH	LOW	NONE

REFINE CONCEPTUAL DESIGNS

A more detailed predesign report, including cost estimates and a refined conceptual design, was developed for one project, the Old Belfair Highway Sidewalk Retrofit. While this project was not the highest rated, it was selected for more detailed concept design development because of the timing of an associated County sidewalk improvement project planned for Old Belfair Highway.

Example Stormwater Retrofit

This retrofit project would be implemented in conjunction with the sidewalk improvement project and would provide stormwater runoff treatment for the roadway. This project would retrofit an existing stormwater ditch with a bioretention system to provide water quality treatment and infiltration of stormwater in a high traffic location in downtown Belfair.

The predesign report is specifically tailored to address application requirements for grants provided by Ecology to fund full design and/or construction. The predesign report for this project can be found in Appendix E.

STORMWATER PROGRAM RECOMMENDATIONS

The County is in the enviable position of not yet falling under the NPDES Phase II permit and therefore being able to adopt a phased and strategic approach to addressing existing and future stormwater concerns. While there are water quality concerns, there are no critical flooding or safety issues; therefore, the emphasis on stormwater management should be on preventing pollution and establishing the building blocks that are essential to an effective management program and that reflect the framework of the NPDES Phase II permit. Building blocks consist of such things as updating stormwater ordinances, developing a stormwater system map and inventory, providing focused public education on priority areas, supporting existing programs, and providing incentives where feasible.

Stormwater Quality

Table 15 provides a general summary of the basic components of the permit, the key requirements of those components and recommendations for the Belfair area.

The sections following Table 15 lay out a series of stormwater program recommendations. Implementation of these recommendations would also help to meet one of the key goals of the County's Comprehensive Plan to protect the quality of the environment.

Table 15. Permit Summary, Requirements and Recommendations for the Belfair Area.[a]

Basic Requirements	Current Activities	Recommendations
Illicit Discharge Detection and Elimination (IDDE)		
Basic Requirements	**Current Activities**	**Recommendations**
This permit component requires mapping and inventory of the stormwater system, development of an ordinance to prohibit illicit discharges, and establishment of an ongoing program to train staff, identify and detect illicit discharges, and track and maintain records related to this.	• The County currently maintains an agreement with Kitsap County to carry out outreach and training and inspection activities related to IDDE in the Belfair area. • There is an existing mechanism for reporting of illicit discharges through Ecology's ERTS reporting system. The County works cooperatively with Ecology to respond to these reports. • The County is adopting IDDE codes and regulations to prohibit non-stormwater discharge and developing an enforcement strategy. • The County is beginning to implement a training program for staff.	• Implement a program to map existing stormwater features in the UGA over a 1- or 2-year period; including private systems. • Develop a system of updating the stormwater inventory as development occurs, mapping all new connections to the MS4, including private systems. • Update the County's IDDE code language to match the language in Ecology's IDDE manual. • Establish a public hotline to report spills and illicit discharges and/or provide this through the County's website.
Controlling Runoff from New Development, Redevelopment, and Construction Sites		
Basic Requirements	**Current Activities**	**Recommendations**
This permit component addresses runoff from new development, redevelopment, and construction site projects. It lays out requirements for a permitting and review, development of a plan for long terms operations and maintenance and inspection of stormwater facilities, and requires staff training. It also requires incorporation of LID principles and BMPs in development-related codes, rules, and regulations.	• The County has an LID ordinance in place that is more restrictive/less flexible than necessary or practicable. • The County notifies new applicants of the stormwater permit requirements for construction and industrial stormwater permits • Currently inspections are carried out by the engineer of record and no formal notification is required to the County. The County only does follow up inspections if there is a complaint. • The County requires project proponents to submit operations and maintenance manuals for engineered stormwater facilities as a part of the design review process.	• Adopt Ecology's 2014 manual and remove the existing LID ordinance. • The County should revise their submittal requirements to include detailed information on stormwater facilities and be sure those are provided in record drawings at project completion. • A private stormwater facility inventory database should be developed and a process implemented for insuring all new facilities are included in the inventory. • The County should consider requiring maintenance inspection forms be submitted every year for all new private facilities and require evidence of maintenance when it has been done.

Table 15 (continued). Permit Summary, Requirements and Recommendations for the Belfair Area.[a]

Basic Requirements	Current Activities	Recommendations
Municipal Operations and Maintenance (O&M)		
Basic Requirements	**Current Activities**	**Recommendations**
This permit component requires that the permittee adopt and implement a stormwater management manual that identifies maintenance standards and inspection requirements for stormwater facilities. The manual must meet the minimum requirements of Ecology's Stormwater Management Manual for Western Washington. This component also includes a long list of activities permittees must address related to practices for reducing stormwater impacts, such as street cleaning, pipe cleaning, and ditch maintenance. It also requires development of detailed stormwater control plans for some facilities, staff training, and record management.	The County has adopted Ecology's 2005 Stormwater Management Manual for Western Washington(2005 SWMMWW).	Adopt Ecology's 2014 Stormwater Management Manual for Western Washington, as Amended in December 2014 (2014 SWMMWW). • Implement a program to map stormwater features in the UGA over a 1- or 2-year period. • The County should continue to inspect and maintain the drainage systems associated with the County road system.
Compliance with Total Maximum Daily Load (TMDL) Requirements		
Basic Requirements	**Current Activities**	**Recommendations**
This permit component requires compliance and implementation of any applicable TMDL requirements.	The Union River TMDL requires:	No gaps identified.

Table 15 (continued). Permit Summary, Requirements and Recommendations for the Belfair Area.[a]		
Monitoring and Assessment		
Basic Requirements	**Current Activities**	**Recommendations**
Description of stormwater monitoring or stormwater-related investigations.	• Ecology maintains one long-term monitoring site in the lower Union River. • Mason County carries out a pollution identification and control (PIC) program that includes monitoring primarily for bacteria. • The County also responds to specific needs when they arise. For example, in response to a past shellfish area downgrade a monitoring program was implemented.	No gaps identified.
Reporting		
Basic Requirements	**Current Activities**	**Recommendations**
This permit component requires submittal of an annual report documenting permit compliance, and lays out requirements for records maintenance.	No stormwater specific reporting occurs currently. However, the comprehensive plan, which is updated annually, contains a summary of stormwater program activities.	The County should prepare a modified (i.e., brief) version of an annual report documenting stormwater activities and plans and maintain it on their website.

[a] The NPDES Phase II permit is a very detailed document with many specific requirements listed for each of the eight permit components. This is meant to briefly summarize the key aspects of the components and by intent does not include all of the requirements.

Flow Control


Example LID BMP: Bioretention

As documented through the modeling effort, Mason County's existing LID ordinance and Ecology's 2014 manual are essentially equivalent in terms of flow control and potential flooding associated with build-out of the UGA. However, the existing ordinance is too prescriptive, allowing little flexibility for developers in terms of how best to meet flow control needs. More important, the existing ordinance requires application of the same LID requirements throughout the UGA: including where there are poor soils, landslide hazards, and other underlying factors that should preclude or minimize use of infiltration based stormwater control.

Recommendation(s):

- Adopt Ecology's 2014 SWMMWW. (Note: Revisions to Mason County Code are already in progress related to this recommendation.)

Source Control

The most effective mechanism for reducing contaminants in stormwater and receiving waters is to eliminate or reduce the sources of contaminants in the watershed. The current NPDES Permit has many requirements related to implementation of illegal discharge detection and elimination (IDDE) program. Some of these elements should be adopted for the Belfair UGA. With the possible exception of bacterial contamination, commercial businesses and roadways are the most likely sources of contaminants. The County currently maintains an agreement with Kitsap County to carry out these activities in the Belfair area.

Recommendation(s):

- Develop an internal program to support source control training and outreach similar to the program previously done through an agreement with Kitsap County. Focus efforts on the Shelton and Belfair UGAs.

Fund the Stormwater Utility

There are permanent, long-term needs associated with managing the stormwater system in the UGA. Most of those needs cannot be met through existing funds or through grant programs. While Mason County adopted an ordinance that establishes a stormwater utility in the Belfair

UGA, they have not adopted a utility rate to support it. Even a low utility fee would allow the County to begin building a program that would meet some of the essential needs of an effective program and to prepare for future growth. In the absence of a dedicated funding mechanism, the County's general fund or roads fund should be used to meet the highest priority needs identified by this plan.

Recommendation(s):

- Fund the stormwater utility.

Public Stormwater System

Conveyance System Inventory and Assessment

Although most of the public stormwater structures have been inventoried in the Belfair area, the conveyance system including pipes and ditches has not been adequately inventoried or assessed. Managing the stormwater system in the Belfair UGA is made more difficult by the lack of this information. For example, the modeling done for this project could not be used to predict actual flooding potential or pinch points in the conveyance system due to lack of infrastructure data on such things as cross-sectional area and invert elevations. Likewise, a maintenance program for the system is difficult to generate without first creating an inventory.

The UGA is primarily served by a network of open channel ditches that provide stormwater conveyance on public and private property. This ditch system may be especially problematic. The ditches are not mapped, are not typically included as part of routine maintenance activities, and are often modified by private property owners without notification. It is unknown the extent to which they may be providing stormwater treatment or control.

Recommendation(s):

- Implement a program to map the conveyance system in the UGA over a 1- or 2-year period, and make initial assessments of the drainage area served by each.

- There are regional studies planned to develop a rating and classification system for ditches based on risk and maintenance needs. The County should support these studies and apply the findings to develop a specific plan and policies to cover maintenance of this part of the stormwater system.

- The County should continue to inspect and maintain the drainage systems associated with the County road system. (As outlined in the recommendations package from the Stormwater Task Force [SWTF] in 2012.)

- The City should continue to be proactive in leveraging planned capital facilities projects to include stormwater system upgrades and repairs.

Public System Retrofits

One of the inherent problems with relying upon the existing stormwater management manual and revisions to ordinances and regulations is that they influence only new development or substantive redevelopment. Thus, even if fully implemented the most they can do is help to maintain the status quo in terms of flow, water quality, and habitat. Retrofitting existing development is one way to improve conditions associated with the existing developed environment. The County must be proactive in identifying retrofit opportunities as part of all routine County construction projects. The County's roadway construction program is the largest likely source of retrofit opportunities.

Recommendation(s):

- The County's CIP should be reviewed annually, and all major construction activities should be evaluated to identify retrofit opportunities.

Private Stormwater System

Private Stormwater System Inventory

As the UGA builds out there will be an increasing number of stormwater treatment and control facilities that are privately owned. Although there are currently no requirements that the County have an inventory of these facilities, it makes good sense to begin development of an inventory program since the information can be collected as part of the site development review process. This is information that is difficult to obtain retroactively, so it is in the County's best interests to begin collecting it as soon as possible. This inventory is also needed to develop an understanding of how much stormwater is currently being controlled and then to estimate how much benefit could be achieved from retrofit of existing development and where best to focus efforts.

Recommendation(s):

- The County should revise their submittal requirements to include detailed information on stormwater facilities and be sure those are provided in record drawings at project completion.

- A private stormwater facility inventory database should be developed and a process implemented for insuring all new facilities are included in the inventory.

Private Stormwater System Inspections and Maintenance

Inventory of Stormwater Systems

As the UGA builds out there will be an increasing number of stormwater treatment and control facilities that are privately owned. These facilities require routine maintenance to perform properly. The County requires submittal of operations and maintenance manuals for all engineered facilities, but there is currently no program in place to ensure this is occurring. The current Phase II permit requires these facilities be inspected every year and maintained when necessary, thus eventually this will be required in the UGA and it is practical to begin building the program.

Recommendation(s):

- The County's website should be updated to include information on the importance of stormwater facility inspections and maintenance needs and requirements. The website should include appropriate checklists and BMP details to assist private property owners.

- The County should require project proponents to submit operations and maintenance manuals for all parts of their stormwater system as a part of the design review process.

- The County should consider requiring maintenance inspection forms be submitted every year for all new private facilities and require evidence of maintenance when it has been done.

Promote Private Stormwater Retrofits

One of the inherent problems with relying upon the existing stormwater management manual and revisions to ordinances and regulations is that they only influence new development or substantive redevelopment. Thus, even if fully implemented the most they can do is help maintain the existing condition in terms of flow, water quality, and habitat. Damage from past development will not be impacted. Even if the County took a very proactive role in providing for stormwater retrofits on their property, publicly owned property is only a small part of the picture. Therefore, any significant improvement over existing conditions would require retrofits on existing private property. Typical techniques for promoting retrofits is to provide education and technical support, although some communities offer financial incentives such as rebates on rain barrels, reimbursement for some of the costs for raingarden construction, and in some cases a reduced stormwater utility fee. Mason County is already providing support to educational and technical assistance programs and these efforts should be continued as recommended below.

Recommendation(s):

- Promote use of raingardens and roof downspouts for private residents through providing educational workshops for designing rain gardens, direct technical support for design, and permit review streamlining.

- Continue supporting WSU Cooperative Extension and Mason Conservation District programs to provide assistance to homeowners and businesses for smaller scale stormwater retrofit and nonpoint source control projects. (As outlined in the recommendations package from the SWTF in 2012.)

Incentivize Connections to Wastewater System

The community has a state-of-the-art wastewater treatment system that is under-utilized and at the same time the area streams continue to have bacteria problems, likely at least partially due to septic system failures. However, it is costly to hook up to the system, this coupled with long term utility bills are a large disincentive for voluntary hookups. One of the key recommendations identified by the SWTF was to establish a system to inventory, track, and assess maintenance for onsite septic systems and this program is now in place.

Recommendation(s):

- Require that septic systems be inspected and tested every 3 years and require that this information be filed with the County.

- Consider implementing a program to reduce initial hookup fees, similar to the fee reductions for low income housing. Focus outreach efforts on the areas with known poor soils.

Enforce Development Regulations

As described in the documentation from the SWTF (2012), new development (and redevelopment) can greatly impact surrounding property and the natural environment unless adequate protection is in place. Development codes and regulations, project review and inspection, and enforcement are important ways to ensure that growth pays for growth, and will reduce the need for expensive retrofits. Further, without enforcement of regulations, the regulations are not applied equally and the long-term burden for problems is likely to fall to County residents rather than project proponents. The SWTF felt strongly that the County needed to ensure "first and foremost" compliance with existing regulations. Their specific recommendations included:

- Restore a code compliance position to assist with enforcement. (Note: Progress has already been made in relation to this recommendation and a code compliance position has been reestablished.)

- Evaluate current codes, development processes and fees and refine language and practices where needed.

- Continue to require project inspections by the engineer of record (rather than County-performed inspections).
- Continue the use of stormwater checklists (rather than County-performed plan review).

Support Clean Water Program

Many of the recommendations developed during this planning effort would benefit if they all fell under the umbrella of an overall program and a related staff position to coordinate a county-wide "Clean Water Program." Public education and outreach, technical assistance, coordination with partners, water quality monitoring, oversight of TMDL implementation, and preparation for eventual NPDES compliance are a few of the key tasks that could be associated with this program/position. This was also a recommendation in the SWTF's 2012 assessment. However, without funding of the stormwater utility it is not practical at this time to support creation of a new position or monitoring program.

Identifying Habitat Improvement Opportunities

Recommendation(s):

- Continue to support the County health department's pollution identification and control (PIC) program.
- Continue to partner with the HCSEG and LWCCC to promote local education and outreach about stormwater and other water quality issues.
- Expand links to public education and outreach materials on the County's website to take advantage of materials and tools already available.

Long-Term Riparian Corridor Acquisition

Even with full enforcement of regulations on new or redevelopment projects, the legacy problems associated with past development will not be significantly impacted. Therefore, to improve already degraded water quality or habitat conditions, a more proactive approach is required.

Recommendation(s):

- Support existing programs spearheaded by groups such as the Hood Canal Coordinating Council and the Hood Canal Salmon Enhancement Group for long-term acquisition and protection of the riparian corridor.

PLAN IMPLEMENTATION

PLAN DEVELOPMENT

There were three public meetings held to discuss the initial plan findings and recommendations during development of this plan. Presentations were made to; the County Commissioners, the Lower Hood Canal Watershed Coalition, and North Mason Rotary Club. The general consensus at those meetings was to adopt Ecology's 2014 SWMMWW manual and eliminate the LID ordinance for the area and there was also support at the community level to start building a framework for a more comprehensive stormwater management program. Actual implementation of the identified CIP projects was not viewed as a high priority by either the community or the Commissioners, especially not when compared to the importance of starting to build some of the critical features of a stormwater management program, such as the mapping and inventory work. Although the County Commissioners are supportive of protecting water resources and understand the importance of a stormwater program, they decided the timing was not right to create an additional fee for the community. To that end, the following Implementation Plan, summarizes funding needs and implementation steps for only the highest priority needs identified, with emphasis on development of the building blocks for a more comprehensive stormwater program.

Example LID BMP

PROGRAM NEEDS

Table 16 lists the priority program improvement and staffing needs that should be slated to occur within the next 2 to 5 years. It is assumed that most of the high priority needs would be carried out (or continue to be carried out) by existing County staff with existing resources and that they would therefore be implemented gradually. One additional FTE has been recommended to assist with improved enforcement of existing regulations. Additional staff would also be required to implement the Clean Water Program, but that has been classified as a lower priority at this time. Again, the emphasis for program needs is to establish the building blocks for a more comprehensive program. (The highest priority recommendation made during development of this plan was to fund the stormwater utility to provide the necessary budget to carry out routine activities and address the many legacy issues related to owning a stormwater system that is many years old. However, at this time there are no plans to do this and therefore it is not included in the implementation program). Another high priority recommendation that also was time sensitive was adoption of Ecology's 2014 SWMMWW; this recommendation is already being implemented.

Table 16. Programmatic Needs and Staffing Needs for Implementation.

Need	Priority	Funded Under Existing Program	Additional Staff Needs[a]
Adopt Ecology's 2014 SWMMWW	High	Yes	
Continue Source Control/ Business Outreach Program Support[b]	High	Yes	
Fund the Stormwater Utility	High	Yes	
Conveyance System Inventory and Assessment[b]	High	Yes	
Public System Retrofits[c]	Low	Yes	
Private Stormwater System Inventory	High	Yes	
Private Stormwater System Inspection and Maintenance	Low	No	
Promote Private Stormwater Retrofits	Medium	Yes	
Incentivize Connections to Wastewater System[d]	High	Yes	
Enforce Development Regulations	High	Yes	1 FTE
Support Clean Water Program	Medium	No	1 FTE
Support Riparian Corridor Acquisition	Low	Yes	
TOTAL			**2 FTE**

[a] These staffing estimates have been revised from what was recommended in the data gaps assessment report (Appendix A).

[b] Although these are high priority actions, they will continue to be implemented in a gradual fashion.

[c] With the exception of those stormwater retrofit projects previously identified that are in design, additional retrofits will occur as opportunity allows as associated with other public works projects or through grants.

[d] These are programs that are the primary responsibility of other County departments or other entities. The stormwater programs role is primarily support.

One of the high priority data gaps identified during the initial phase of this project was critical areas mapping; such as wetlands and steep slopes. The modeling done as part of this project required development of this data, therefore this data gap has been addressed.

CIP Projects

Table 17 includes a list and cost estimate of the highest priority CIP projects identified. (More detail on these projects is provided in Appendix D.) Since there are no current plans to implement these, no attempt has been made to allocate funding for them to specific time periods. However, it should be noted that the community vision for development of the Belfair UGA as documented in the County's comprehensive plan is that it be a "more cohesive community with a more integrated, positive identity." A number of the projects identified were specifically selected and sited to both function as stormwater control and treatment structures and as attractive features to promote development of an aesthetically pleasing urban core.

Table 17. Identified CIP Projects.	
Project	**Estimated Cost**
SR 300 Linear Bioretention Retrofit (East QFC)	$309,000
Sweetwater Creek Stream and Wetland Restoration	Data Requested
William Hunter Park Bioretention (West)	$54,000
Roy Boad Road Bioretention	$535,000
William Hunter Park Bioretention (East)	$42,000
Old Belfair Highway Sidewalk Retrofit	$60,000
William Hunter Park Expansion	$311,000
SR 300 Linear Bioretention Retrofit (North QFC)	$36,000
SR 300 Ditch Improvement	$49,000
Viola Creek Fish Passage Improvement	$50,000
Irene Creek Fish Passage Improvement	$50,000
Belfair Creek Fish Passage Improvement	$50,000

SUMMARY AND CONCLUSIONS

Belfair UGA is arguably the most significant developed area along Hood Canal, a premier part of Puget Sound. This location, and the fact that it is directly adjacent to the Bremerton UGA (a quickly growing area), indicates that the regional population is expected to expand. This expansion will bring with it the typical development impacts and increased pressure on water quality, habitat, and surface water systems. The recent improvements to SR 3 and the addition of a wastewater treatment facility represent major upgrades that address some of the development pressures. However, as has been experienced across the Puget Sound area, it can be expected that ecosystem function in the Belfair UGA will be at best maintained in its current condition and more likely will continue to degrade.

Modeling at the site scale indicated that nothing is being gained by Mason County's existing LID ordinance and there are significant drawbacks to the program. As a result, a key recommendation of this study is that Ecology's most recent stormwater manual be adopted. The County is already implementing this recommendation.

Modeling at the watershed scale indicated that there are areas near the urban core where notable increases in stormwater discharge will occur as the UGA develops. (This is predicted to occur even with implementation of required stormwater controls for new development because of predictions about the way the development is expected to occur.) These areas (Figure 10) should be targeted for stormwater retrofit projects with a focus on flow control.

CIP projects were selected to both treat stormwater and in many cases to promote aesthetic development in what will become the urban core of Belfair. A total of 18 CIP projects were initially conceived and evaluated. Of these, 12 CIP projects were developed into preliminary concept and one was developed into a more detailed predesign plan. CIP project concept summary sheets are provided in Appendix D and the predesign concept is provided in Appendix E. However, generally there is no immediate plan for implementing these projects.

There is support from the community to start building the framework for a more complete stormwater management program. The initial building blocks identified in this plan include developing inventory and mapping databases and establishing internal procedures for tracking and documentation. In the absence of a funded stormwater utility, these needs will have to be met through the County's general fund and through grants where applicable.

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APPENDIX A

Data Gaps and Needs

DATA GAPS AND NEEDS ASSESSMENT FOR THE BELFAIR UGA STORMWATER BASIN PLAN

Mason County Public Works

Prepared by
Herrera Environmental Consultants, Inc.

Note:
Some pages in this document have been purposely skipped or blank pages inserted so that this document will copy correctly when duplexed.

DATA GAPS AND NEEDS ASSESSMENT FOR THE BELFAIR UGA STORMWATER BASIN PLAN

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Introduction

Mason County and Herrera Environmental Consultants (Herrera) are working in partnership with the Washington State Department of Ecology (Ecology) to develop a basin plan for the Belfair Urban Growth Area (UGA). The plan will provide a pathway forward for development and redevelopment of the UGA that ensures sound stormwater management and policies that are protective of the region's natural resources.

Management decisions for the new plan will be guided by modeling results and evaluation of existing data and known problems. For the modeling portion of this study, accurate information on existing conditions and detailed information that will help predict future conditions are critical for developing an accurate model. Likewise, complete and accurate data, where available, is valuable for evaluating real, known conditions that have been documented through monitoring and observation. The first step of both these processes is compiling existing data and identifying areas where data is lacking (data gaps).

The process of compiling data and evaluating completeness is ongoing and iterative. This document identifies the data sources that have been identified for developing the basin plan, and identifies limitations in the available data. The review of documents focuses on reports and information that were completed after 2005. The data gaps identified in this report represent those that were known at the outset of the project, and those that have been revealed as data has been compiled. If additional data gaps or data sources are identified, they will be addressed as the project moves forward.

Methods

The first step in the data collection and evaluation effort was to convene a workshop. In September 2015, staff from Mason County's Departments of Public Works, Community Development, and Public Health met with Herrera, Hood Canal Salmon Enhancement Group (HCSEG), and Mason Conservation District. The purpose of the meeting was to discuss project goals, problem areas, and available data and information. The data gaps identified at that meeting are discussed throughout this document in the appropriate sections.

Since the workshop, Herrera has focused on compiling and reviewing data relevant to the basin planning effort, this has included collecting GIS data and documents containing information pertaining to existing environmental conditions, existing development and infrastructure, and administrative constraints on new development and redevelopment. The results of this document and data review and limitations on the basin planning effort are described below.

Documents Review

A number of recent studies and plans contain information relevant to the development of the Belfair UGA basin plan. Several of these resources are planning documents that impact the way stormwater is managed in the UGA now and in the future. It is important that the basin plan account for planned changes within the watershed and to facilitate integration of existing and planned projects conducted by multiple agencies and groups. The documents that will be most informative to the development of the Belfair basin plan are listed and summarized briefly below.

- *Hood Canal Regional Stormwater Retrofit Project* (Herrera 2014). This report summarized an effort by a coalition of state and county agencies, tribes, and community groups to identify the most potentially beneficial stormwater retrofit opportunities throughout the Hood Canal watershed. Though the document addressed the entire Hood Canal watershed, and therefore examined stormwater issues and solutions at a larger scale, many of the same principles apply to the Belfair UGA. In some cases the data sources used will also be helpful in the development of the Belfair basin plan. Additionally, several sites within the Belfair UGA were identified as candidate sites for stormwater retrofits.

- *Hood Canal Stormwater Retrofit Infiltration Feasibility Assessment* (Aspect 2013). This report is a companion analysis to the Hood Canal Regional Stormwater Retrofit Project noted above. This report presents the results of an assessment of the potential of infiltrating stormwater in selected portions of the Hood Canal Basin. This assessment was completed to assist in the identification, screening, and conceptual design of potential stormwater retrofit projects. The primary products from this report are maps of feasibility for both shallow and deep infiltration. This will be important for identifying and modeling future stormwater retrofit opportunities in the Belfair UGA during the basin plan development. This assessment was completed for selected priority areas for the entire Hood Canal Basin and includes a portion but not all of the Belfair UGA.

- *County Municipal Code and Stormwater Ordinances* (Multiple Documents). County codes dictate allowable land uses within the UGA. There are also ordinances in place that prescribe or limit the types of stormwater management that may be used (e.g., LID for new development within the UGA, and required adherence to the 2005 Western Washington Stormwater Management Manual throughout Mason County). Management recommendations in the basin plan will need to consider modifications of these ordinances, and address complications that may be posed by natural factors such as slow infiltration rates in areas of the UGA. Municipal code and ordinances will also be important for the modeling studies because they help predict future development patterns and provide reference points for testing different stormwater management scenarios. The code documents that will be evaluated are:
  - *Belfair Urban Growth Area Zoning and Development regulations*
  - *Belfair UGA LID Ordinance (Ordinance Number 76-08)*
  - *Mason County Stormwater Management Ordinance (Ordinance No. 81-08)*
  - *Mason County Stormwater and Surface Utility Ordinance (Ordinance No. 80-08)*
  - *Mason County Fish and Wildlife Habitat Conservation Areas*
  - *Mason County Resource Ordinance*

- *USEPA 303(d) List of Impaired Waters* (EPA 2012). The 303(d) list identifies water bodies that consistently exceeded one or more water quality standards. The current approved 303(d) list was created in 2012. A new updated 303(d) list is pending approval. Both lists will be used for identifying known water quality problems within the UGA and contributing watersheds.

- *Drainage Alternative Selection: SR 3 Belfair Area Widening and Safety Improvements* (WSDOT 2009). The WSDOT State Route 3(SR 3) widening project compared stormwater drainage and treatment options for the SR 3 widening project in the Belfair area. It identified feasibility, environmental costs and benefits, and economic requirements of two different drainage options. Ultimately it recommended traditional stormwater conveyance and impoundment in stormwater ponds. This document may help inform development of the basin plan because it identifies issues of concern for the area, provides rationale for stormwater infrastructure selection, and details the existing drainage characteristics of stormwater infrastructure along SR 3. Construction plans should also be available, although they have not yet been provided.

- *Belfair Urban Growth Area Stormwater Management Plan* (Otak 2007). This provides background information about watershed characteristics and conditions, some assessment of culvert capacity, and a basic catalog of resources within the Belfair UGA. The document's primary focus and recommendations are for regional treatment facilities, although some potential site-scale retrofits were identified.

- Belfair Urban Growth Area Stormwater Management Plan Addendum (Otak 2007). Due to concerns about the focus on regional treatment facilities in the original plan, an addendum was prepared shortly after that entirely changed the focus of the plan to a decentralized approach using Low Impact Development(LID) techniques and retrofitting of existing development.

- *Union River Watershed TMDL Documents* (Ecology 2001, 2003; Cadmus Group 2010). The three documents related to the Union River fecal coliform TMDL document a known water quality problem within the Belfair UGA. The TMDL implementation plan also lays out a framework for addressing the problem. The basin plan will need to incorporate management strategies consistent with the Lower Union River TMDL implementation plan.

- *Lower Union River Stormwater Study* (ESA Inc. 2006). The 2006 Lower Union River Stormwater Study was a modeling effort that estimated runoff quantity and quality of stormwater originating in the Belfair UGA. It calculated predicted runoff for existing and future land use. It also recommended conveyance and treatment options for future and existing land use scenarios. The report's appendix is comprised of older documents that characterize the watershed. Although some of the content is outdated, this report and it's appendices provide a good inventory of watershed characteristics including: basin delineation, stormwater conveyance systems, soil type and drainage class, and stream habitat. This document will provide a useful cross reference for comparing new data sources and the assumptions that will be used for basin modeling.

- *Woodard Creek Stormwater Retrofit Study QAPP* (Thurston County 2005). The Woodard Creek stormwater retrofit study used modeling for comparing future build out and varied stormwater management strategies to (modeled) existing conditions for the purpose of prioritizing and optimizing stormwater retrofits in the area. A similar strategy will be used for modeling future conditions within the Belfair UGA. The QAPP provides useful suggestions with respect to quality assurance for the basin modeling.

GIS Assessment

Herrera completed an inventory of relevant GIS data available from Mason County and state and regional agencies. A summary of the datasets compiled during this inventory is provided in Table 1. Specific datasets are described in more detail in the appropriate sections below. An additional provisional dataset that may be added to the inventory is one recently developed by WDFW on land cover change detection in Puget Sound.

Table 1. GIS Data Sources.

Category	Dataset	Source
Base Data	UGA, RAC, and Hamlet boundaries	Mason County
	Parcel boundaries	Mason County
	Street centerlines and site addresses	Mason County
	Common places	Mason County
	County bridges	Mason County
Land Use and Planning	Belfair UGA zoning	Mason County
	2010 parcel-based land use	Department of Ecology (Ecology)
	National Land Cover Database (NLCD) 2011 land cover	US Geological Survey (USGS)
	NLCD 2011 percent developed imperviousness	USGS
	NLCD 2011 percent tree canopy	USGS
Topography	5- and 10-foot contours	Mason County
	2005 LiDAR data	Puget Sound LiDAR Consortium
Utilities	Catch basins, culverts, outfalls, and detention ponds	Mason County
Stormwater and Water Quality	2012 303(d) listed waterbodies	Ecology
	TMDL boundaries	Ecology
	Potential retrofit sites	Herrera
	Areas of concern	Mason County
Hydrology	HUC boundaries (2, 4, 6, 8, 10, 12)	Ecology
	WRIA boundaries	Ecology
	National Hydrography Dataset (NHD) flowlines and waterbodies	Department of Natural Resources (DNR)
	Waterbodies and watercourses	Ecology
Environmental	Fish passage barriers	WA Department of Fish and Wildlife (WDFW)
	Geologic units (24K)	DNR
	FEMA floodplain	Ecology
	Shoreline stability	Ecology
	Wellhead protection areas	Department of Health (DOH)
	Shellfish biotoxin closure zones	DOH
	Beach ends	DOH
	Commercial shellfish permitted harvesting sites	DOH
	Deep and shallow infiltration potential	Aspect Consulting
	Soils	DNR

Stormwater System

Based on available information, the stormwater infrastructure within the UGA is fairly minimal. The conveyance network consists primarily of open ditches and swales. Within the UGA there are a small number of stormwater features (e.g., detention ponds) owned by the County, WSDOT, and private entities. The network of stormwater drainages and features dictates how stormwater is managed in the UGA. A clear understanding of the location and functional aspects of the stormwater network is important for guiding the modeling process.

Data Assessment

County-Owned Public Facilities

The County maintains a network of open-ditch systems that are used for stormwater conveyance. The County also maintains a small number of detention ponds. Parts of the County-owned stormwater drainage network are mapped in ESA (2006), however critical information such as invert elevations for culverts and ditch cross sectional area is missing. These data are important for modeling drainage capacity and flooding potential. A GIS layer mapping the existing stormwater drainage network is not currently available. The drainage network can likely be determined using detailed elevation models of the UGA, but certain flow characteristics that would be valuable to the modeling study will still be lacking. Known stormwater facilities are documented in Table 2 and their ownership identified, where known.

Table 2. Stormwater Infrastructure in Belfair UGA.

Device Type	Total	County	WSDOT	Private
Catch Basins[b]	35	29	0	6
Culverts[b]	23	Unknown	Unknown	Unknown
Catch Basin Culverts[b]	32	Unknown	Unknown	Unknown
Outfalls[b]	6	Unknown	Unknown	Unknown
Detention Facilities[b]	5	2	3	0
Regional Facilities	1	0	0	1[a]

[a] Hood Canal Salmon Enhancement Group maintains a regional stormwater facility at the Northwest Pacific Salmon Center.

[b] Source: Mason County Public Works (2013).

Private Facilities

According to ESA (2006) there are approximately 20 businesses, or groups of business that maintain on-site stormwater detention and treatment. Otak (2007) mentioned that some of the newer commercial developments have onsite water quality and flow controls, but suggested that most of the older developments release their water untreated. There is no database for private stormwater facilities. A regional treatment facility was recently built at the Pacific Northwest Salmon Center (PNSC). However, specific details on the facility have not yet been obtained. Known private stormwater facilities are listed in Table 2.

WSDOT Facilities

WSDOT facilities including culverts and detention ponds are documented in the WSDOT stormwater features inventory database. As with the County-owned facilities, invert elevations for most culverts are unknown. All stormwater features associated with the SR 3 widening project are well documented on site plans provided by WSDOT. WSDOT has a GIS layer with location attributes for their stormwater features; this data has been requested but not yet received.

Data Gaps and Needs

There are substantial data gaps related to the existing stormwater infrastructure in the Belfair UGA. Although there are reports that describe or refer to stormwater features, none of the reports provide a complete inventory of stormwater infrastructure features, and details describing the features are lacking.

The stormwater conveyance network is poorly mapped and dimensional data for the network (e.g., cross-sectional area) is also unknown. The locations of catch basins and culverts are well documented in County and WSDOT databases; however, critical information such as invert elevations is not available.

There is no complete inventory of privately-owned facilities. The location of some of the facilities can be obtained from ESA (2006), however the size and drainage area of these features are not documented.

Although there are substantial data gaps, the modeling and GIS planning effort is still feasible; it will require use of assumptions as well as application of standard GIS analysis techniques and some limited additional data collection. For instance, in areas where details of the stormwater conveyance network are needed to delineate drainage basins, drainage pathways will need to be interpolated from watershed topography (via a flow accumulation grid) and the known location of other stormwater system features. For flooding analyses, where ditch, stream, or culvert dimensions are unknown for targeted areas, additional data collection may be required to obtain the missing dimensions. All modeling assumptions have the potential to distort the model results. As such, assumptions will need to be made carefully and thoroughly detailed in subsequent project documents.

Water Resources

Managing and protecting water and the associated resources within and downstream of the Belfair UGA is the primary purpose of the basin plan. As with any planning process, a reliable inventory of those resources is a natural starting point for developing a management plan. The following sections provide an overview of the data sources identified that inventory and describe natural resources and conditions within the UGA. Data gaps are also discussed to identify where more information would facilitate basin plan development.

Data Assessment

Water Quality

Most of the water quality monitoring in the Belfair UGA conducted during the past decade is related to the Union River Fecal coliform TMDL. Frequent and regular bacteria monitoring occurred at sites on the Lower Union River and Belfair Creek, within the UGA. Ecology operates one long-term monitoring station in the lower Union River where monthly sampling for conventional water quality parameters (e.g., temperature, conductivity, bacteria, dissolved and total nutrients) was conducted in 1998 and 2008. For many years Mason County has operated the Pollutant Identification and Correction (PIC) program, which primarily focuses on testing and identifying fecal coliform sources. Most of the fecal sampling occurs along the shoreline of Hood Canal. Several of the sampling sites are adjacent to the Belfair UGA. The PIC program also has ambient water quality monitoring stations to track long-term trends in a range of water quality constituents. However, Mason County does not operate any ambient monitoring stations in any of the drainages within the Belfair UGA.

A new source of water quality data will be associated with the Puget Sound Regional Stormwater Monitoring Program (RSMP). One site within the Belfair UGA has been included as part of the long-term status and trends monitoring network for the RSMP. The monitoring program is just completing the first year of data collection; it is unlikely data from this site will be available to inform this project.

There may also be other data available from Ecology associated with volunteer monitoring being performed in the Union River; this information has been requested.

Flooding

According to Mason County staff and based on complaints by residents (L. Swanson, personal communication, October 27, 2015), there is known or suspected flooding in several discrete residential and commercial areas within the UGA (e.g., a residential area behind QFC, bank property on NE Roy Boad Road, and along the western side of SR 3). The extent and cause of the flooding in these areas is unknown, and there are no maps defining the impacted area.

Species and Habitat

Several streams in the Belfair UGA provide spawning habitat for Pacific Salmon. Washington Department of Fish and Wildlife (WDFW) maintains the SalmonScape database which contains an inventory of salmon bearing streams in Washington as well as the location and types of barriers to fish passage. Several barriers to fish passage are identified within the Belfair UGA.

Aquifers, Water Supply and Infiltration Potential

Protecting groundwater resources is a high priority of the basin plan. It is important to identify areas that can influence municipal or private drinking water wells or critical recharge aquifers so that stormwater treatment devices that rely on infiltration can be placed such that they minimize risk to groundwater.

There is a critical aquifer recharge area adjacent to the western boundary of the UGA. A map showing this area has been provided in the Belfair Urban Growth Area Plan.

There is also a GIS layer that depicts wellhead protection areas for the UGA. There are four wellhead protection areas depicted on this map layer that have boundaries assigned by hydraulic travel time (i.e., 1, 5, and 10 year). There are however several wellhead protection areas listed for which there is not a wellhead protection plan in place, and do not have assigned protection zones based on localized groundwater hydrology. These represent Group A or B drinking water wells.

Infiltration potential has been mapped for a portion but not all of the UGA.

Data Gaps and Needs

Water resource data is sparse for several important facets of stormwater planning. Other than spot checks for fecal coliform bacteria, water quality data is only available for the largest streams within the UGA, and it is limited in terms of frequency and duration. There is relatively complete information on salmon habitat and salmon bearing streams.

Beyond local knowledge and anecdotal reports there appears to be no formal documentation of flooding problems or flood prone areas within the UGA.

Wellhead protection areas and critical aquifer recharge areas are also well documented and mapped. Infiltration potential is mapped for a portion of the project area, and the analysis can be applied to the remaining UGA.

Although there are limitations in the water resource data available, these data gaps are not critical to the basin plan development process. General water quality, climatic, and hydrologic variables will be used in lieu of basin specific data as input for the model and for informing management recommendations.

Land Use/Land Cover

Existing and predicted future land use and/or land cover data are critical elements that will be incorporated into the model used for development of the basin plan. Accurate information on existing land use/land cover and reasonable predictions of future land use/land cover are needed to develop and target basin planning. Quantifying current land use/land cover is a matter of cataloging existing data. Predicting future conditions is more complex and involves integrating data on known existing land use or land cover with administrative and physical factors that will influence the type and locations of future development.

A number of factors influence how and where future development will occur and as a result data sources used for predicting future development are varied. The following subsections aim to catalog the data sources that will be used for characterizing current and future land use/land cover for building reliable runoff and pollutant loading models.

Data Assessment

Land Use

Mason County has provided existing land use data at the parcel scale within the Belfair UGA. This information is documented as part of their parcel database and is classified into 40 land use designations that fit into eight broad categories: Residential, Commercial, Transportation, Trade, Services, Recreational, Resources, and Undeveloped. The County is working on reclassifying the designations into new categories specifically for the purposes of this project. Land use data is important for determining pollutant loading and for determining where and how future development will occur.

Land Cover

Land cover data for 2011 is available from the Multi-Resolution Land Characteristics Consortium (MRLC) as a raster dataset with 30-meter pixels. The data is classified into 21 land cover classifications that can be grouped into eight broad categories: Water, Developed, Barren, Forest, Shrubland, Herbaceous, Planted/Cultivated, and Wetlands. Supplemental datasets from MRLC include 2011 percent imperviousness and percent canopy cover. Land cover data is an important input for the hydrologic modeling of the Belfair UGA basin as it is critical for determining runoff potential. Another source of land cover data that will be reviewed and accessed if it is available is from WDFW and is related to land cover change detection. This is data that has not yet been acquired and may not yet be available. It will be added to the list of datasets when and if it is acquired.

Critical Areas

Critical areas are designated to prevent harm to the community from natural hazards and to protect natural resources. Generally speaking, natural hazards are frequently flooded areas and geologically hazardous areas (e.g., steep slopes). Natural resources include certain streams, wetlands, fish and wildlife habitat conservation areas and areas with a critical recharging effect on aquifers used for potable water. Specific definition for critical area criteria are documented in the Mason County 2006 Critical Area Update (Mason County 2006). There is no comprehensive data source (i.e., critical areas map) that details all of the critical areas in the UGA, rather, some specific critical areas are described in a number of sources.

Natural hazards are well defined and are documented in a number of sources. The most pertinent natural hazards affecting development potential within the Belfair UGA are landslide hazard and flooding. There are a number of criteria, based on Mason County's Critical Areas Ordinance, that qualify an area as a landslide hazard. For the purpose of modeling future development, the defining characteristic for landslide hazard areas will be hillslopes with grades in excess of 15 percent. Hillslope will be calculated and mapped for the UGA using 2005 LiDAR data with a pixel resolution of 6 feet. Flooding risks will be determined from FEMA 100-year flood maps.

Several sources catalog natural features qualifying as critical areas. In general these datasets are available as GIS layers from their respective sources. These natural features with data sources and data format are listed in Table 3.

Table 3. Critical Areas (Natural Resources) Data Sources.

Resource	Data Source	Data Format
NWI Wetlands	USFWS	GIS
Fish Habitat	WDFW	GIS
Priority Habitat and Species	WDFW	GIS
Riparian Buffers	Not mapped	
Critical Aquifer Recharge Area	Mason County	GIS

Wastewater and Septic Systems

Information on the location of the service area for the wastewater treatment facility has not yet been provided but should be available. Septic systems are not mapped but can be inferred.

Data Gaps and Needs

There are several data gaps related to land use and critical areas that are an important consideration in determining an appropriate modeling approach. GIS techniques will be used to synthesize these datasets to characterize land cover at a practical resolution for stormwater modeling. Characterizing future land cover will build on the existing datasets (including synthesizing future land cover from existing land use/land cover relationships) and account for zoning requirements, critical areas (e.g., habitat, wetlands, steep hillslopes, and critical aquifer recharge areas), and assumptions about buildable lands. Future land cover will also need to account for the rate and character of redevelopment in the UGA over the planning timeframe.

All of the critical areas data compiled to date are from state agencies and are lower resolution than is ideal for modeling and analysis purposes. For example, no data has been identified for riparian buffers, locally surveyed wetlands, or geohazards. Steep slopes can be derived from LiDAR data, and wetlands can also be inferred by LiDAR using a wetlands topographic wetness index. General assumptions will need to be applied for assigning riparian buffers.

Mason County is preparing parcel data with sewer connection status for the Belfair UGA, as well as sewer service areas by phase. The County will also be providing a dataset that summarizes undevelopable lands, such as those in conservation areas. These datasets are critical for this analysis.

Summary and Conclusions

Developing the Belfair basin plan is dependent on compiling, and integrating data from multiple sources. Previous planning efforts and studies provide some information and data, however, that data is often limited in scope, so it may be challenging to apply at the basin scale. A summary of the data sources, gaps, and pathways forward in light of the existing data set are detailed in Appendix A.

The physical characteristics (e.g., topography, drainage, and land use) are well described for the UGA, and data is fairly complete. These are some of the most critical watershed characteristics that will drive the modeling process. Unfortunately specific characteristics of the stormwater conveyance network (e.g., culvert invert elevations) that allow for accurate calculations of storage and flood potential are lacking.

Much of the planning criteria that will drive future land use and development patterns is well established through existing Mason County ordinances. The exception to this is critical areas, which are not well documented or mapped. Where this data is deemed critical, the first step will be to do an additional search for “hard copy” of the critical area that can be digitized.

Otherwise this information can be derived or inferred using standard GIS analysis techniques. Methods and assumptions will be documented.

Many of the data gaps identified in this document were known at the outset of this project. Knowing that data is limited, the plan has been to rely on modeling that uses regional water quality and climatic data to drive decision making related to basin planning. Some of the data gaps identified may limit some specificity of the models, which will result in more general basin planning recommendations. However, the overall basin planning process is still expected to serve its purpose of providing a balanced evaluation of future conditions under different management scenarios and is not expected to be greatly hampered by limitations in the existing datasets.

APPENDIX A

Data Gaps Summary Table

Table A-1. Data Gaps Summary.

	Data Sources	Data Summary	Solutions and Ramifications
Stormwater System			
Conveyance Network	• (ESA 2006)	• Mapping of stormwater conveyance network is limited. • Ditch cross sectional area is unknown • ESA mapped portions of stormwater network in 2005 but digital files are not currently available.	The stormwater conveyance network drainage pathways can be interpolated from topographic data for key drainage areas. Modeling capabilities will be limited for estimating capacity and flooding potential without ditch cross sectional areas. Cross sectional area would need to be obtained by time consuming and expensive field surveys.
Culverts	• GIS Layer	• Culverts are identified and locations are known. However, invert elevations and pipe diameter are unknown for most locations.	Modeling capabilities will be limited for estimating capacity and flooding potential without pipe diameter and invert elevation data. Pipe diameter and invert elevations would need to be attained via field survey.
Catch Basins	• GIS Layer	• Catch basin locations are identified and locations are known. However, invert elevations and pipe diameter are unknown for most locations.	Modeling capabilities will be limited for estimating capacity and flooding potential without pipe diameter and invert elevation data. Pipe diameter and invert elevations would need to be attained via field survey.
Detention Ponds	• (ESA 2006) • (Otak 2007) • GIS Layer	• Locations of newly constructed and publicly funded detention ponds are well known • Location and capacity of many private detention ponds unknown	Stormwater system storage capacity cannot be accurately estimated without better data on the size and location of stormwater ponds. Relatively simple field survey could determine location of private stormwater facilities. A more detailed survey and review of construction records (if available) would be necessary to accurately estimate storage capacity.

Table A-1 (continued). Data Gaps Summary.

	Data Sources	Data Summary	Solutions and Ramifications
Water Resources			
Water Quality	• (Ecology, 2003, 2007, 2010) • Mason County PIC Program	• Most conventional water quality data related Union River TMDL • Limited number of sampling sites in UGA (no data for smaller drainages) • Majority of PIC data fecal only	Although water quality data specifically for the Belfair UGA is limited, water quality modeling can be accomplished with relatively high confidence using regional water quality averages.
Flooding	• Loretta Swanson (personal communication)	• Flooding areas are not well mapped. • Known problem areas identified verbally at kick off meeting	Areas that were verbally identified at the kick off meeting will be added as a GIS layer to map products. Flooding problems may also be modeled for areas where details of the stormwater conveyance network are well documented.
Species and Habitat	• (WDFW 2015) • (Otak 2007) • GIS Layer	• Salmon presence documented in several area streams • Barriers to salmon migration well documented	Salmon habitat and presence is likely well documented for most streams within the UGA.
Groundwater	• GIS Layer • (Robertson et al. 2004)	• Wellhead protection zones well documented in GIS • Critical Aquifer recharge area well documented	Groundwater resources and areas vulnerable to contamination appear to be well documented and in a readily used (GIS) format.
Aquifer	• (Robertson et al. 2004)	• Belfair's aquifer recharge area is well documented • Specifics of groundwater hydrology within the UGA are not readily available	Groundwater resources and areas vulnerable to contamination appear to be well documented and in a readily used (GIS) format.
Infiltration Potential	• Aspect 2013	• Infiltration potential has previously been estimated and mapped for a portion of the UGA	The analysis technique used previously will be applied using the best available data to the remainder of the UGA.

Table A-1 (continued). Data Gaps Summary.

	Data Sources	Data Summary	Solutions and Ramifications
Land Use			
Existing Land Use	• Available through Mason County Parcel data	• Currently the parcel data is in 40 land use categories.	Land use data will be used for the pollutant loading assessment. The County is in the process of synthesizing the land use categories into fewer units for this assessment.
Existing Land Cover	• MRLC 2011 mapped data	• Recent data available for the entire UGA. However it is at coarse scale.	This data will be the key source for flow modeling due to the availability of impervious area data.
Future Land Use and Stormwater Management	• Various Mason County Ordinances	• Detailed zoning regulations allow for accurate prediction of future development patterns • Detailed stormwater management ordinances/requirements allow for detailed modeling scenarios	The level of detail provided in Mason County's zoning regulations and stormwater management ordinances provide good guidance for setting future land use parameters in modeling studies.
Critical Areas	• Mason County Critical Areas Ordinance • (Otak 2007) • (ESA 2006)	• Critical areas not well mapped • Habitat features listed in multiple disparate data sources • Stream buffers not established	Identifying critical areas is important for developing future land use scenarios. The lack of existing critical areas data will make this aspect of scenario development difficult. It may be possible to justify different data sources that have some critical areas information into a useable format, but it will be time consuming.
Wastewater and Septic Systems	• Mapped service area	• Phase 1 service area is in place and should be well mapped. Future phases should be available as predictions	The County is expected to provide this as a map unit that can be digitized.

APPENDIX B

Modeling Approach

TECHNICAL MEMORANDUM: MODELING APPROACH FOR THE BELFAIR UGA STORMWATER BASIN PLAN

Prepared for
Mason County, Washington

Prepared by
Herrera Environmental Consultants, Inc.

Note:
Some pages in this document have been purposely skipped or blank pages inserted so that this document will copy correctly when duplexed.

TECHNICAL MEMORANDUM: MODELING APPROACH FOR THE BELFAIR UGA STORMWATER BASIN PLAN

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February 9, 2018

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INTRODUCTION

Background

Mason County (County) and Herrera Environmental Consultants (Herrera) are working in partnership with the Washington State Department of Ecology (Ecology) to develop a basin plan for the Belfair Urban Growth Area (UGA). The plan will provide a pathway forward for development and redevelopment of the UGA that ensures sound stormwater management and policies that are protective of the area's natural resources. Management decisions for the new plan will be guided by modeling of various existing and future build-out scenarios. This document presents the modeling approach for the basin plan.

Overall Goals and Objectives

The project has multiple goals related to water quality and environmental improvements. The primary goals of the resultant basin plan are to:

- Reduce stormwater impacts to the Union River, Belfair Creek, and Union Cove
- Preserve aquatic habitats and hydraulic functions that support those habitats within the Belfair area
- Reduce barriers to low-impact development (LID) retrofits
- Increase stormwater management understanding and participation in private projects
- Increase coordination with resource management partners

Within the context of the basin plan development, the County must make decisions about the regulatory requirements that will govern future development and redevelopment projects and the necessary capital projects that will need to be undertaken outside of the development/ redevelopment process to improve water quality and the environment in the Belfair UGA. Various modeling analyses will be used to support these decisions and develop the stormwater basin plan. The specific modeling objectives to meet these goals are as follows:

1. Evaluate and compare the hydrologic performance of two regulatory schemes applied to development in the Belfair UGA:
    a. Maintain current stormwater management requirements set forth in the *2005 Stormwater Management Manual for Western Washington* (SWMMWW; Ecology 2005) and the 2008 Mason County Low Impact Development Ordinance (No. 76-08)

b. Modify stormwater management requirements by adopting those set forth in the 2012 SWMMWW as Amended December 2014 (2014 SWMMWW)

This evaluation will identify the optimal regulatory scheme for future development in the Belfair UGA based on the water quality and flow control performance of site scale stormwater management (i.e., performance measured against Minimum Requirements 5, 6 and 7 of the 2014 SWMMWW).

2. Evaluate and compare runoff volumes and peak recurrence interval under existing conditions and full build-out conditions (with future redevelopment/development governed by the optimal regulatory scheme selected) that can be expected in the Belfair UGA. This evaluation will aid in the identification of existing and future priority basins where potential capital projects can be targeted to address expected increases in runoff volumes and flows.

The remainder of this technical memorandum provides the proposed modeling approach for the two objectives identified above. The first modeling objective is concerned with comparing the impacts and benefits of stormwater regulatory requirements for future development. As such, this objective lends itself to a modeling evaluation on an individual site-scale. The second objective is concerned with evaluation of environmental conditions associated with full build-out across the UGA. This will require a larger UGA-scale modeling analysis. The modeling approaches for both objectives are discussed in more detail in the sections that follow.

Review of Previous Modeling Analyses in Study Area

Several stormwater-related modeling studies have been conducted over the past 10 years for the Belfair UGA, including the 2006 *Lower Union River Stormwater Study* (ESA 2006) and the 2007 *Belfair UGA Stormwater Management Plan* (Otak 2007). In addition, the *Hood Canal Regional Stormwater Retrofit Project* (Herrera 2014) was completed in 2014 for the entire Hood Canal watershed, including the Belfair UGA. The modeling element of each of these studies is discussed further below.

- *Lower Union River Stormwater Study* (ESA 2006).This study involved modeling using the StormShed2G and MGSFlood software programs to estimate the quantity and quality of stormwater runoff originating in the Belfair UGA. In this study, predicted runoff for existing and future land use was calculated. The study authors also recommended runoff conveyance and treatment options for existing and future land use scenarios.

- The *Belfair UGA Stormwater Management Plan* (SMP) and the subsequent addendum (Otak 2007) were developed to identify stormwater related infrastructure needed to avoid water quality and habitat impacts associated with continued development in the Belfair UGA. Modeling for this effort involved using MGSFlood to estimate peak flows at road culverts for capacity evaluation and to quantify stormwater management volume requirements for conceptualization of regional and site-scale BMP retrofits.

- *Hood Canal Regional Stormwater Retrofit Project* (Herrera 2014). This project report summarized an effort by a coalition of state and county agencies, tribes, and community groups to identify the most potentially beneficial stormwater retrofit opportunities throughout the Hood Canal watershed. Retrofits were evaluated based on managed runoff volumes calculated using MGSFlood. A number of priority retrofits were identified in the Belfair UGA.

Site-Scale Regulatory Evaluations

Modeling Objective

Site-scale modeling will be performed to compare the two regulatory schemes being considered for the Belfair UGA and to determine the optimal regulatory scheme for anticipated future development.

Mason County has adopted the 2005 SWMMWW for the Belfair UGA. Additionally, the County has adopted special LID standards within the UGA. The LID standards apply to new development within the UGA but do not apply to re-development or construction of single-family residential units on a legal lot of record. In anticipation of its future National Pollutant Discharge Elimination System (NPDES) Phase II Municipal Stormwater Permit, the County may choose to adopt the 2014 SWMMWW for the Belfair UGA. The site-scale modeling evaluation will need to compare the difference between maintaining the current approach (i.e., the 2005 SWMMWW in combination with the LID standard) and adopting the 2014 SWMMWW. The comparison will need to address various types of development to adequately evaluate the overall impact of each regulatory scheme across the Belfair UGA.

Review of Previous LID Cost Analysis Modeling Evaluation

A study conducted for Ecology in 2013 evaluated the comparative cost difference associated with meeting the minimum requirements of the 2005 SWMMWW versus the 2014 SWMMWW for new development (Herrera et al. 2013). The study defined three hypothetical sites with stormwater management dictated by the two manuals being compared. The hypothetical sites included:

- 10-acre single-family residential development
- 1-acre commercial development
- 10-acre commercial development

It was assumed that all minimum requirements from both the 2005 SWMMWW and 2014 SWMMWW applied to all three of the site types and that all three constituted new development. This meant that each example development project:

- Had less than 35 percent existing hard surface coverage before development (triggering the new development requirements for all regulatory settings)
- Resulted in 5,000 square feet or greater of new and replaced hard surface, or the project converted 0.75 acres or more of vegetation to lawn or landscaped area

The 2013 study also considered the impact that specific soil types have on stormwater management. As such, the sites were modeled separately as if they were developed on outwash soils and till soils. The study used MGSFlood to perform conceptual sizing of stormwater management facilities and to measure overall hydrologic performance.

Site Development Scenarios

For this site-scale regulatory evaluation, a modified version of the small commercial site described above will be used as the basis to evaluate the two regulatory schemes being considered for the Belfair UGA. The site will be modified to ensure it fits the development type and scale that occurs in the Belfair area and to ensure that it is consistent with Belfair UGA zoning and development codes. Development type and scale will be determined by reviewing existing development patterns in the Belfair UGA and in consultation with the County. In total, four separate scenarios will be evaluated based on the two regulatory requirements, and two site soil types; outwash and till.

Model Inputs

MGSFlood will be run using a continuous precipitation and evaporation time series and a 15-minute computational time step. Belfair is located in the Western Puget Sound Lowlands region with a mean annual precipitation depth ranging between 55 and 58 inches (MGS 2006). The Puget West precipitation time series with an annual depth of 56 inches in MGS Flood will be used.

Land cover inputs for each development site will include impervious areas and landscaped areas on till soils or outwash soils. LID BMPs for each site will be represented in MGSFlood according to the modeling methods prescribed in the 2005 and 2014 SWMMWW. Similar to the 2013 Ecology study, uncorrected infiltration rates of 0.3 inches per hour for till soils and 6 inches per hour for outwash soils will be used for all infiltrating facilities.

Model Output

Output of this analysis will include typical stormwater facility sizes to meet the two regulatory requirements at the site scale. Annual runoff, infiltration, and overflow volumes will also be presented.

UGA-Scale Evaluation

General Approach

A UGA-scale model will be developed to aid in the identification of existing and potential future problem areas and development of potential capital projects, including regional flow control facilities, site-scale BMP retrofits, and environmental restoration projects. An existing conditions scenario will be evaluated first to establish baseline conditions. A future build-out scenario will then be evaluated with stormwater management dictated by the chosen regulatory scheme from the site-scale modeling evaluation, but will exclude any future stormwater retrofit or environmental restoration projects. As noted above, it is anticipated that both the existing and future conditions scenarios will help inform the identification of future capital projects.

Determination of Future Build-out Conditions

Full build-out conditions will be developed from a buildable lands inventory. This inventory will be created from existing map layers of UGA zoning and statewide land use and then modified by applying buffers and constraints (e.g., related to environmental critical areas) as identified through a review of County codes. Full build-out conditions, assuming full utilization of existing zoning and densities, will be defined for each subbasin included in the model.

Development of Future Capital Projects

Herrera will work with the County and stakeholders to develop specific types, locations, and extents of future stormwater retrofit projects, habitat restoration projects, and regional flow control facilities. It is anticipated that these projects will include those identified during previous planning studies as well as new projects stemming from modeling described herein and observations of existing stormwater conveyance problems, flooding issues, and water quality impairments. A single set of these future capital projects will be included in the modeled scenarios.

Model Calibration

Quantitative calibration will not be performed for any of the models as flow data for calibration purposes are unavailable and there is not a requirement for calibration under the 2014 SWMMWW. Furthermore, the lack of model calibration is less important because of the comparative nature of the UGA-scale modeling objective (i.e., comparison of downstream hydrologic impacts of different regulatory schemes and stormwater retrofit alternatives). Qualitative checks and best professional judgment will be used to ensure that model results are reasonable and representative of known conditions.

Hydrologic Model

Modeling Objectives

A hydrologic model will be developed and run for existing conditions and future build-out conditions. The future conditions model will identify subbasins with increased peak flows and runoff volumes. Flow control retrofits will be selected and added to the future conditions model to characterize expected flow control benefits for each project.

Model Selection

The selected hydrologic model will represent rainfall runoff for continuous or discrete storm events in order to characterize runoff volumes and peak flows. Additionally, the model will need to represent stormwater flow control facilities. Hydrologic models considered for this analysis included the Western Washington Hydrology Model (WWHM), MGSFlood, and EPA's Storm Water Management Model (SWMM). MGSFlood was selected as the preferred model.

WWHM and MGSFlood are similar in that they are continuous hydrologic models that use HSPF based computations and allow use of precipitation data appropriate for Western Washington. While they both also produce similar rainfall runoff profiles and facility sizing, and can represent stormwater flow control facilities with infiltration, MGSFlood provides faster computational results for complex facilities such as infiltrating bioretention.

SWMM is also a robust hydrologic model that can use a continuous or a discrete precipitation time series, however the precipitation data must be developed outside the model. SWMM can also represent flow control facilities such as vaults and ponds, however infiltration cannot be included at these storage nodes in the model. SWMM has LID controls that represent infiltrating facilities such as bioretention and vegetated swales, but the model does not provide computation of the routing upstream and between LID facilities.

Model Domain

The UGA will be delineated into 19 drainage subbasins, similar to those identified in previous work (Otak 2007) but modified based upon recent LiDAR data that enables refining subbasin boundaries with greater accuracy than could be done in that previous work. Subbasin delineation refinements will also reflect any known drainage changes that have occurred since the 2007 delineation.

Model Scenarios

The existing conditions scenario will represent current land cover and existing stormwater management facilities. The model will estimate peak runoff volume and flow for each subbasin within the UGA. Peak runoff flows to be modeled include 2-year return period storms to evaluate channel forming flows and 25-year and 100-year storms to facilitate flooding evaluations. These values will be used as a baseline to compare future conditions results.

The future build-out scenario will represent future land cover based on the determination of future build-out conditions described previously. The model will estimate future peak runoff volume and flow rates for each subbasin, for the same return periods as targeted in the existing conditions model results. Subbasins in which large increases in flows are predicted compared to the existing conditions model will be identified as potential targets for stormwater programs that limit development impacts.

Stormwater detention and LID facilities for identified capital improvement projects will be explicitly modeled in MGSFlood and include infiltration. Facilities represented in the model will have typical storage depth and layout configurations that meet applicable stormwater management requirements.

Model Inputs

Table 1 below provides a summary of the expected model inputs and associated data sources for the hydrologic model. MGSFlood will be run using a continuous precipitation time series and a 15-minute computational time step. As noted previously, Belfair is located in the Western Puget Sound Lowlands region with a mean annual precipitation depth ranging between 55 and 58 inches (MGS 2006). Similar to the site-scale modeling evaluation, the Puget West precipitation time series with an annual depth of 56 inches in MGS Flood will be used.

Table 1. Hydrologic Model Inputs and Data Sources.

Model Parameter	Data Source	Model Values
Catchment Area	Basin delineation – Otak 2007	Area in acres
Land Cover	NLCD 2011 Land Cover – USGS, Land Use Washington State 2010 – Ecology, Belfair UGA Zoning – Mason County GIS	Percent of catchment area designated forest, pasture, grass, and impervious
Soil Type	Statewide Soil – USDA	Percent of non-impervious land covers overlaying till and outwash soil
Topography	10-foot Contours, Belfair Bypass Contours – Mason County GIS	Average catchment slope
Overland Flow Length	Basin delineation – Otak 2007, 10-foot Contours, Belfair Bypass Contours – Mason County GIS, Digital Elevation Model – USGS	Maximum catchment flow length
Stormwater Facilities	Stormwater detention ponds – Mason County GIS	Stormwater detention pond volume and outlet configuration

Ecology = Washington State Department of Ecology.

USDA = US Department of Agriculture.

USGS = US Geological Survey.

Catchment area divided into land cover types will be determined for each of the 19 subbasins. Land cover will represent impervious, forest, pasture, and grass ground cover on till soils or outwash soils. If the average catchment slope and maximum overland flow length varies significantly from default HSPF values, then they will be modified to better represent each subbasin. Runoff routing other than to existing detention facilities will be ignored.

Existing detention facilities to be represented in the model will be based on as-built drawings provided by the County.

Model Output

Annual runoff volume and the 2-year, 25-year, and 100-year peak flows will be determined for each subbasin.

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APPENDIX C

Modeling Report

MODELING REPORT
FOR THE
BELFAIR UGA STORMWATER BASIN PLAN

Prepared for
Mason County, Washington

Prepared by
Herrera Environmental Consultants, Inc.

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MODELING REPORT
FOR THE
BELFAIR UGA STORMWATER BASIN PLAN

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INTRODUCTION

Mason County (County) and Herrera Environmental Consultants (Herrera) are working in partnership with the Washington State Department of Ecology (Ecology) to develop a basin plan to address stormwater management for the Belfair Urban Growth Area (UGA). This plan will allow the County to address long-term needs in relation to stormwater management. To this end, the County needs to make decisions about the regulatory requirements that will govern future development projects and about the necessary programs and capital projects to help mitigate flooding and protect water quality and environmental health in the Belfair UGA. Various hydrologic modeling analyses were used to support these decisions and development of the stormwater basin plan. This document presents a summary of these modeling analyses.

Modeling was completed at two scales. At the site-scale, modeling was employed to evaluate hydrologic implications of different stormwater management regulatory schemes. At the UGA-scale, modeling was employed to establish baseline hydrologic conditions basin-wide and to identify potential future development-related problem areas.

The specific modeling tasks included:

1. Site-Scale Regulatory Evaluation

   Evaluation of the hydrologic implications of two regulatory schemes applied to development in the Belfair UGA. The two regulatory schemes were:

   - Maintain current stormwater management requirements set forth in the *2005 Stormwater Management Manual for Western Washington* (SWMMWW) (Ecology 2005) and the 2008 Mason County Low Impact Development (LID) Ordinance (No. 76-08)

   - Modify stormwater management requirements by adopting those set forth in the 2012 SWMMWW

   This evaluation was intended to aid in identifying the optimal regulatory scheme for future development in the Belfair UGA.

2. UGA-Scale Evaluation

   Evaluation of changes in hydrology between existing conditions and full build-out conditions that could theoretically occur in the Belfair UGA. This evaluation aided in the identification of existing and potential future problem areas and development of potential programs and capital projects to address those problems.

MGS Flood was used for both modeling tasks to characterize runoff volumes and peak flows. The selection of MGS Flood as the hydrologic model for this effort as well as additional information on the modeling approach are presented in the Modeling Approach Technical Memorandum (Herrera 2018).

The remainder of this report presents a detailed summary of each modeling task including the modeling objectives, model scenarios, model inputs, model results, and conclusions drawn from each effort.

Site-Scale Regulatory Evaluation

Modeling Objective

Mason County is currently using the 2005 SWMMWW for stormwater management in the Belfair UGA. Additionally, the County has adopted a special LID Ordinance (No. 76-08) (see Chapter 17-80, Mason County Municipal Code) that supplements the 2005 SWMMWW and applies to new development and redevelopment within the UGA. In anticipation of its future National Pollutant Discharge Elimination System (NPDES) Phase II Municipal Stormwater Permit, the County is investigating the merits and implications of adopting the 2012 SWMMWW for the Belfair UGA. The site-scale modeling evaluation compared the difference between maintaining the current approach (i.e., the 2005 SWMMWW in combination with the LID ordinance) versus adopting the 2012 SWMMWW.

The primary difference between the 2005 and 2012 SWMMWW is related to on-site stormwater management (i.e., Minimum Requirement #5). The 2005 SWMMWW requires projects to infiltrate, disperse, and retain stormwater runoff onsite to the maximum extent feasible without causing flooding or erosion. The requirement language is minimal and non-specific for management of hard surfaces. The 2012 SWMMWW includes the LID performance standard for onsite stormwater management that applies to all new hard surfaces. Under the 2012 SWMMWW, all new development must satisfy the LID performance standard or select the first feasible management facility from a list of LID best management practices (BMPs).

Mason County's LID Ordinance requires LID for new development and redevelopment sites within the Belfair UGA, but the requirements are prescriptive and do not take into account infeasibility criteria such as steep slopes, high groundwater, or other conflicts. The LID Ordinance has a maximum impervious surface limit, prescribes the use of permeable pavement for 20 percent of all paved surfaces, prescribes bioretention facilities along 75 percent of County-owned roadways, requires infiltration of 100 percent of runoff on outwash soils, and requires reforestation of native vegetation areas. The ordinance also requires treatment of 95 percent of runoff, which exceeds Ecology's 91 percent requirement for water quality treatment (i.e., Minimum Requirement #6).

The objective of the site-scale modeling is to compare the size, cost and hydrologic performance of stormwater management strategies that meet the two regulatory schemes.

Modeling Scenarios

To evaluate and compare site-scale regulatory schemes, modeling scenarios were developed based on a hypothetical new small commercial development. This hypothetical development is similar to the small commercial site analyzed in the 2013 Ecology study, *Cost Analysis for Western Washington LID Requirements and Best Management Practices*. As noted in the Modeling Approach Technical Memorandum (Herrera 2018), the hypothetical small-scale commercial development was modified to ensure that it fits the development type and scale that occurs in the Belfair area and to ensure that it is consistent with Belfair UGA zoning and development codes. Development type and scale were determined by reviewing existing development patterns in the Belfair UGA and in consultation with the County. A basic schematic of the hypothetical development is presented in Figure 1.

In addition to scenarios employing the two different regulatory schemes being evaluated, the modeling also considered the impact that specific soil types (outwash and till) have on managing stormwater. In total, the analysis included four scenarios based on the two manuals (2005 and 2012) and the two soil types. An overview of the modeling scenarios is presented in Table 1.

Table 1. Modeling Scenarios.

Scenario	Development Type	Soil Type	Required Infiltration/ Filtration Percent	Regulatory Scheme
1	1 acre small commercial	Till	95%	2005 SWMMWW + Mason County LID Code
2			91%	2012 SWMMWW
3		Outwash	100%	2005 SWMMWW + Mason County LID Code
4			91%	2012 SWMMWW

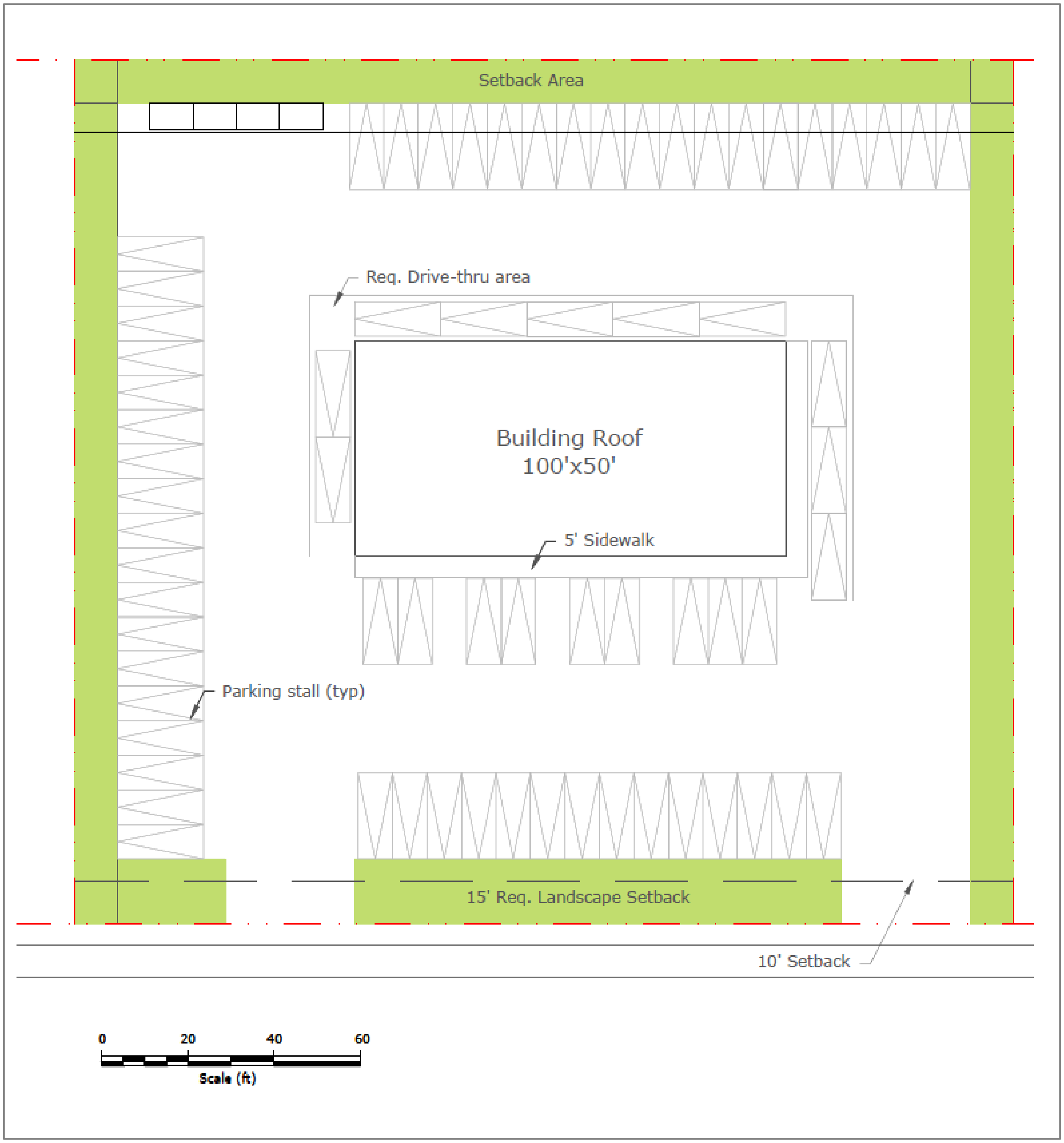


Figure 1. Hypothetical Small Commercial Development Schematic.

Modeling Inputs

Hydrology

MGS Flood was used to simulate each scenario's hydrology over a 158-year time series. Belfair is located in the Western Puget Sound Lowlands region with a mean annual precipitation depth ranging between 55 and 58 inches (MGS 2006). Therefore, the Western Puget Sound precipitation time series with an average annual depth of 56 inches was used. While climate change may impact the average annual rainfall, the change if modeled would be consistent across the scenarios and therefore would not be expected to impact this analysis.

Land Cover

For each modeling scenario, land cover inputs were developed based on the maximum allowable impervious area stipulated in Mason County's LID requirements (70 percent for Commercial land use) and typical commercial site development land cover in the Belfair UGA. See the table in Figure 1 for the baseline land cover assumptions.

LID and Stormwater Management

It was assumed that under both regulatory schemes all minimum requirements of the underlying regulations would be met. As previously noted, the important difference between the 2005 and 2012 SWMMWW is the change to Minimum Requirement #5. In the 2012 SWMMWW, the definition of on-site stormwater management was refined to specify management of flow durations from 8 percent through 50 percent of the 2-year peak flow. The 2005 SWMMWW did not define the flows that needed to be controlled but instead required stormwater runoff be controlled to the maximum extent feasible.

In addition to meeting different flow control needs, the comparison between scenarios required making decisions about which stormwater BMPs to model. While there are numerous combinations of BMPs that could be implemented on a site, three were selected for this modeling analysis: permeable pavement, bioretention, and infiltration ponds. Permeable pavement was selected since it is a required BMP under the Mason County LID ordinance. Bioretention and infiltration ponds were also selected since they are both cost effective and commonly used LID and flow control management practices. Each facility type was sized to meet minimum requirements as defined by the underlying regulatory scheme. For all infiltrating facilities, an infiltration rate of 0.3 inches per hour for till soils and 6 inches per hour for outwash soils was used.

For the 2005 SWMMWW scenarios, the BMPs needed to meet stormwater management requirements are prescribed in the Mason County LID code with limited flexibility. The code requires that permeable pavement be used for 20 percent of paved surfaces irrespective of soil type. Where flow control is required, conventional detention ponds are required, but may be reduced in size based on the amount of additional LID that is provided. Thus, for modeling the

2005 SWMMWW scenarios, a combination of three BMPs (permeable pavement, bioretention, and infiltration pond) was used.

For the 2012 SWMMWW scenarios, there are no specific requirements for any one BMP in the manual. Although a development might be expected to use a combination of BMPs, for the purposes of the modeling analysis, each BMP was evaluated as a separate alternative (i.e., all stormwater control and treatment needs would be met by one of the BMPs). This provides a range of potential sub-scenarios to compare to the 2005 SWMMWW scenario.

Model Results

For each modeling scenario, annual runoff volume, treatment volume, and performance against flow control and water quality requirements were determined to drive facility size estimates. The stormwater management facility footprints for each scenario are listed in Table 2.

Table 2. Facility Sizes by Modeling Scenario.

Modeling Scenario					Facility Footprint (square feet)			
Scenario	**Development Type**	**Soil Type**	**Regulatory Scheme**	**LID Management BMP(s)**	**Permeable Pavement**	**Bioretention**	**Pond**	**TOTAL**
1	1 acre small commercial	Till	2005 SWMMWW + MC LID	All three BMPs	6,100	1,850	3,940	11,890
2a			2012 SWMMWW	Permeable pavement	24,650			24,650
2b				Bioretention		14,190		14,190
2c				Infiltration pond			7,930	7,930
3		Outwash	2005 SWMMWW + MC LID	All three BMPs	6,100	3,480	2,870	12,450
4a			2012 SWMMWW	Permeable pavement	12,100			12,100
4b				Bioretention		6,800		6,800
4c				Infiltration pond			4,500	4,500

For development on slow draining till soils, the area dedicated to stormwater management facilities under the 2005 SWMMWW and Mason County LID regulatory scheme is approximately 12,000 square feet of a 1-acre commercial lot. This compares to approximately 8,000 to 25,000 square feet depending on the BMP employed for the 2012 SWMMWW till scenario. This difference in BMP area needed is because of the changes in flow control requirements between the 2005 and 2012 SWMMWW. On well-draining outwash soils, the area dedicated to stormwater management facilities under the 2005 SWMMWW and Mascon County LID regulatory scheme changes very little and still totals approximately 12,000 square feet. The key difference between till and outwash scenarios is the size of the pond; Mason County allows a reduction in pond volumes of 80 percent on well-draining soils. Under the 2012 SWMMWW regulatory scheme and outwash soils, the facility area required to meet stormwater requirements is significantly smaller than under the existing regulations, and ranges from approximately 4,500 to 12,000 square feet depending upon the BMP. In summary, the existing regulations generally result in smaller facilities on till soils and larger facilities on outwash soils.

Despite the differences in regulatory requirements, the hydraulic performance of the BMPs under each scenario perform similarly. As a result of using infiltrating facilities sized to meet stormwater management requirements including flow control, the majority of the rainfall runoff would be infiltrated in all cases. The average annual runoff infiltrated in each scenario is listed in Table 3. Since all scenarios used infiltrating facilities, the range of flows associated with the LID requirements (i.e., 8 percent through 50 percent of the 2-year peak flow) is fully infiltrated. Additionally, since the infiltrating stormwater facilities were sized to meet flow control requirements, significantly more runoff volume is infiltrated than is required under water quality treatment requirements (i.e., 91 percent for the SWMMWW and 95 percent for Mason County LID requirements). This results in infiltration of nearly all (i.e., 97 to 100 percent) of the average annual runoff volume in all scenarios.

Table 3. Average Annual Runoff Volume Infiltrated by Modeling Scenario.

Development Type	Soil Type	Regulatory Scheme	LID Management BMP(s)	Percent Average Annual Runoff Infiltrated
1 acre small commercial	Till	2005 SWMMWW + MC LID	All three BMPs	97.3%
		2012 SWMMWW	Permeable pavement	100%*
			Bioretention	99.5%
			Infiltration pond	98.4%
	Outwash	2005 SWMMWW + MC LID	All three BMPs	100%
		2012 SWMMWW	Permeable pavement	100%[a]
			Bioretention	100%[a]
			Infiltration pond	98.4%

[a] Some runoff in these scenarios bypasses the system, but only account for less than 0.01 percent of total runoff.

UGA-Scale Evaluation

Modeling Objective

A UGA-scale model was developed to aid in the identification of existing and potential future development-related problem areas. An existing conditions scenario was evaluated to establish baseline conditions. A future build-out scenario was then evaluated to determine locations of increased flow. Taken together, the findings from these scenarios were used in the basin planning effort to inform development of potential programs and capital projects to address problem areas.

Model Inputs

Existing Conditions

The Belfair UGA was delineated into 19 drainage subbasins; some of which extend beyond the UGA boundary. See Figure 2. These were the same subbasins identified in previous work (Otak 2007) but modified based upon more recent LiDAR data. Existing land use, soil type, and slope were determined using NRCS soil survey maps and Mason County parcel and zoning data.

The 2011 National Land Cover Database (NLCD) was initially identified to provide impervious areas within the UGA. Upon examination, however, the NLCD data was deemed to be too coarse for this modeling effort and not representative of existing conditions within the UGA. As such, a new impervious cover dataset was created. Using ERDAS Imagine software, recent aerial images were used to classify existing pervious or impervious areas within the UGA. The results of this effort are shown in Figure 3.

A summary of the model inputs and data sources is presented in Table 4.

Table 4. Hydrologic Model Inputs and Data Sources.

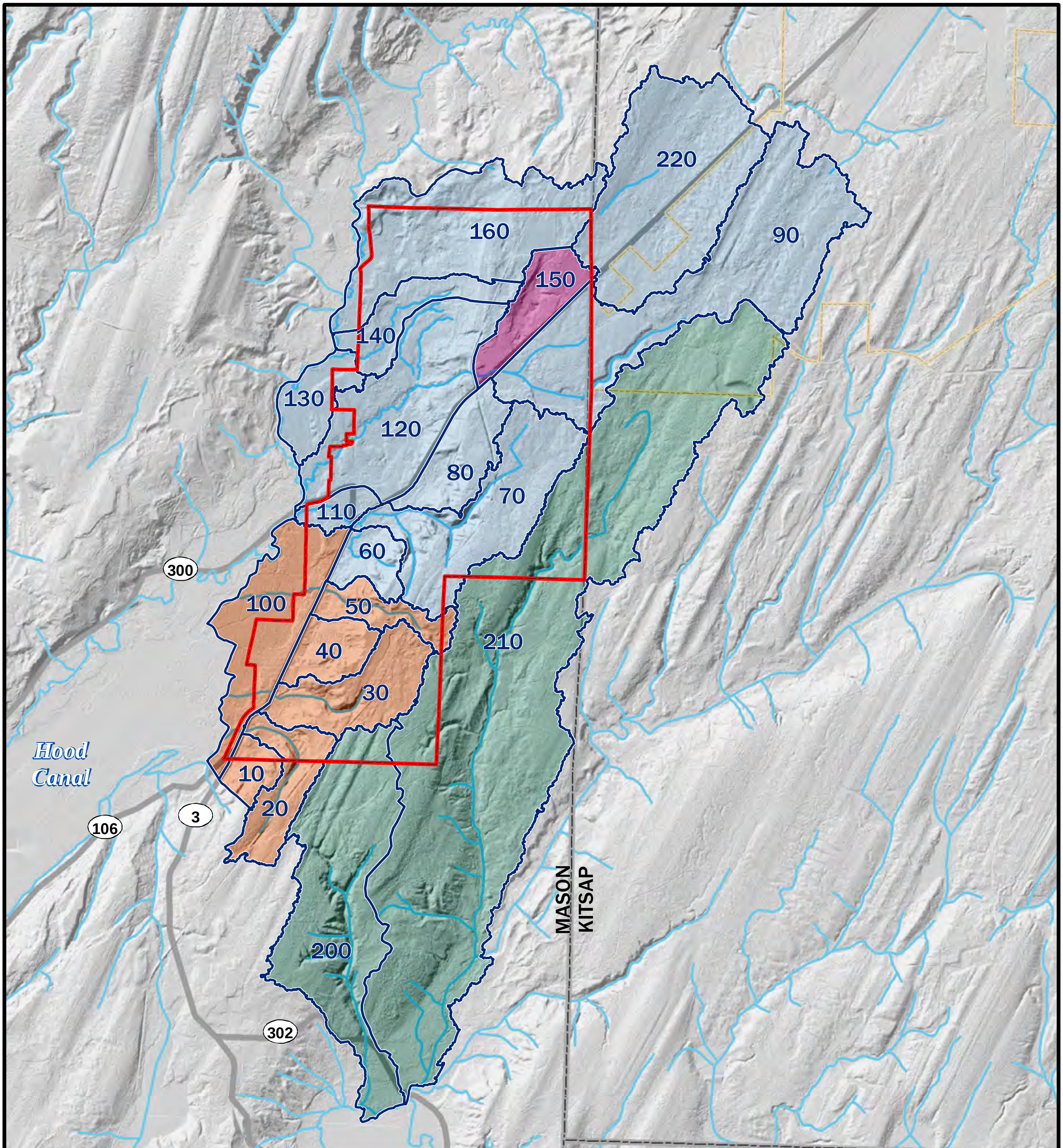
Model Parameter	Data Source	Model Values
Catchment Area	Basin delineation – Otak 2007	Area in acres
Land Cover	Land Use Washington State 2010 – Ecology, Belfair UGA Zoning – Mason County GIS New impervious dataset – Herrera	Percent of catchment area designated forest, pasture, grass, and impervious
Soil Type	Statewide Soil – USDA	Percent of non-impervious land covers overlaying till and outwash soil
Topography	10-foot Contours, Belfair Bypass Contours – Mason County GIS	Average catchment slope
Overland Flow Length	Basins – Otak 2007, 10-foot Contours, Belfair Bypass Contours – Mason County GIS, Digital Elevation Model – USGS	Maximum catchment flow length
Stormwater Facilities	Stormwater detention ponds – Mason County GIS	Stormwater detention pond volume and outlet configuration

Ecology = Washington State Department of Ecology.

NLCD = National Land Cover Database

USDA = US Department of Agriculture

USGS = US Geological Survey



Legend

- Subbasin boundary
- Receiving Water
  - Union River
  - Hood Canal
  - Closed Depression/Hood Canal
  - Case Inlet
- Belfair UGA
- Stream or river
- Highway
- City limit
- County boundary

Figure 2.
Subbasins Within the Belfair UGA.

N

0 2,000 4,000 8,000 Feet

HERRERA

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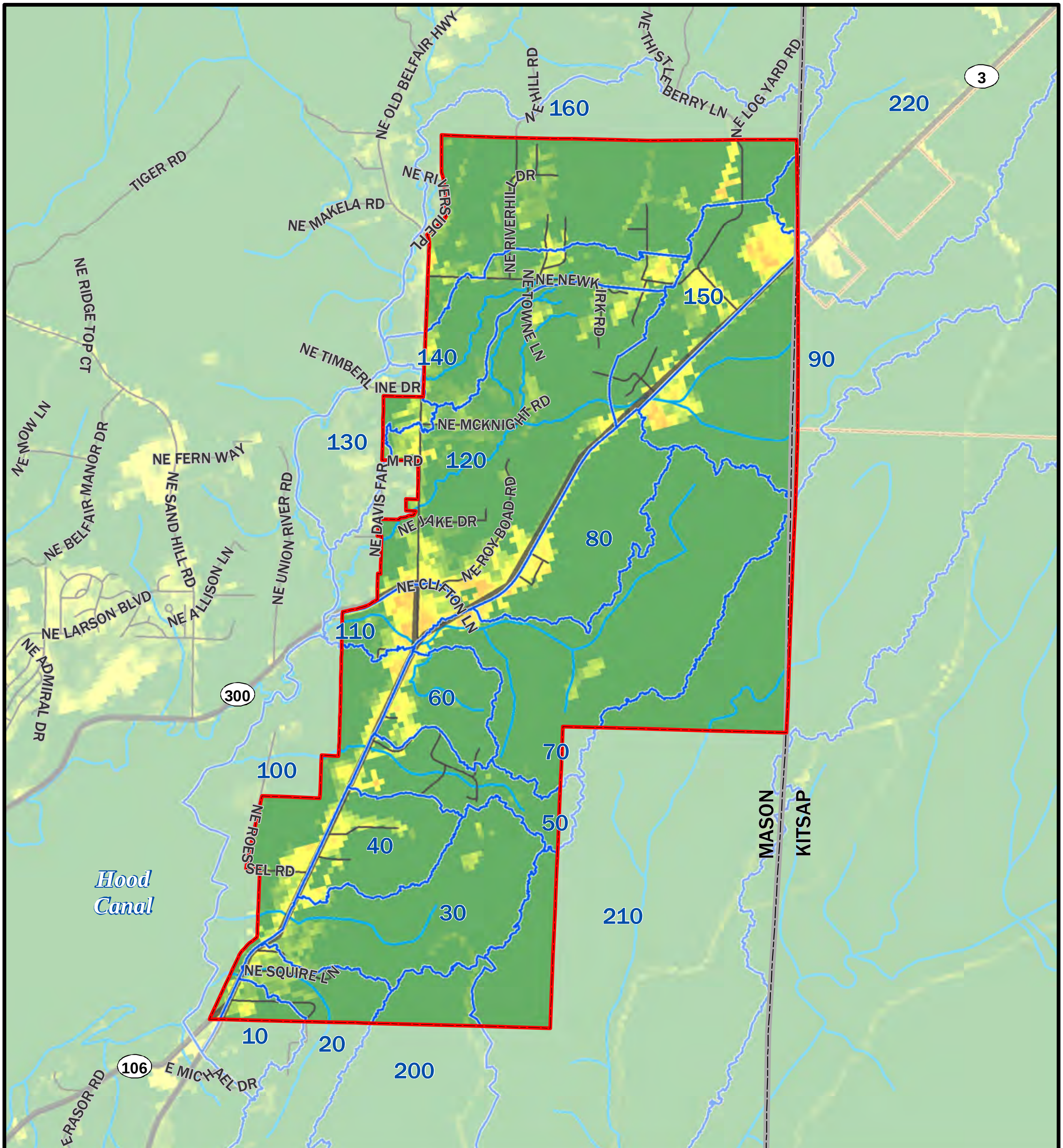

Legend

NLCD Percent Developed Imperviousness

100%

0%

Belfair UGA

Stream or river

Subbasin boundary

Street

Highway

City limit

County boundary

Figure 3.
Impervious Surfaces in the Belfair UGA.

N

0 1,250 2,500 5,000 Feet

HERRERA

MRLC, Percent Developed Imperviousness (2011)

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A breakdown of land cover across the 19 subbasins is presented below in Table 5. The average impervious area across the subbasins is 6.9 percent. As shown in Figure 3, most of the developed portions of the UGA are oriented along State Route (SR) 3, which generally runs north and south through the area. This includes Subbasin 110 (44 percent impervious), which is dominated by commercial land-use and is considered "downtown" Belfair, and Subbasin 150 (47 percent impervious), which is dominated by several landscaping supply yards north of downtown.

Table 5. Existing Land Cover by Soil Type for each Subbasin and Calculated Total Impervious Area.

Subbasin	Forest on Till (acres)	Pasture on Till (acres)	Lawn on Till (acres)	Forest on Outwash (acres)	Pasture on Outwash (acres)	Lawn on Outwash (acres)	Pervious (acres) [%]	Impervious (acres) [%]	Total Area (acres)
10	–	–	–	38	–	8	46 [90%]	5 [10%]	51
20	–	–	–	104	–	19	123 [92%]	10 [8%]	133
30	–	–	–	160	–	17	177 [98%]	4 [2%]	181
40	–	–	–	64	–	8	72 [84%]	14 [16%]	86
50	–	–	–	68	–	2	70 [84%]	13 [16%]	83
60	–	–	–	52	–	8	60 [86%]	10 [14%]	70
70	5	–	–	315	–	8	328 [97%]	9 [3%]	337
80	–	–	–	114	–	6	120 [89%]	15 [11%]	135
90	15	–	1	567	–	26	609 [98%]	14 [2%]	623
100	109	39	16	25	5	25	219 [84%]	43 [16%]	262
110	9	–	8	3	–	4	24 [56%]	19 [44%]	43
120	82	4	46	126	1	38	297 [86%]	48 [14%]	345
130	6	17	23	8	29	10	93 [95%]	5 [5%]	98
140	29	4	15	57	3	27	135 [87%]	21 [13%]	156
150	–	–	–	41	–	23	64 [53%]	56 [47%]	120
160	75	18	9	234	9	43	388 [88%]	53 [12%]	441
200	22	–	3	454	–	24	503 [98%]	10 [2%]	513
210	62	–	3	1,639	–	49	1,753 [98%]	38 [2%]	1,791
220	4	–	–	424	–	32	460 [95%]	25 [5%]	485

Note: Subbasin areas exclude land use designated as wetland and gravel pit accounting for approximately 45 acres.

Future Build-Out Conditions

Future build-out conditions were developed from a buildable lands inventory. This inventory was created from existing map layers of UGA zoning and statewide land use and then modified by applying buffers and constraints associated with "undevelopable lands" identified through a review of County codes. The undevelopable lands dataset included FEMA floodplain area, NWI wetlands, riparian buffers (i.e., 150 feet from fish-bearing streams or shorelines of the state, 100 feet from non-fish-bearing streams or streams typed as "other" or with no type), slopes greater than 15 percent derived from LiDAR (cleaned up to remove small pixelated areas less than 1,000 square feet), and other parcels excluded from future development identified by Mason County. All of these areas are excluded from build-out consideration (964 acres of area in total). See Figure 4 for a map with the locations of these undevelopable lands.

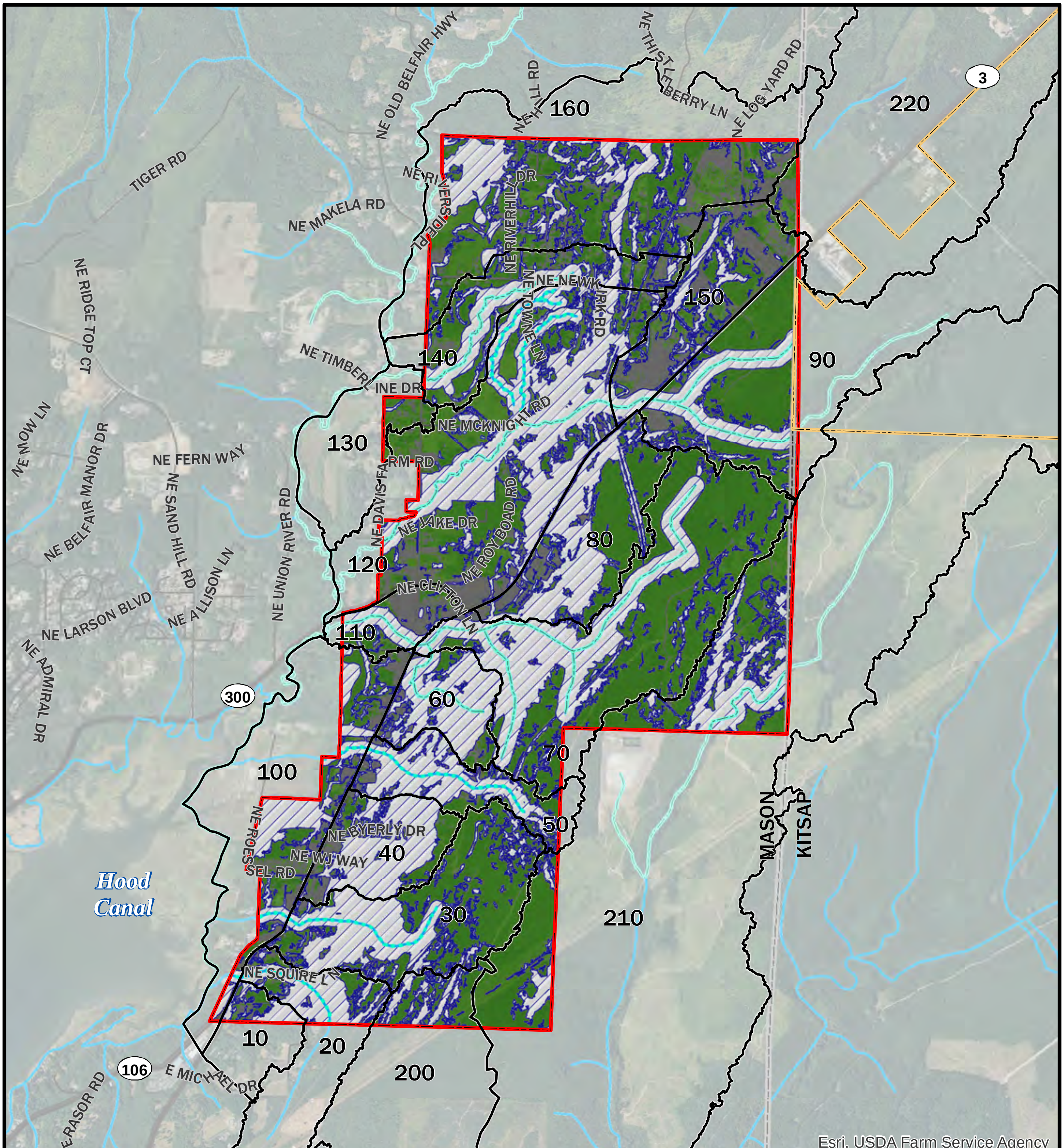
As there is no planning time horizon for the future build-out conditions modeling, it was assumed that all undeveloped lands eligible to be developed would do so and that current development in the Belfair UGA would eventually redevelop. Future build-out conditions were defined for each subbasin by omitting the undevelopable lands noted above and assuming full utilization of existing zoning and densities for the remaining land area that is not currently developed. To determine the conditions associated with full utilization, a typical impervious cover break down for each zoning type was determined from existing conditions. This full utilization information was used to represent the predicted future new land cover for each undeveloped parcel in each subbasin.

Not all development and redevelopment though would necessarily be sufficiently sized (greater than 5,000 square feet) to trigger Ecology's treatment and flow control requirements. To estimate how much future development and redevelopment would theoretically trigger these requirements, an analysis of existing impervious cover for each zoning type was performed to identify the percentage of parcels that currently exceed the threshold. These percentages, presented in Table 6, were used as a proxy for the amount of future development and redevelopment that would be subjected to the Ecology's stormwater management requirements.

Table 6. Portion of Future Impervious Cover that will Trigger Ecology's Stormwater Management Requirements.

Zoning Type	Percent of Impervious Requiring Management
Mixed Use	99%
Single Family Residential	90%
Multi-Family Residential	91%
Medium Density Residential	86%
General Commercial	100%
Festival Retail	100%
Business Industrial	100%
General Commercial & Business Industrial	100%
Long Term Agricultural	0%

Future build-out conditions were modeled assuming that future development and redevelopment would be required to meet the flow control and treatment requirements in the 2012 SWMMWW.



Legend

- Areas of future development constraints
- Existing impervious area
- Areas of potential future development
- Non-fish bearing streams
- Fish-bearing streams
- Belfair UGA
- Subbasin boundary
- Street
- Highway
- City limit
- County boundary

Figure 4.
Areas of Future Development Constraint.

N

0 1,250 2,500 5,000 Feet

HERRERA

MRLC, Percent Developed Imperviousness (2011)

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Future build-out conditions are summarized below by subbasin in Table 7 and depicted on the map in Figure 5. The average impervious area across the subbasins in the future build-out condition increased to 11 percent, however 28 percent of future impervious cover will trigger management requirements. Comparing existing versus future conditions, the following observations were made:

- Subbasins with the highest existing imperviousness (Subbasins 110 and 150) are already built out and saw virtually no increase in impervious area in the future build-out condition.

- Four subbasins (Subbasins 30, 70, 80, and 90) saw impervious area increase over 100 percent in the future build-out condition. Each of these subbasins is located east of SR 3.

- Two other subbasins (Subbasins 120 and 140) saw impervious area increase to 20 percent or more in the future build-out condition. These subbasins are located west of SR 3 immediately adjacent to the downtown Belfair area.

Model Results

Existing and future runoff volume and peak recurrence interval flow rates for each subbasin were estimated in MGS Flood. The average annual runoff volume by subbasin are shown in Table 8. Additionally, Table 8 provides the average increase in flow predicted in future conditions over existing conditions in the range of flows matching half the 2-year through the 50-year flows from a predeveloped forest. These results indicate which basins can expect to see an increase in runoff volume and flow exceedances due to future development and redevelopment. These results are not necessarily predictive of flooding, as conveyance capacity is not well known.

Predictably, the highest runoff volumes and flow increases were observed in subbasins with significant development within the UGA due to increased impervious land cover and decreased forest and pasture land covers. Subbasins 100, 110, 130, and 140 currently experience the highest runoff volumes normalized by subbasin area. However, because these areas will redevelop and trigger stormwater management under existing regulations, they are not predicted to see an increase in runoff volumes or flow exceedances. Some future development areas will not trigger management under the existing stormwater management regulations. In Subbasins 30 and 70, future development is predicted to result in an increase in runoff volume and flow exceedances due to the forecasted amount of development. Twelve of the subbasins are expected to see a net decrease in flows and runoff volumes due to redevelopment and new development that trigger stormwater flow control requirement.

Table 7. Future Build-Out Land Cover by Soil Type for each Subbasin and Calculated Total Impervious Area.										
Subbasin	**Forest on Till (acres)**	**Pasture on Till (acres)**	**Lawn on Till (acres)**	**Forest on Outwash (acres)**	**Pasture on Outwash (acres)**	**Lawn on Outwash (acres)**	**Pervious (acres) [%]**	**Impervious (acres) [%]**	**Total Area (acres)**	**Difference in Impervious over Existing Conditions (acres) [%]**
10	–	–	–	38	–	7	45 [88%]	6 [12%]	51	1 [20%]
20	–	–	–	102	–	19	121 [91%]	12 [9%]	133	2 [20%]
30	–	–	–	136	–	15	151 [83%]	30 [17%]	181	26 [650%]
40	–	–	–	61	–	10	71 [83%]	15 [17%]	86	1 [7%]
50	–	–	–	66	–	3	69 [83%]	14 [17%]	83	1 [8%]
60	–	–	–	50	–	9	59 [84%]	11 [16%]	70	1 [10%]
70	5	–	–	263	–	8	276 [82%]	61 [18%]	337	52 [578%]
80	–	–	–	98	–	6	104 [77%]	31 [23%]	135	16 [107%]
90	15	–	1	504	–	21	541 [87%]	82 [13%]	623	68 [486%]
100	103	39	15	24	5	27	213 [81%]	49 [19%]	262	6 [14%]
110	8	–	9	3	–	4	24 [56%]	19 [44%]	43	0 [%]
120	76	4	43	118	–	35	276 [80%]	69 [20%]	345	21 [44%]
130	6	16	23	8	28	10	91 [93%]	7 [7%]	98	2 [40%]
140	25	4	14	50	3	27	123 [79%]	33 [21%]	156	12 [57%]
150	–	–	–	41	–	23	64 [53%]	56 [47%]	120	0 [%]
160	73	15	8	220	8	41	365 [83%]	76 [17%]	441	23 [43%]
200	22	–	3	449	–	24	498 [97%]	15 [3%]	513	5 [50%]
210	62	–	3	1,611	–	49	1,725 [96%]	66 [4%]	1,791	28 [74%]
220	4	–	0	424	–	32	460 [95%]	25 [5%]	485	0 [%]

Note: Subbasin areas exclude land use designated as wetland and gravel pit accounting for approximately 45 acres.

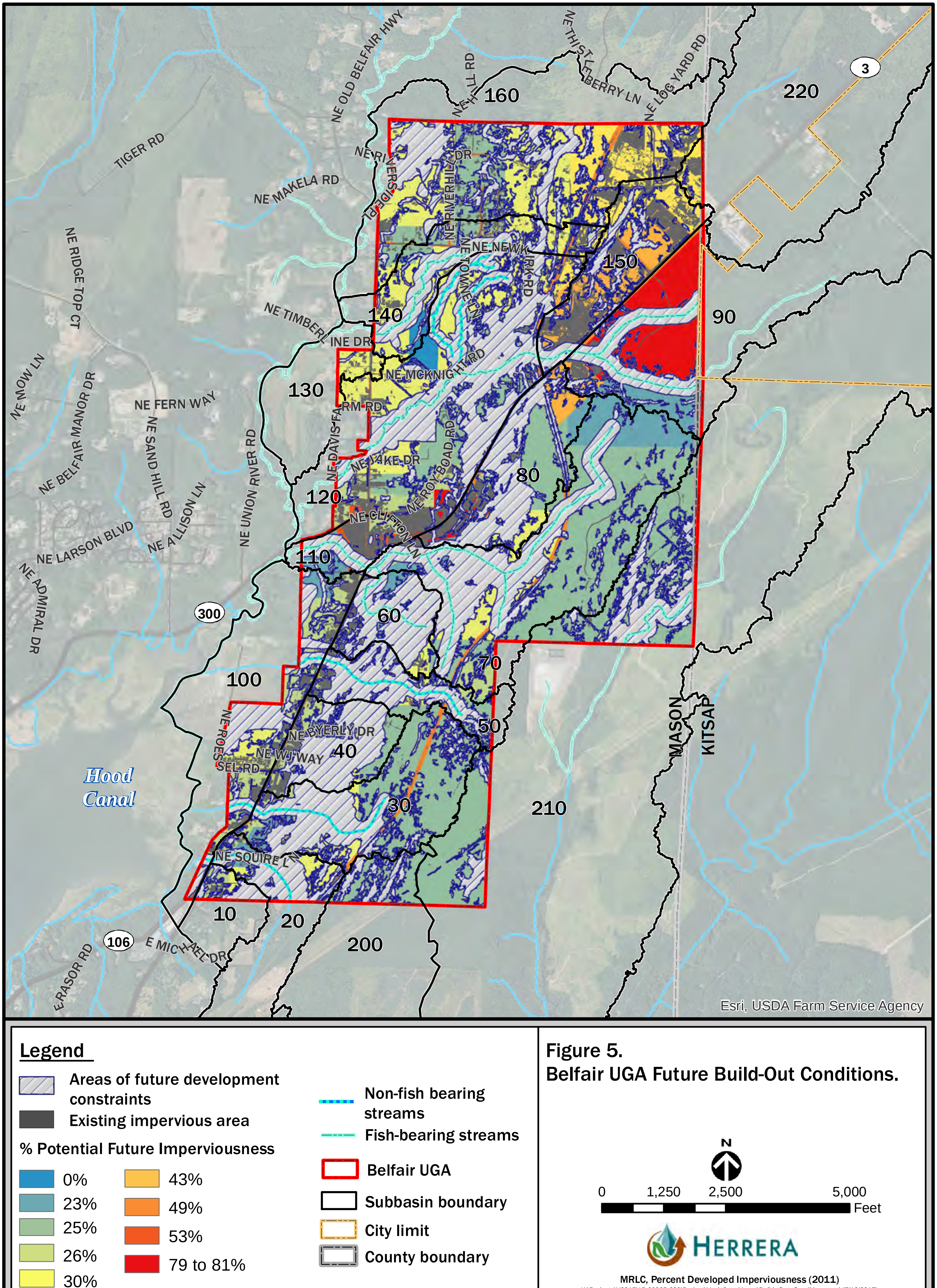

Figure 5.
Belfair UGA Future Build-Out Conditions.

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MRLC, Percent Developed Imperviousness (2011)

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Table 8. Model Results by Subbasin.											
Subbasin	Area (acres)	Average Annual Runoff Volume (acre-feet)			Average Annual Runoff Volume Normalized by Area (feet)			Future Flow Durations Exceed Existing Flow Durations	Average Increase in Flow in Future Over Existing in Exceedance Range of Interest[a]	Future Increase in Impervious Area Over Existing	Portion of All Impervious Managed in Future Condition
		Forest	Existing	Future	Forest	Existing	Future				
10	51	0.2	21	13	0.004	0.41	0.25	No	-24%	20%	54%
20	133	0.5	43	28	0.004	0.32	0.21	No	-17%	20%	48%
30	181	0.7	18	33	0.004	0.10	0.18	Yes	13%	650%	74%
40	86	0.3	60	19	0.004	0.70	0.22	No	-44%	7%	70%
50	83	0.3	57	33	0.004	0.69	0.40	No	-32%	15%	47%
60	70	0.3	43	12	0.004	0.61	0.18	No	-43%	0%	72%
70	337	9	49	56	0.03	0.15	0.17	Yes	6%	578%	82%
80	135	0.5	66	26	0.004	0.49	0.19	No	-39%	107%	80%
90	623	27	86	72	0.04	0.14	0.12	No	-9%	493%	89%
100	262	280	472	375	1.07	1.80	1.43	No	-22%	14%	64%
110	43	43	114	62	0.99	2.65	1.43	No	-53%	0%	86%
120	345	238	456	345	0.69	1.32	1.00	No	-25%	44%	75%
130	98	76	124	113	0.78	1.27	1.15	No	-8%	40%	56%
140	156	82	182	131	0.53	1.17	0.84	No	-22%	57%	75%
150	120	0.5	237	45	0.004	1.98	0.37	No	-67%	-5%	81%
160	441	168	401	260	0.38	0.91	0.59	No	-30%	43%	75%
200	513	44	86	76	0.09	0.17	0.15	No	-5%	50%	52%
210	1,791	108	269	261	0.06	0.15	0.15	No	-1%	74%	46%
220	485	8	115	49	0.02	0.24	0.10	No	-24%	0%	62%

[a] The exceedance range of interest is the range for half the Q2 through the Q50 for the predeveloped Forest flows, see exceedance probability plots in Appendix A.

KEY:

Orange cell gradient used to represent an increase in future flow exceedances over existing flows.

Green cell gradient used to represent a decrease in future flow exceedances over existing flows.

Conclusions

Site-Scale Regulatory Evaluation

The two regulatory schemes perform similarly when the stormwater facilities are designed to meet all minimum requirements, which includes flow control. The flow control requirement drives the size of facilities and results in infiltration of most of the runoff. Considering the Mason County LID requirements, LID facility sizes do not decrease with better infiltration and filtration rates. Therefore, in scenarios with good draining soils, the current Mason County stormwater requirements result in larger design of facilities. Given this and the lack of flexibility inherent in selecting LID BMPs under current regulatory scheme, it is recommended that Mason County consider adopting the 2012 SWMMWW.

UGA-Scale Evaluation

Subbasins 100, 110, 120, 130, 140, and 150 are recommended as the focus areas for capital improvement projects since these basins currently experience the highest peak flows and runoff volumes normalized by basin area. Based on future conditions modeling, Subbasins 30, 70, 80, 90, 160, 200, and 210 are expected to see substantial increases in peak flows and runoff volumes at full build-out compared to existing conditions. It is recommended that these subbasins be the focus for any potential programmatic recommendations that serve to mitigate future development pressures.

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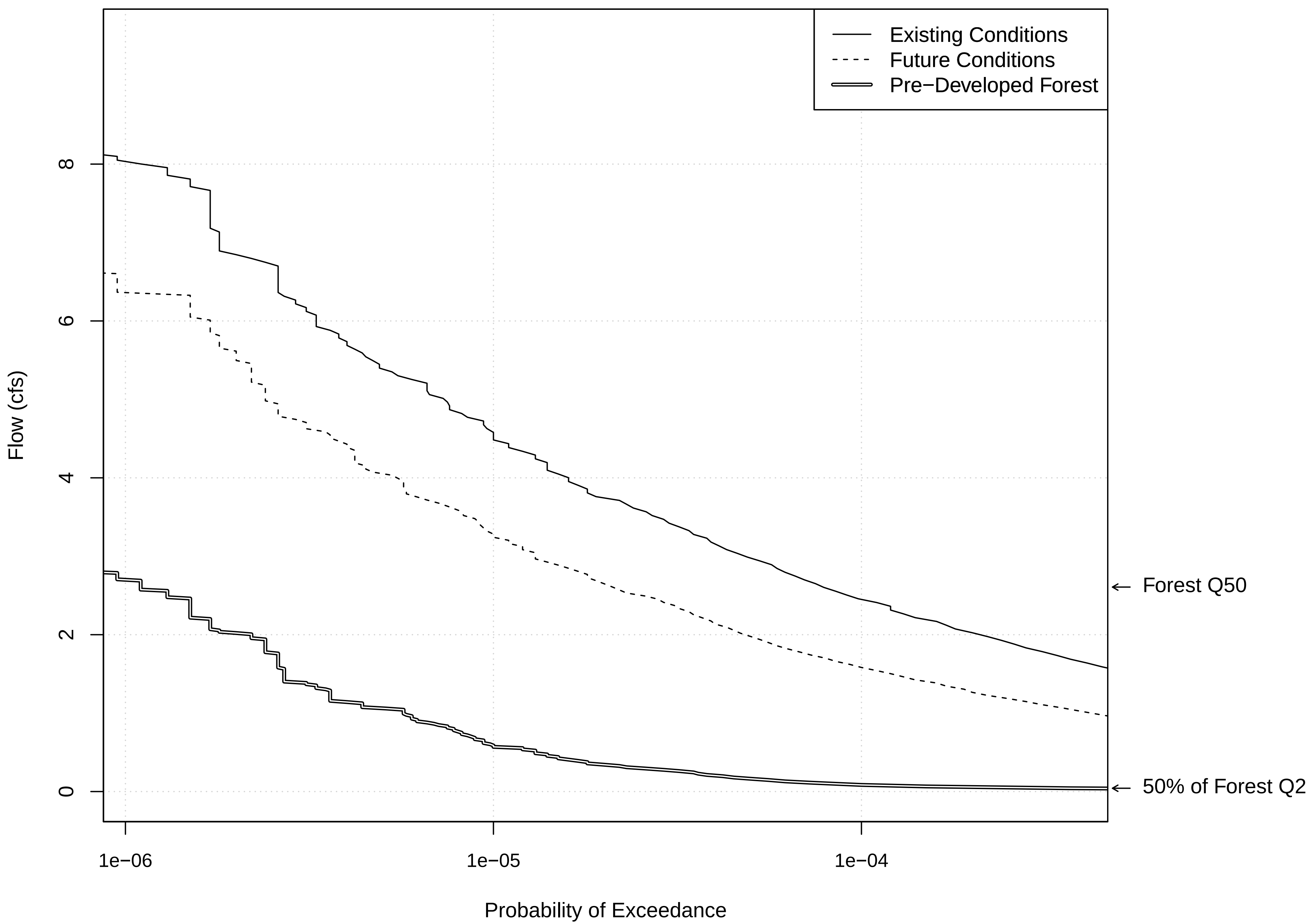
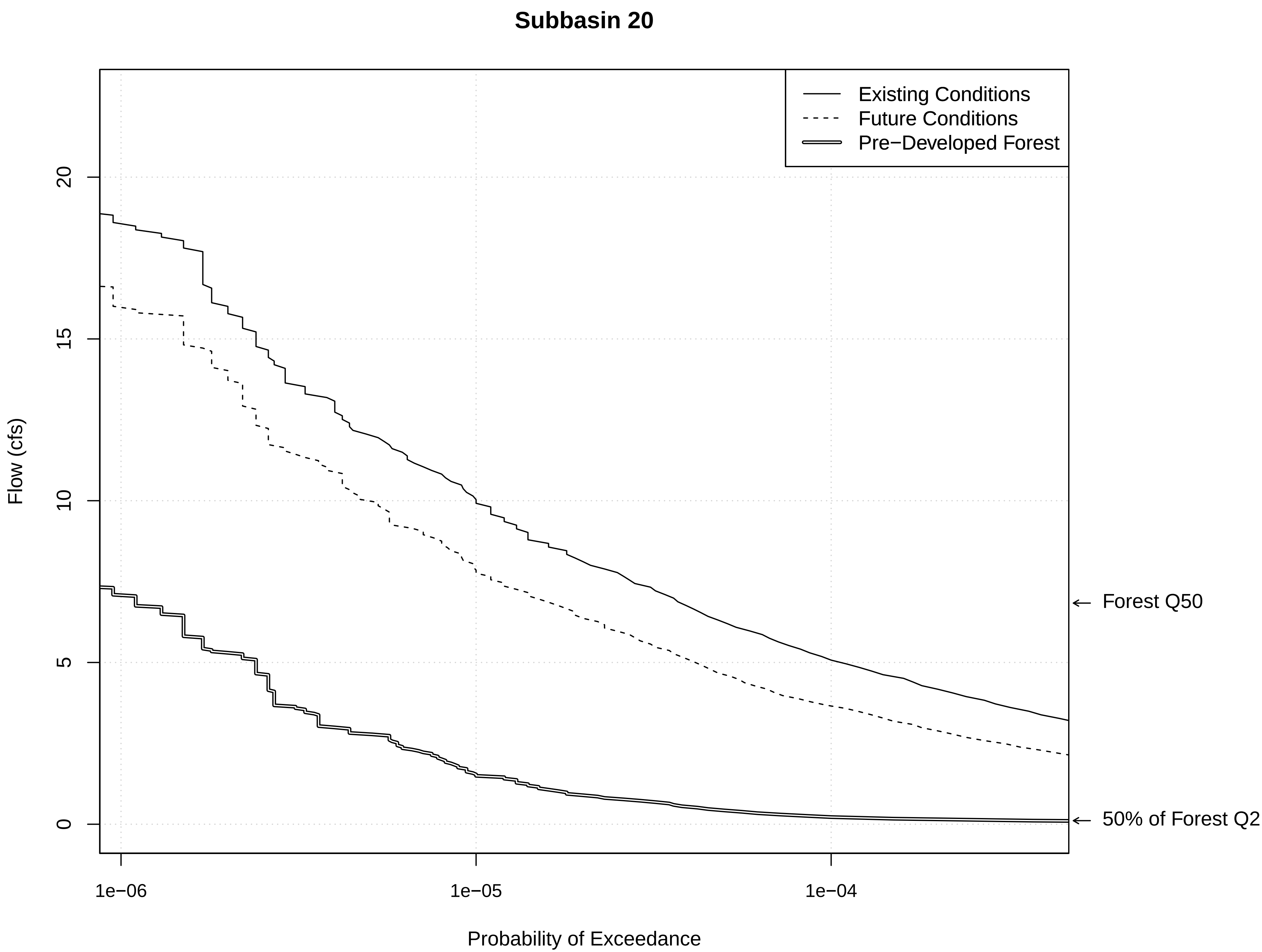
APPENDIX A

Flow Exceedance Probability Plots by Basin

Subbasin 10

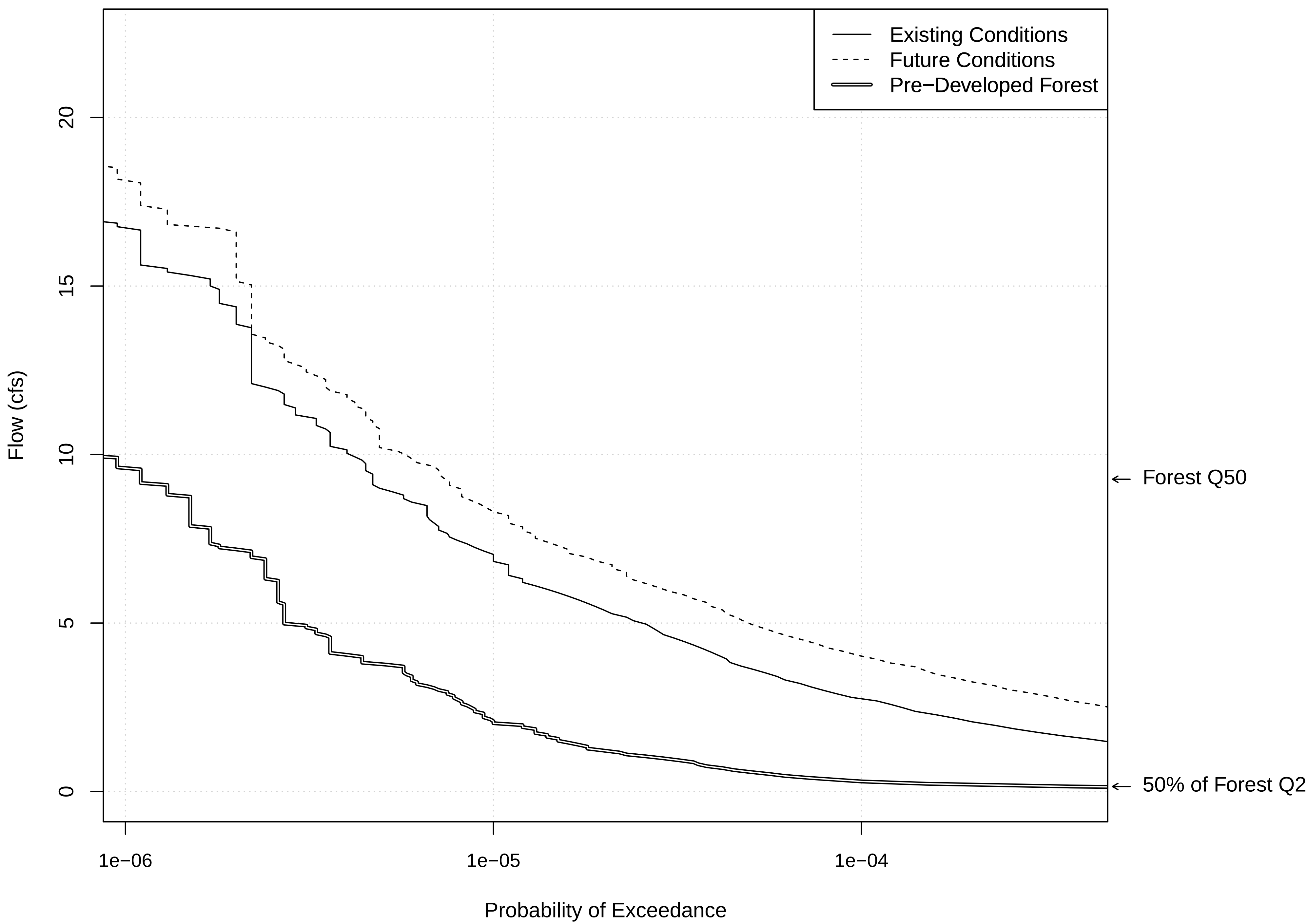


Existing Conditions
Future Conditions
Pre−Developed Forest
Forest Q50
50% of Forest Q2
Flow (cfs)
0
2
4
6
8
1e−06
1e−05
1e−04
Probability of Exceedance

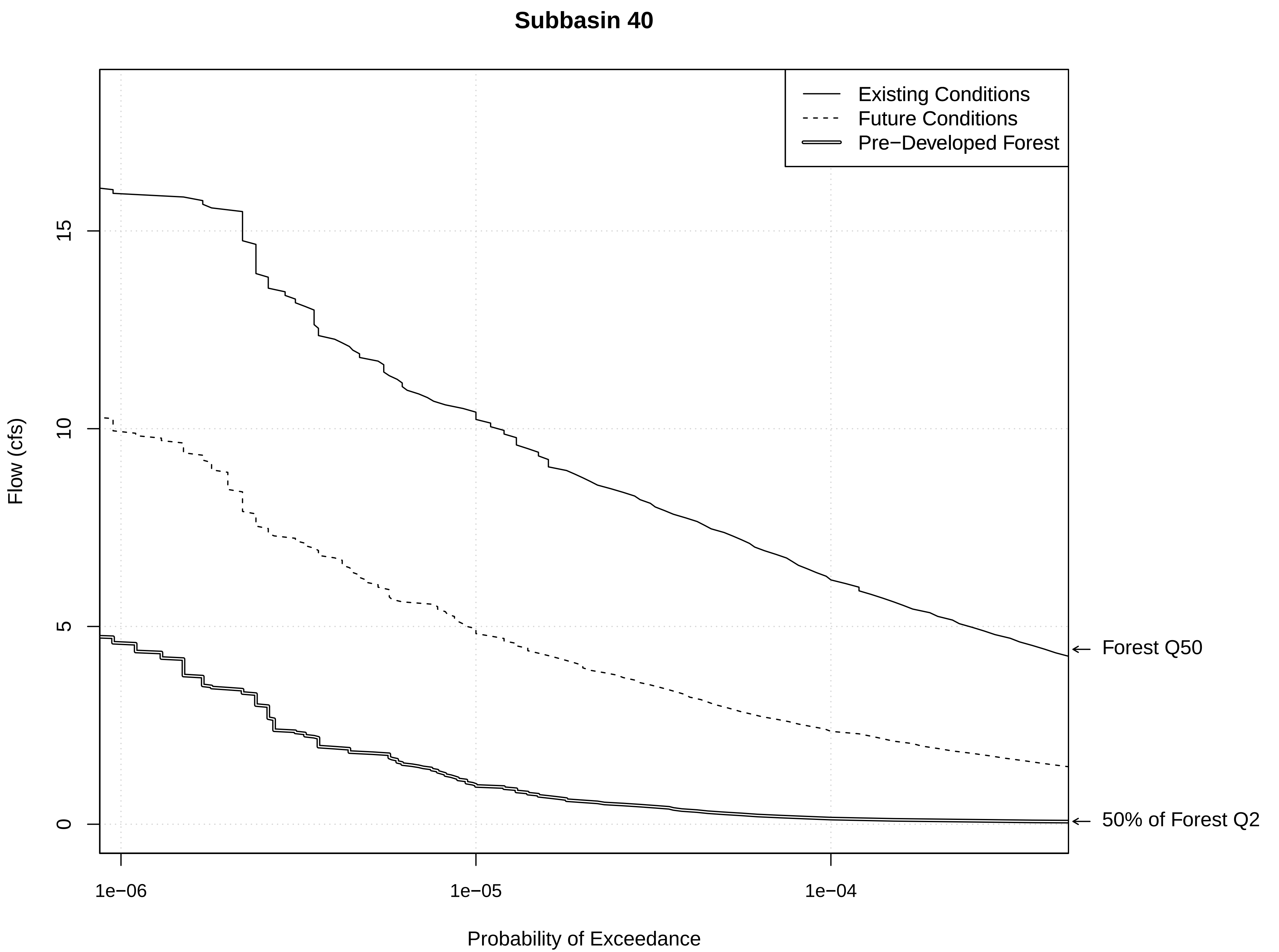


Subbasin 20
Existing Conditions
Future Conditions
Pre−Developed Forest
Flow (cfs)
0
5
10
15
20
1e−06
1e−05
1e−04
Probability of Exceedance
Forest Q50
50% of Forest Q2

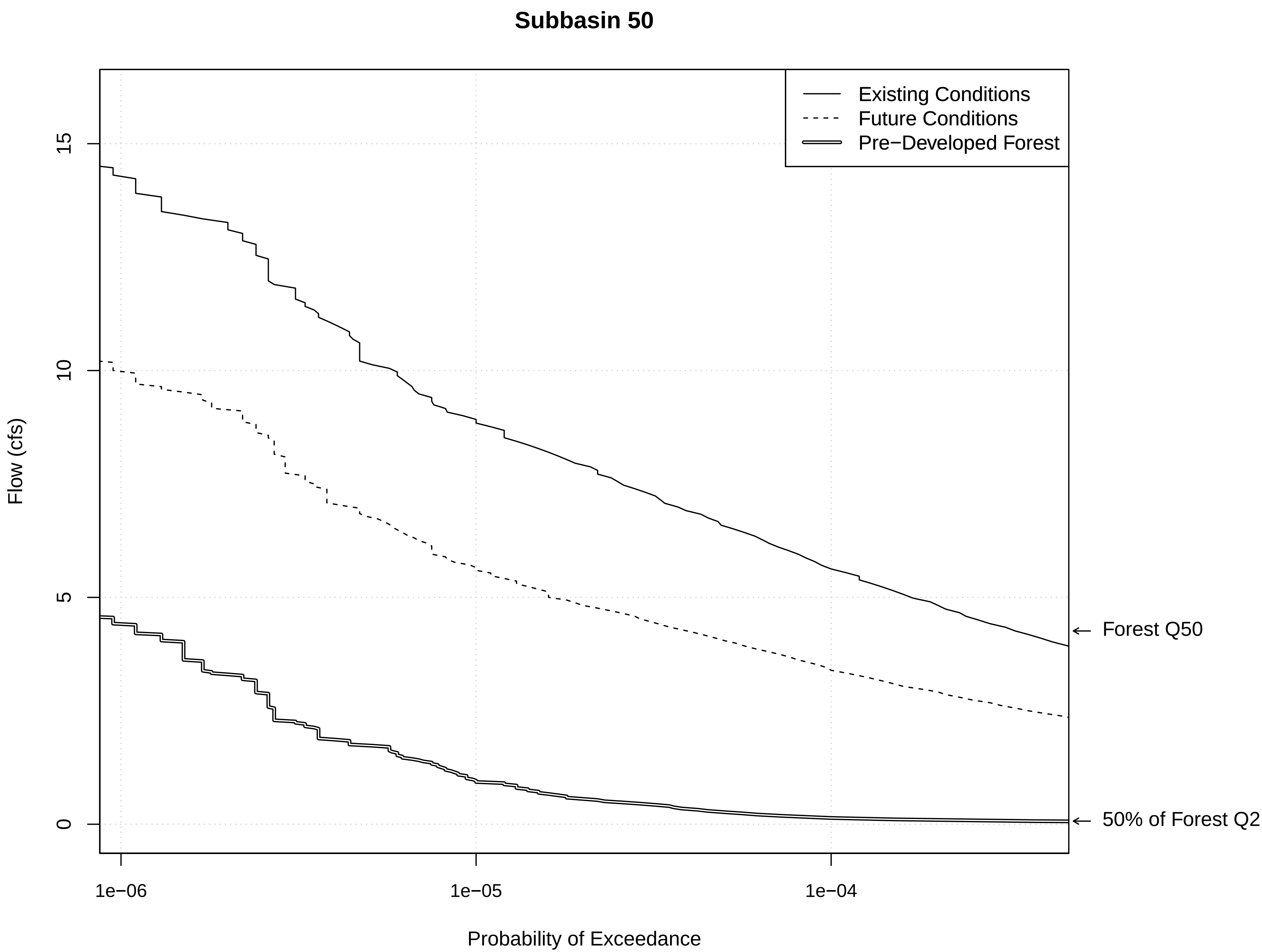
Subbasin 30



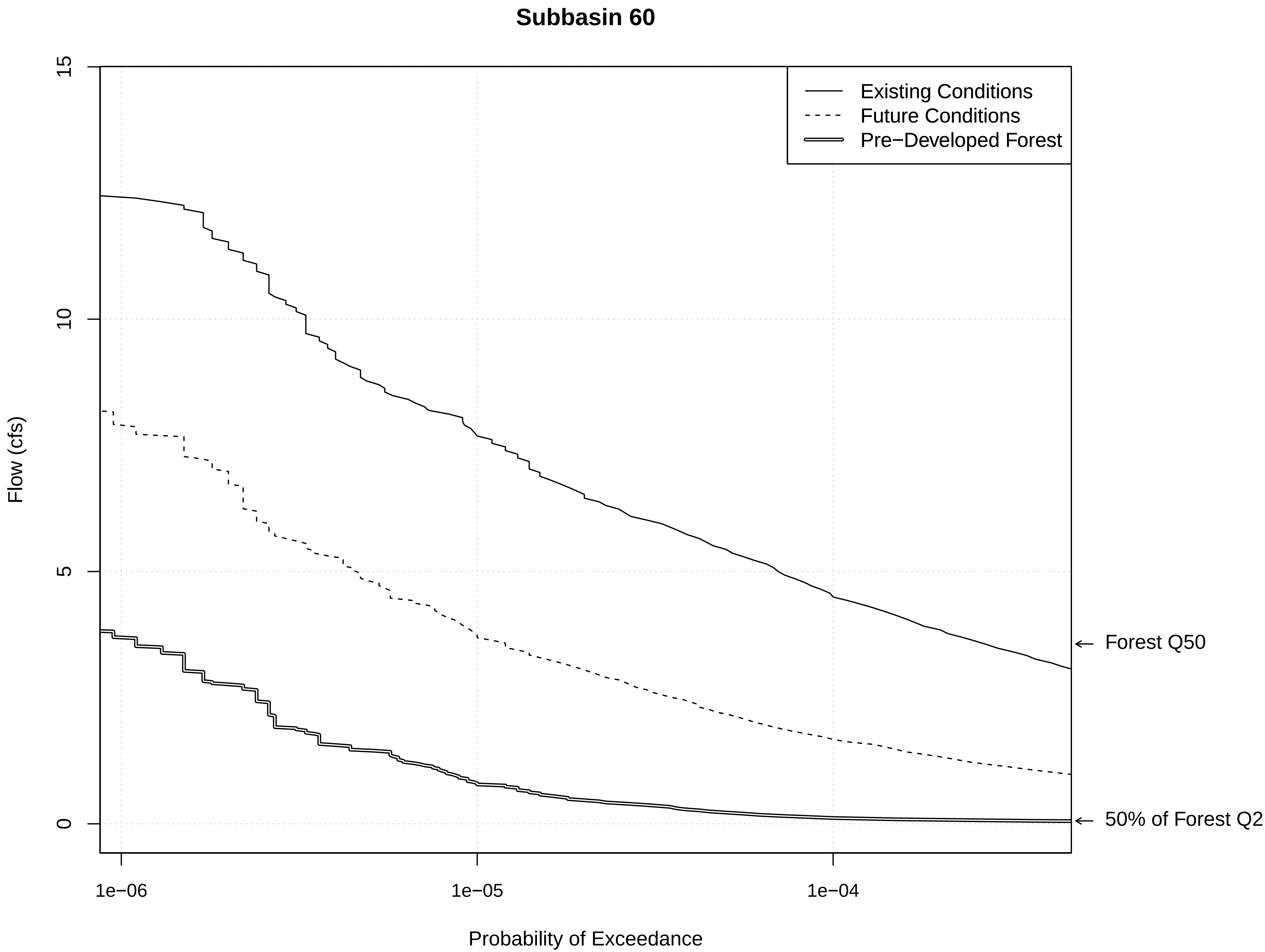
Existing Conditions
Future Conditions
Pre−Developed Forest
Flow (cfs)
0
5
10
15
20
Forest Q50
50% of Forest Q2
1e−06
1e−05
1e−04
Probability of Exceedance



Subbasin 40
Existing Conditions
Future Conditions
Pre−Developed Forest
Flow (cfs)
0
5
10
15
1e−06
1e−05
1e−04
Probability of Exceedance
Forest Q50
50% of Forest Q2



Subbasin 50
Existing Conditions
Future Conditions
Pre−Developed Forest
Flow (cfs)
15
10
5
0
1e−06
1e−05
1e−04
Probability of Exceedance
Forest Q50
50% of Forest Q2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Existing Conditions
Future Conditions
Pre−Developed Forest
Flow (cfs)
15
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5
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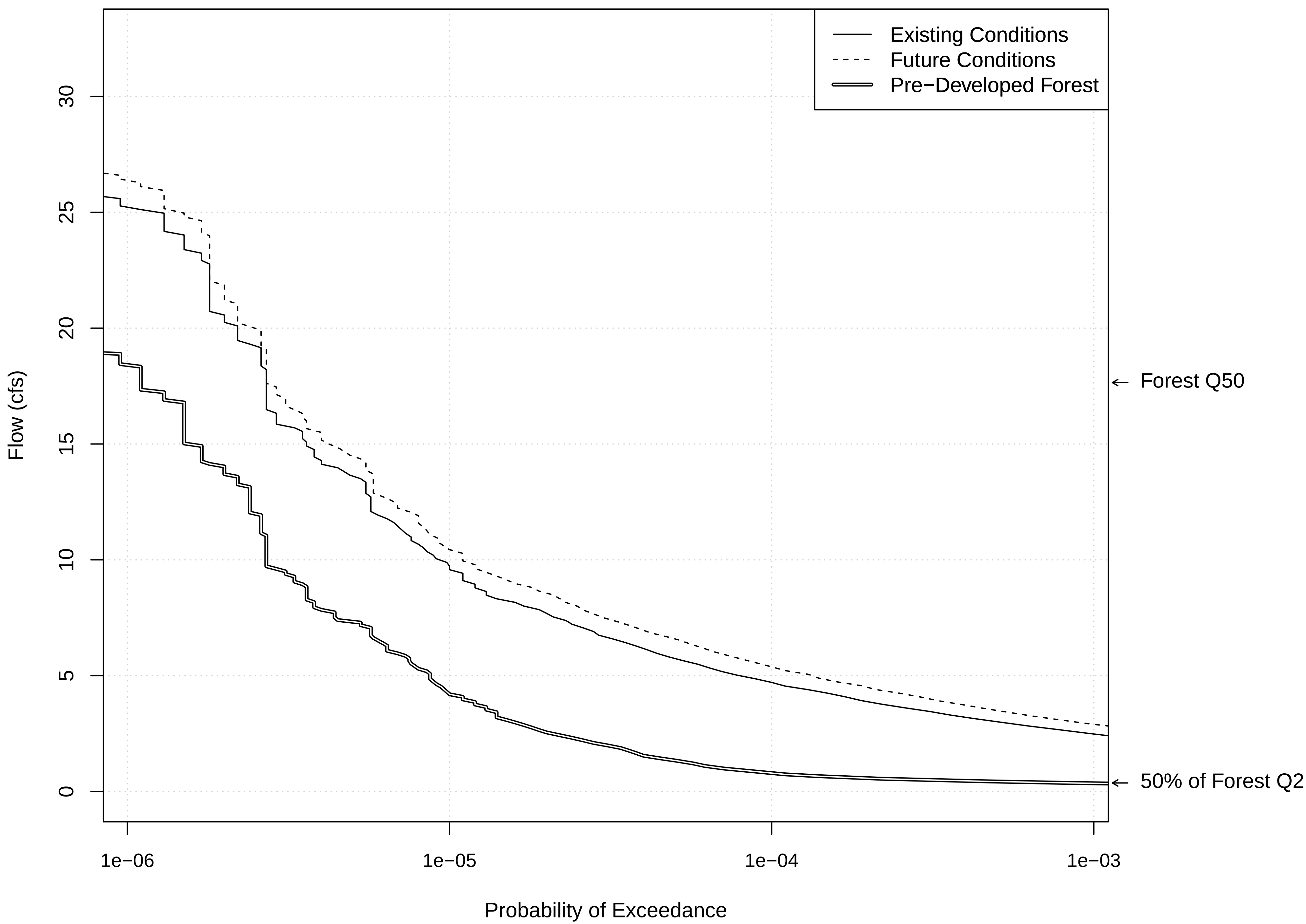
1e−06
1e−05
1e−04
Probability of Exceedance
← Forest Q50
← 50% of Forest Q2

Subbasin 70



Subbasin 70
Existing Conditions
Future Conditions
Pre−Developed Forest
← Forest Q50
← 50% of Forest Q2
Flow (cfs)
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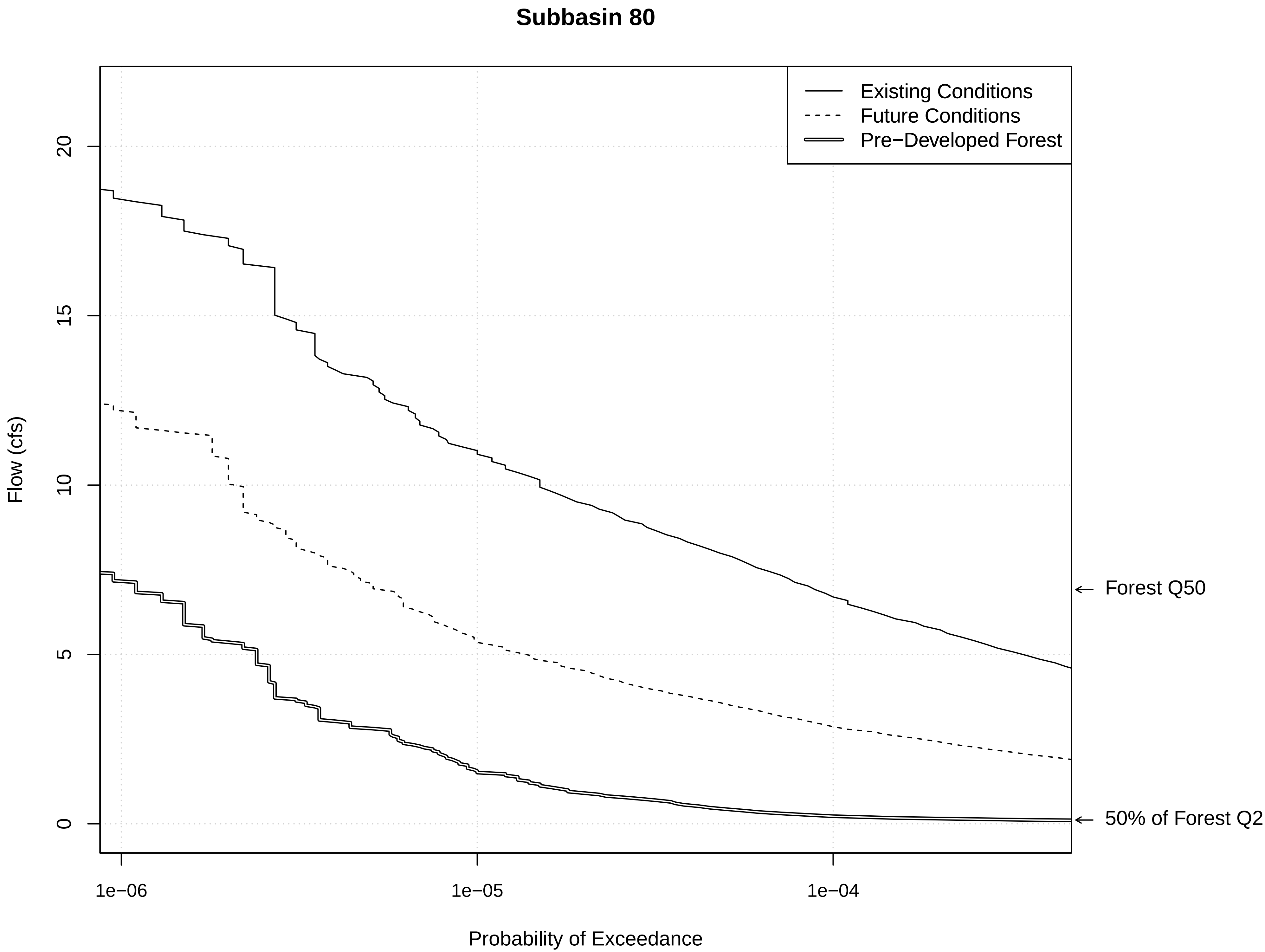
5
10
15
20
25
30
1e−06
1e−05
1e−04
1e−03
Probability of Exceedance



Subbasin 80
Existing Conditions
Future Conditions
Pre−Developed Forest
Flow (cfs)
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5
10
15
20
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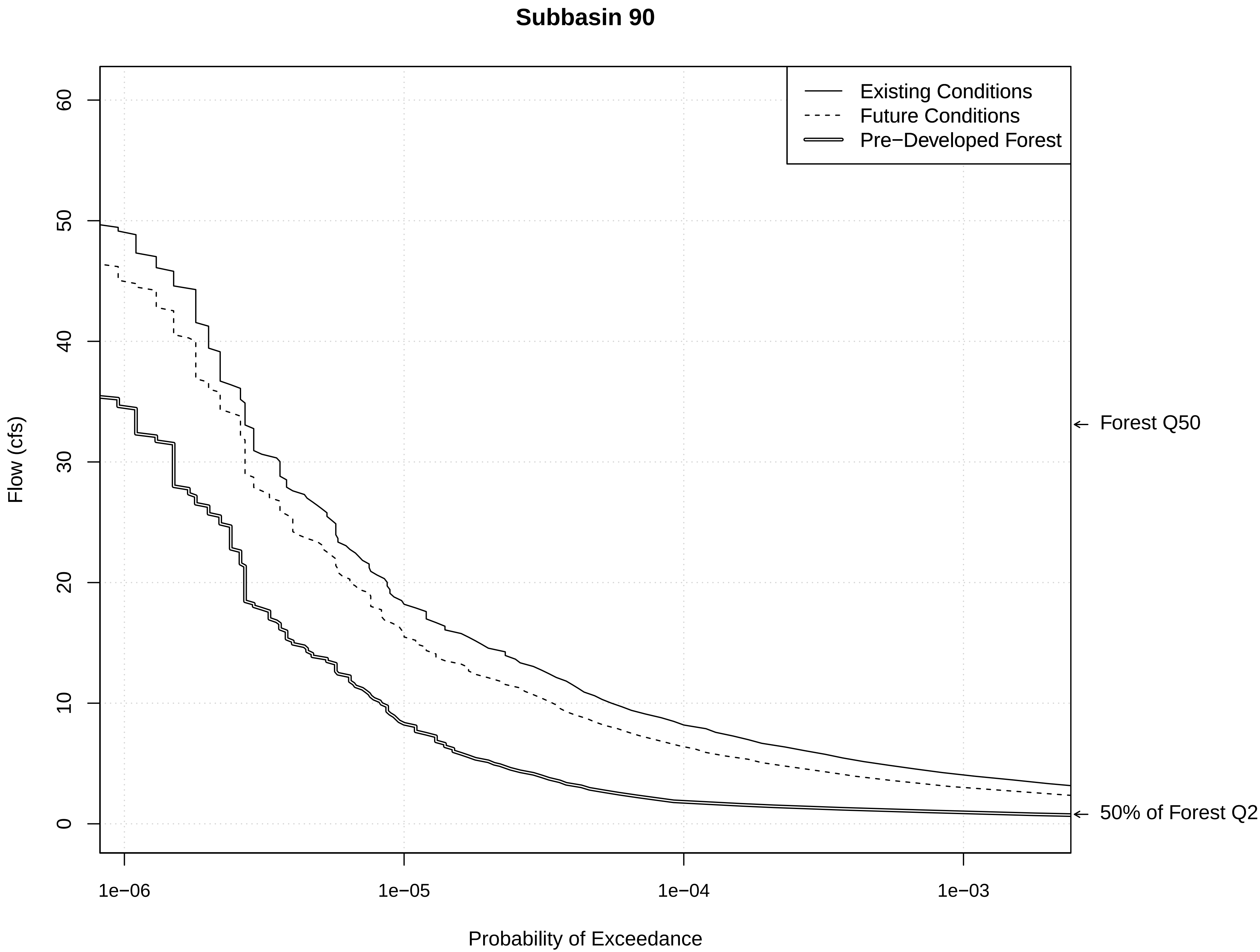
1e−04
Probability of Exceedance
Forest Q50
50% of Forest Q2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Future Conditions
Pre−Developed Forest
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50% of Forest Q2
Flow (cfs)
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60
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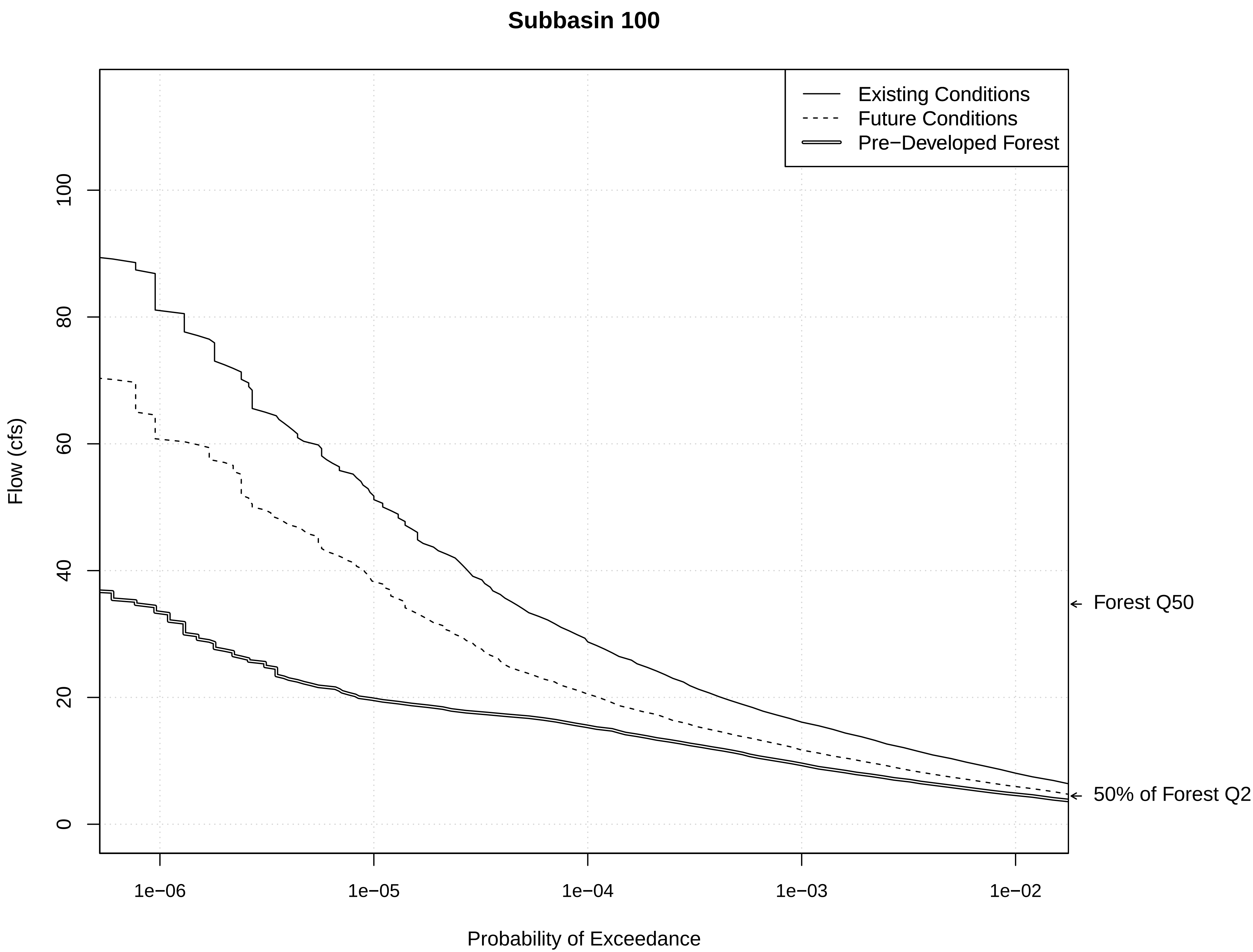
1e−03
Probability of Exceedance


Subbasin 100
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Future Conditions
Pre−Developed Forest
Flow (cfs)
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40
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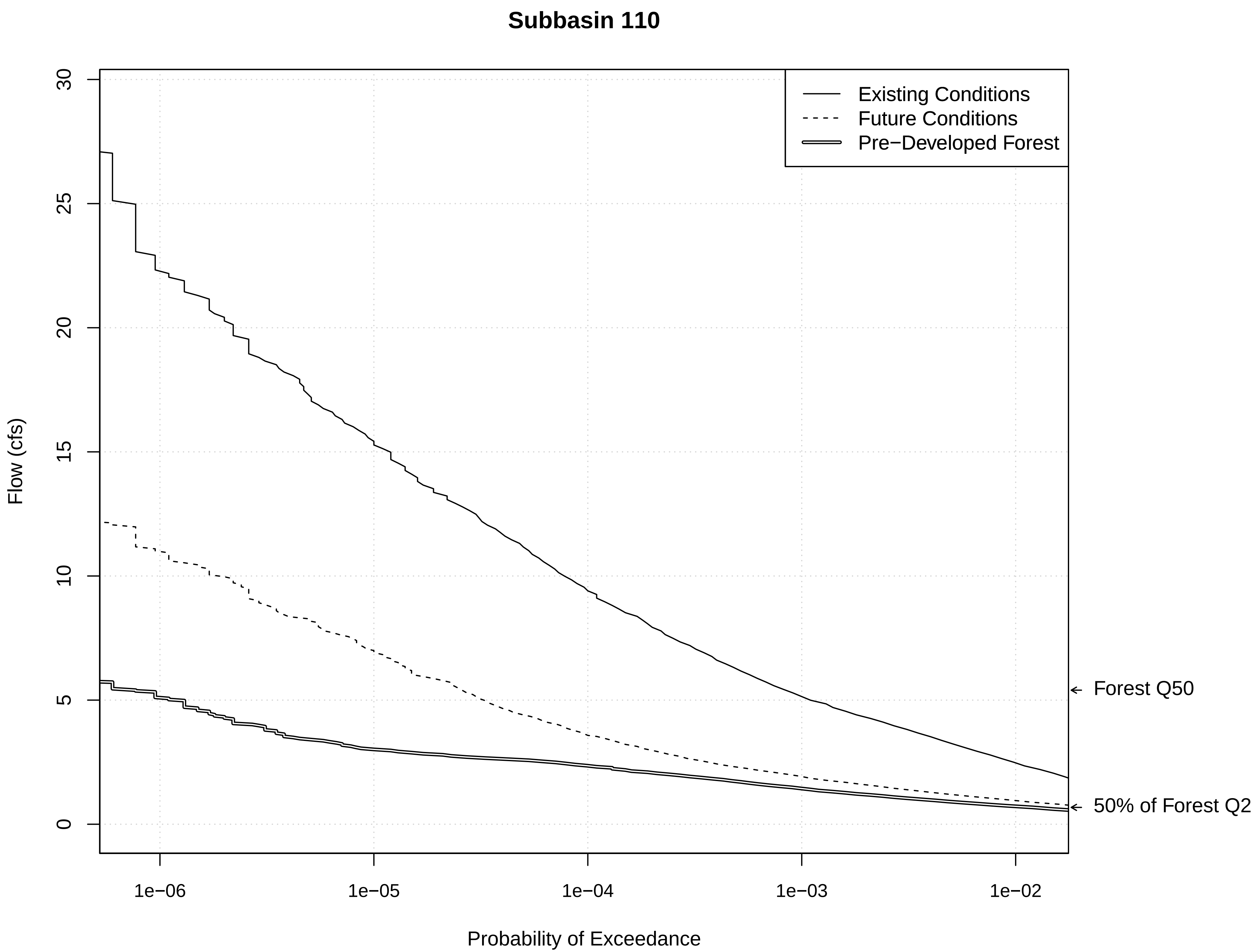
Probability of Exceedance
Forest Q50
50% of Forest Q2



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Future Conditions
Pre−Developed Forest
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Flow (cfs)
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25
30
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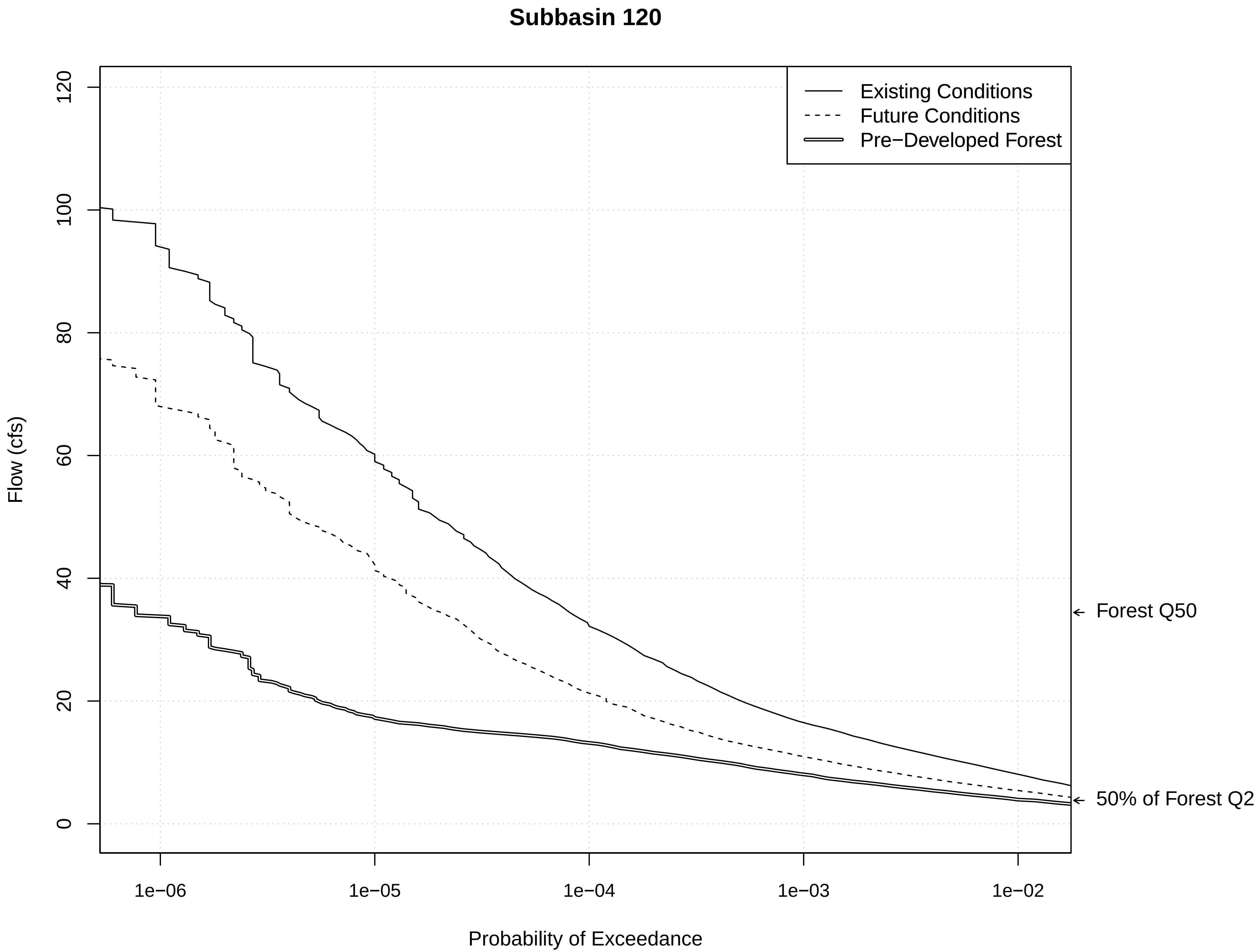
1e−04
1e−03
1e−02
Probability of Exceedance



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Future Conditions
Pre−Developed Forest
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Flow (cfs)
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Probability of Exceedance
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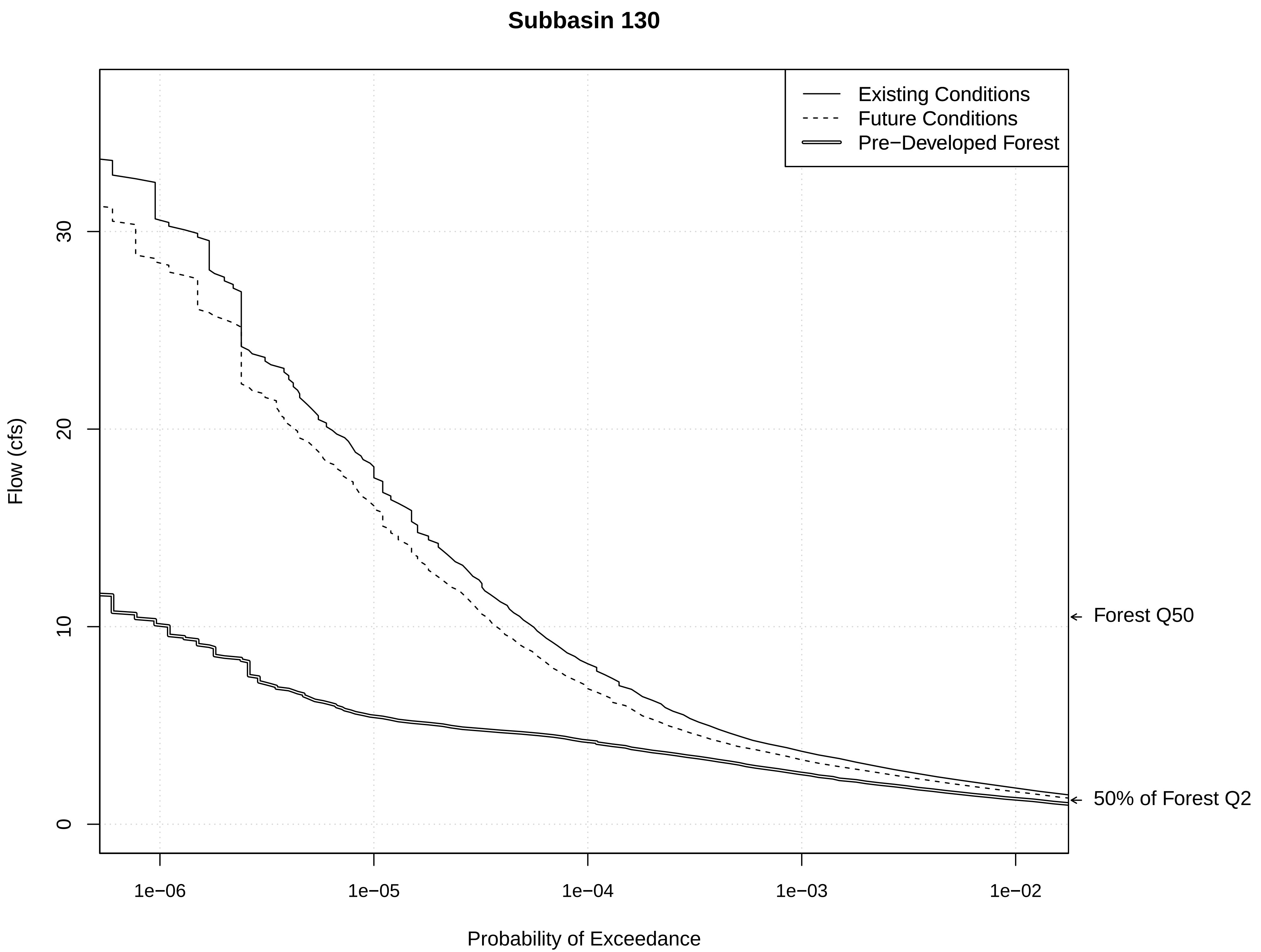
1e−02



Subbasin 130
Existing Conditions
Future Conditions
Pre−Developed Forest
Flow (cfs)
0
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20
30
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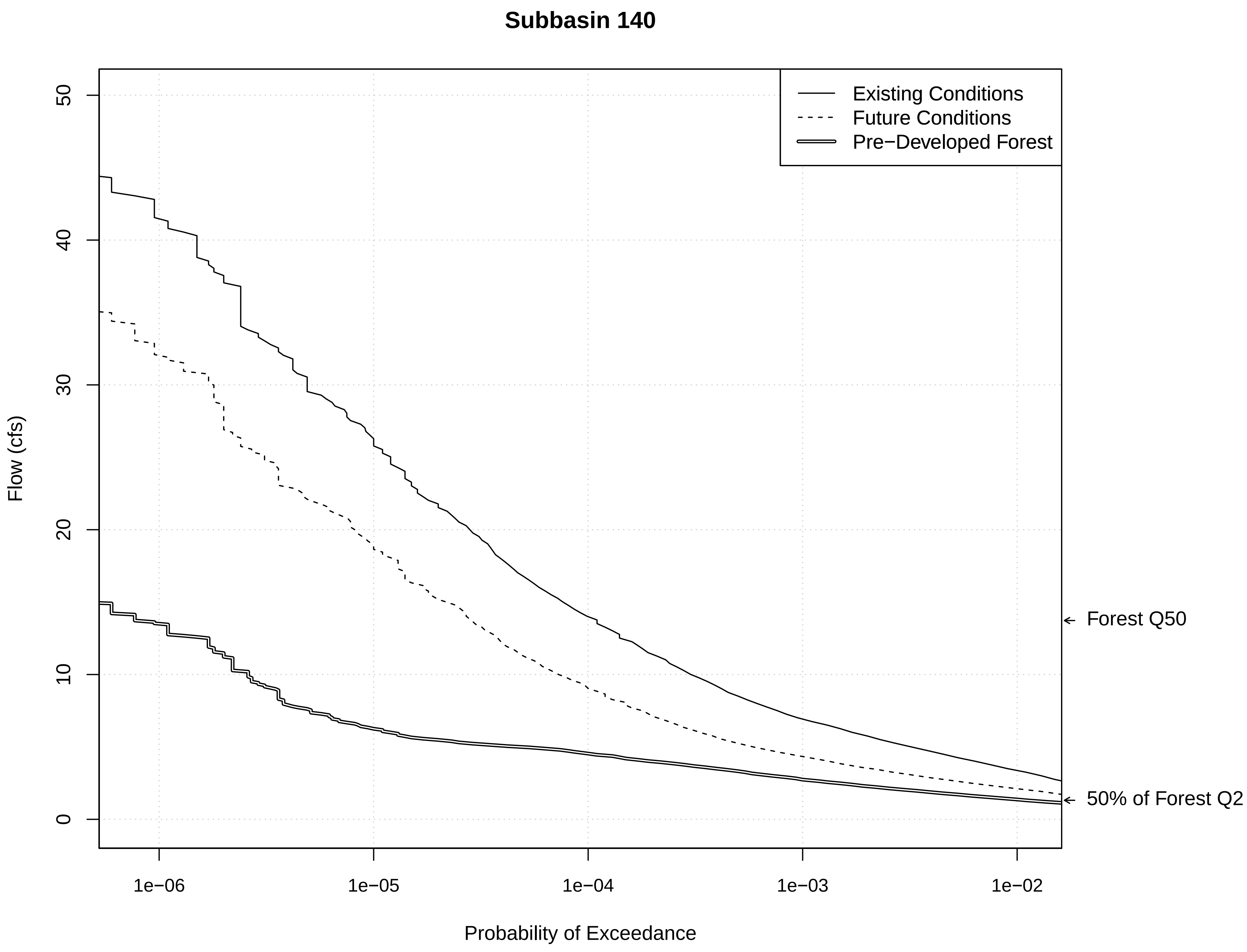
1e−02
Probability of Exceedance
Forest Q50
50% of Forest Q2



Subbasin 140
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Future Conditions
Pre−Developed Forest
Flow (cfs)
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20
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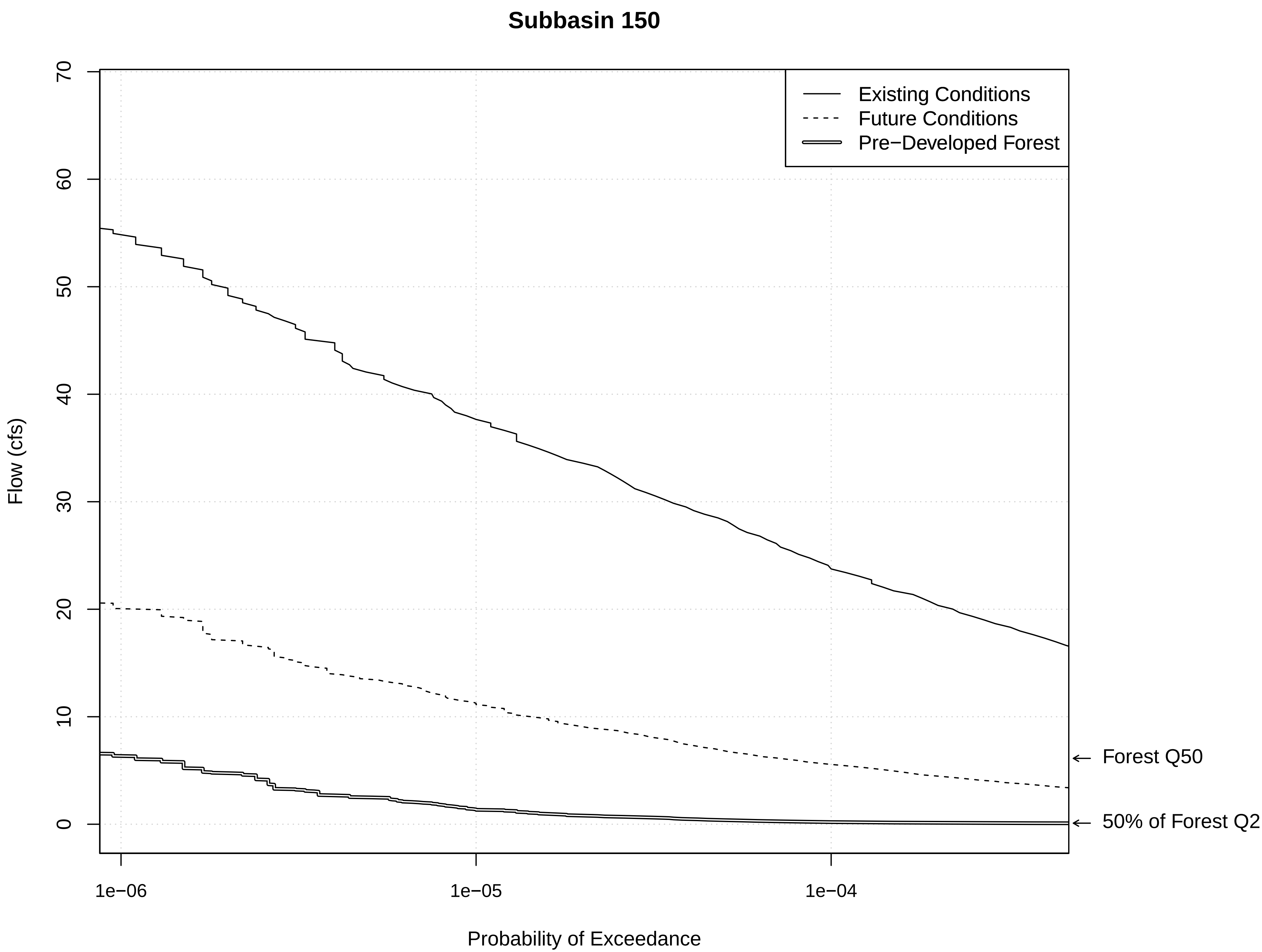
1e−04
1e−03
1e−02
Probability of Exceedance
Forest Q50
50% of Forest Q2



Subbasin 150
Existing Conditions
Future Conditions
Pre−Developed Forest
Flow (cfs)
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10
20
30
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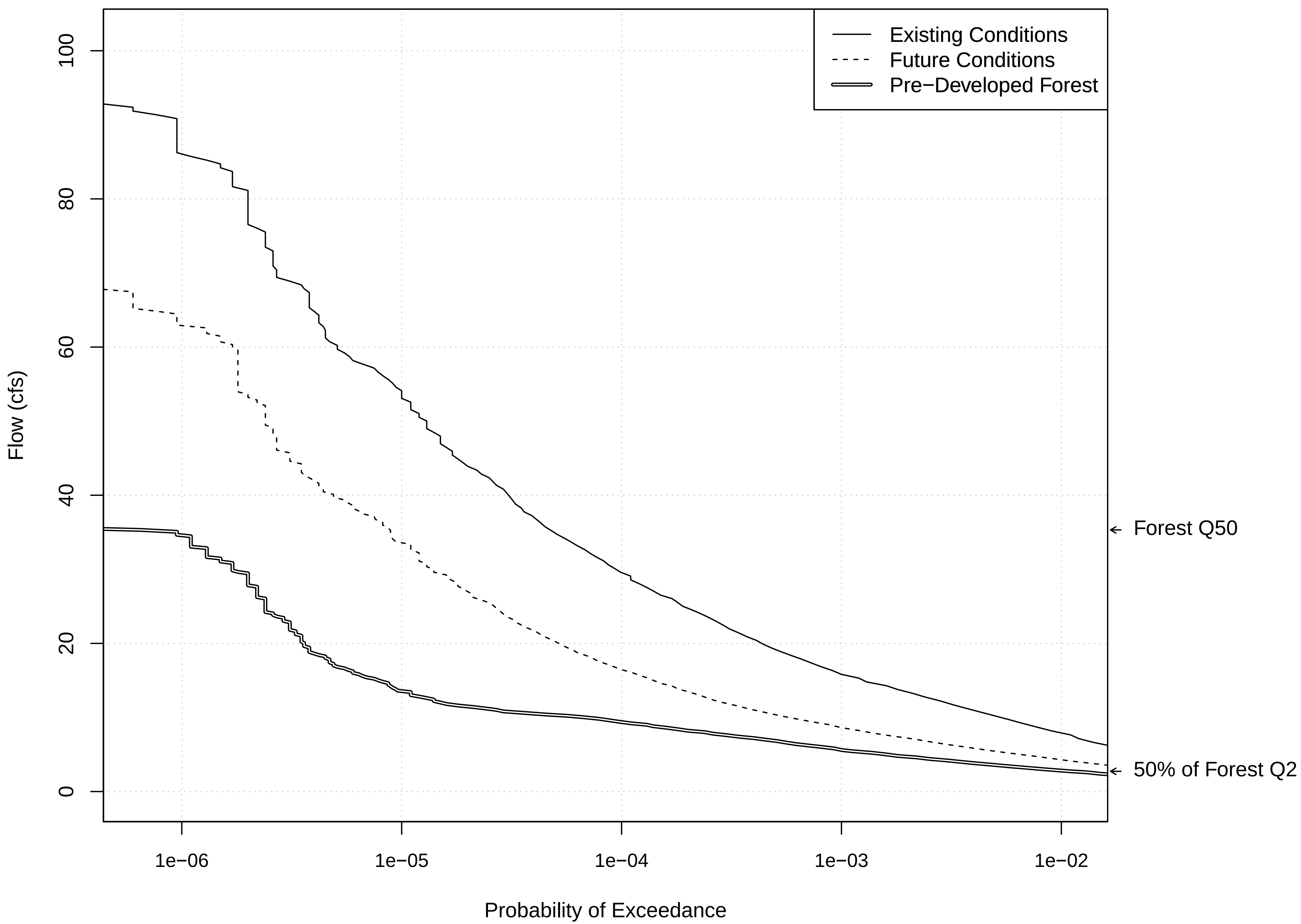
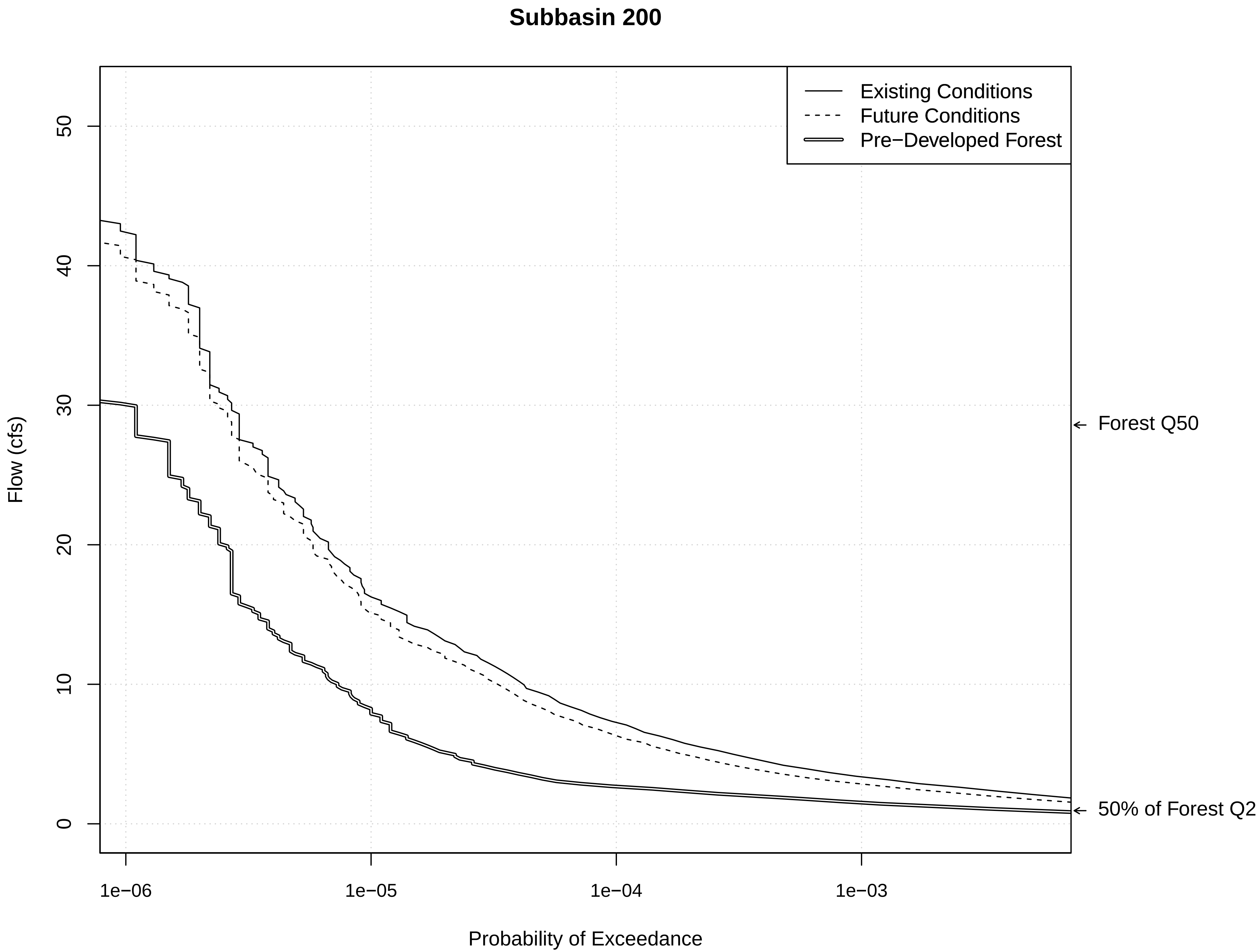
70
1e−06
1e−05
1e−04
Probability of Exceedance
← Forest Q50
← 50% of Forest Q2

Subbasin 160





Subbasin 200
Existing Conditions
Future Conditions
Pre−Developed Forest
Flow (cfs)
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20
30
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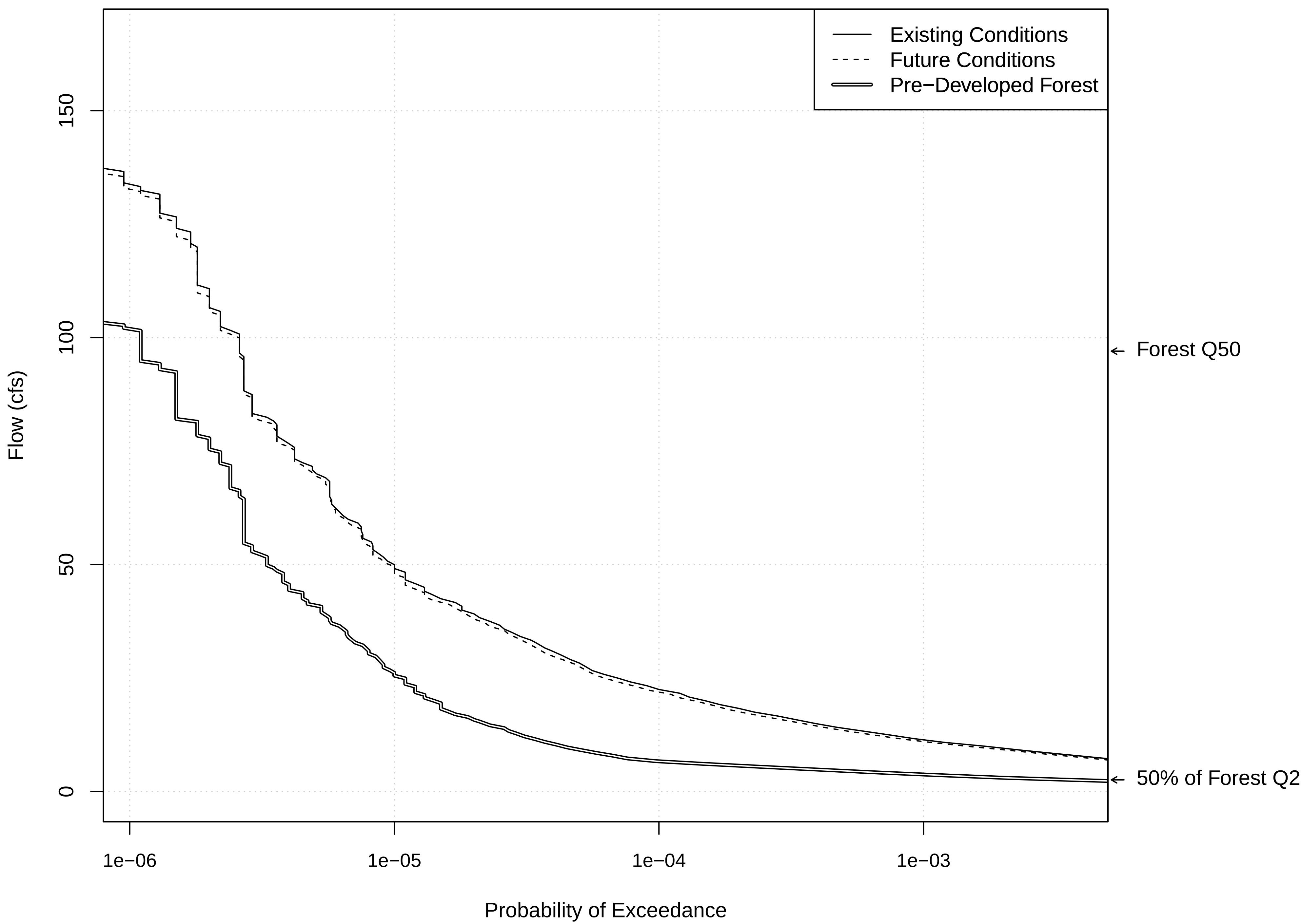
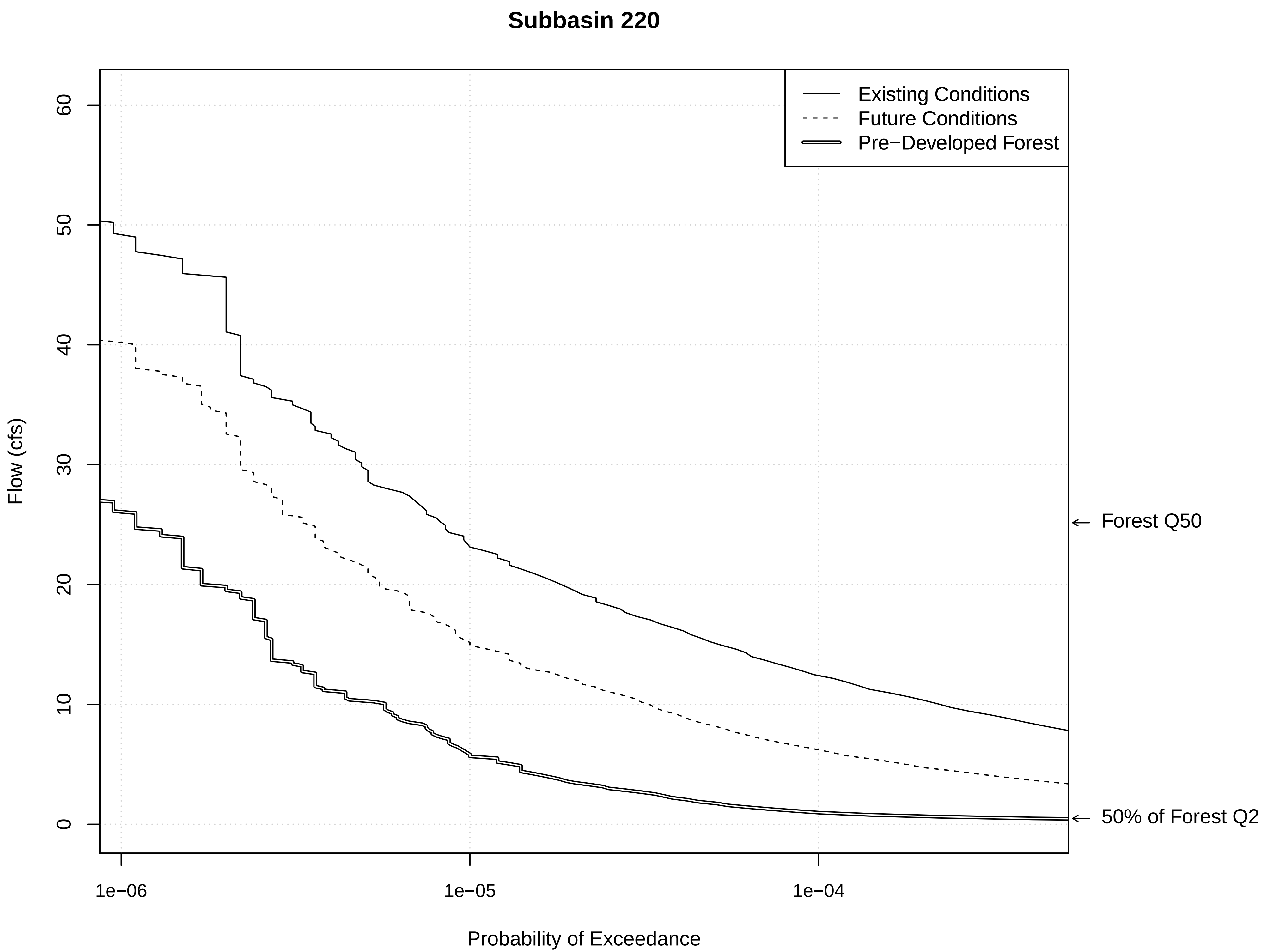
1e−05
1e−04
1e−03
Probability of Exceedance
Forest Q50
50% of Forest Q2

Subbasin 210





Subbasin 220
Existing Conditions
Future Conditions
Pre−Developed Forest
Flow (cfs)
0
10
20
30
40
50
60
1e−06
1e−05
1e−04
Probability of Exceedance
Forest Q50
50% of Forest Q2

APPENDIX D

CIP Summary Sheets

Mason County - Belfair UGA Capital Improvement Program Project Summary Sheet	
Name:	**Viola Creek Fish Passage Improvements**
Need:	**Address fish barrier**
Project Type:	**Fish passage improvement**
Estimated Cost:	**$50,000**

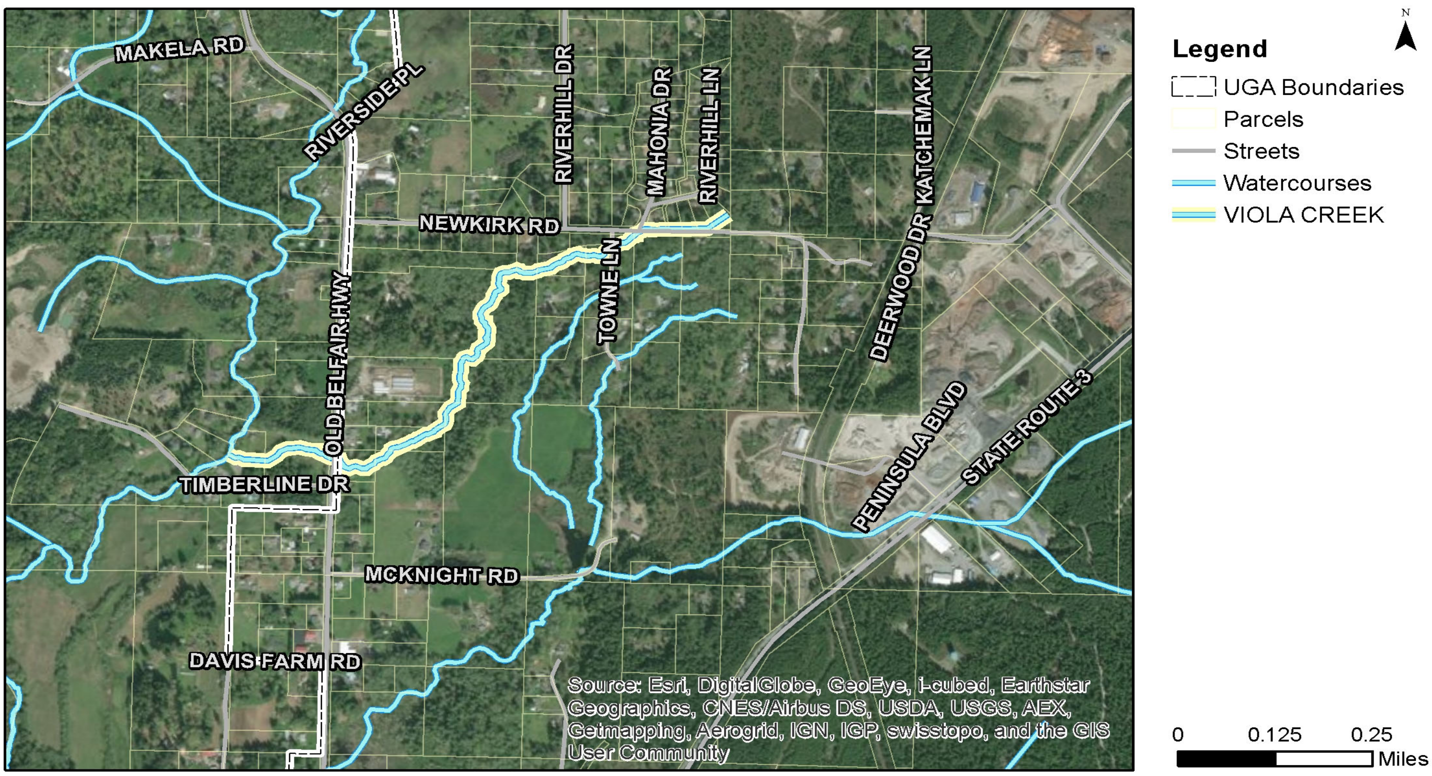
PROJECT SUMMARY

Viola Creek is a salmon bearing stream and the culvert beneath Old Belfair Highway is a fish passage barrier according to HCSEG. Conduct a fish passage improvement investigation for Viola Creek. Coordinate with WDFW and HCSEG to develop options and costs for passage improvement.

PRIORITIZATION

Impaired Infrastructure	STORMWATER		ECOLOGICAL	EDUCATION AND COMMUNITY	
Addresses Existing Infrastructure Issue	**Reduces Water Quantity**	**Improves Water Quality**	**Habitat Creation/ Rehabilitation**	**High Visibility**	**Enhances Public Space**
YES	NONE	NONE	HIGH	LOW	NONE

PROJECT MAP



EXISTING CONDITIONS

PHOTOS NEEDED

Caption

Caption

Mason County - Belfair UGA Capital Improvement Program Project Summary Sheet

Name:	**Irene Creek Fish Passage Improvements**
Need:	**Address fish barrier**
Project Type:	**Fish passage improvement**
Estimated Cost:	**$50,000**

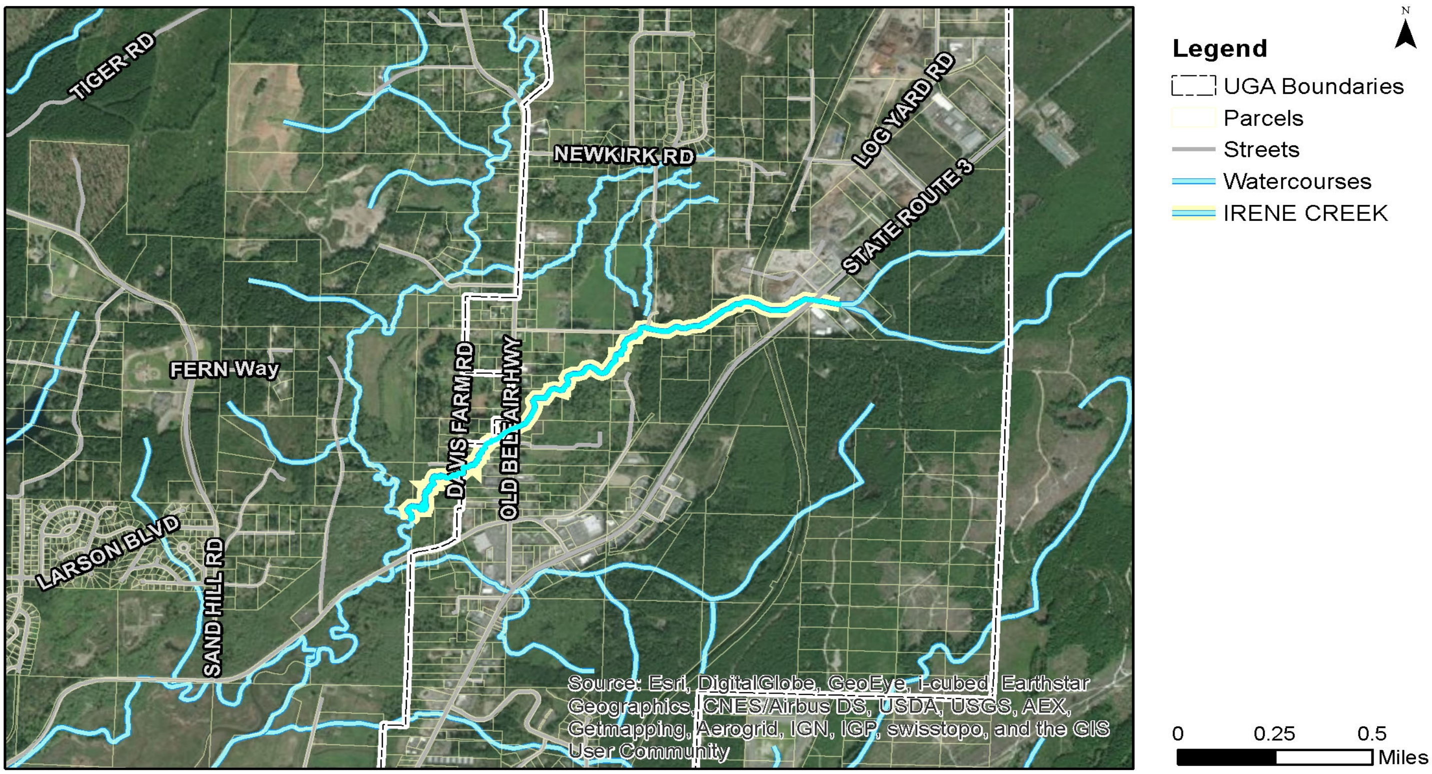
PROJECT SUMMARY

Irene Creek is a salmon bearing stream and the culvert beneath Old Belfair Highway is a fish passage barrier according to HCSEG. Conduct a fish passage improvement investigation for Irene Creek. Coordinate with WDFW and HCSEG to develop options and costs for passage improvement.

PRIORITIZATION

Impaired Infrastructure	STORMWATER		ECOLOGICAL	EDUCATION AND COMMUNITY	
Addresses Existing Infrastructure Issue	**Reduces Water Quantity**	**Improves Water Quality**	**Habitat Creation/ Rehabilitation**	**High Visibility**	**Enhances Public Space**
YES	NONE	NONE	HIGH	LOW	NONE

PROJECT MAP



EXISTING CONDITIONS

PHOTOS NEEDED

Caption

Caption

Mason County - Belfair UGA
Capital Improvement Program
Project Summary Sheet

Name:	**Belfair Creek Fish Passage Improvements**
Need:	**Address fish barrier**
Project Type:	**Fish passage improvement**
Estimated Cost:	**$50,000**

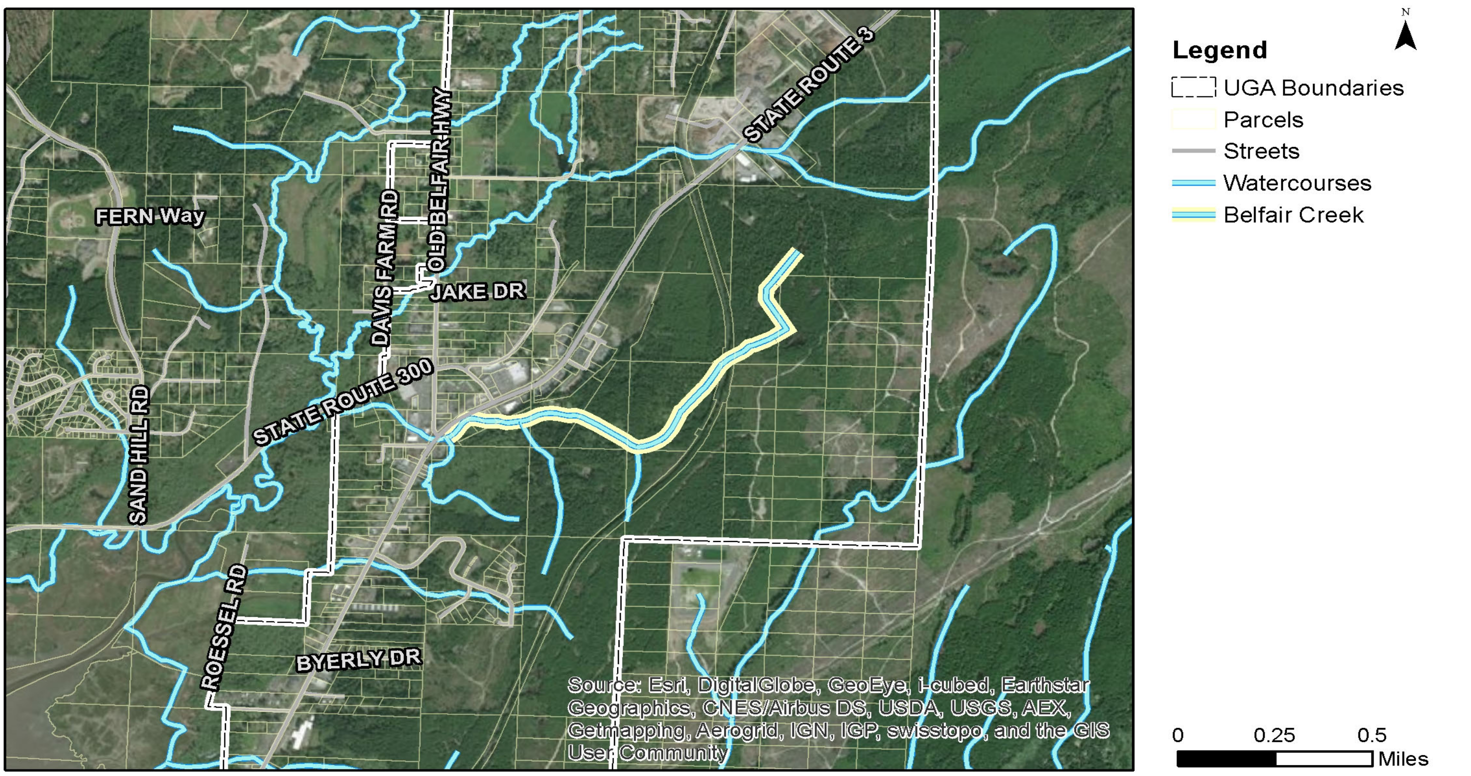
PROJECT SUMMARY

Belfair Creek is a salmon bearing stream and the culvert beneath the road is a fish passage barrier according to HCSEG. Conduct a fish passage improvement study for Belfair Creek from the east side of SR 3 to the existing active stream west of the commercial area. The study would include an alternatives analysis for stream location, accommodation of existing commercial uses, and preparation of preliminary plans. Coordinate with WDFW and HCSEG to develop options and costs for passage improvement. This project was previously identified in the 2007 Stormwater Management Plan (Otak 2007a; Otak 2007b).

PRIORITIZATION

Impaired Infrastructure	STORMWATER		ECOLOGICAL	EDUCATION AND COMMUNITY	
Addresses Existing Infrastructure Issue	Reduces Water Quantity	Improves Water Quality	Habitat Creation/ Rehabilitation	High Visibility	Enhances Public Space
YES	NONE	NONE	HIGH	LOW	NONE

PROJECT MAP



EXISTING CONDITIONS

PHOTOS NEEDED

Caption

Caption

Mason County - Belfair UGA
Capital Improvement Program
Project Summary Sheet

Name:	**Sweetwater Creek Stream and Wetland Restoration**
Need:	**Address fish barrier**
Project Type:	**Aquatic habitat improvement**
Estimated Cost:	**$0**

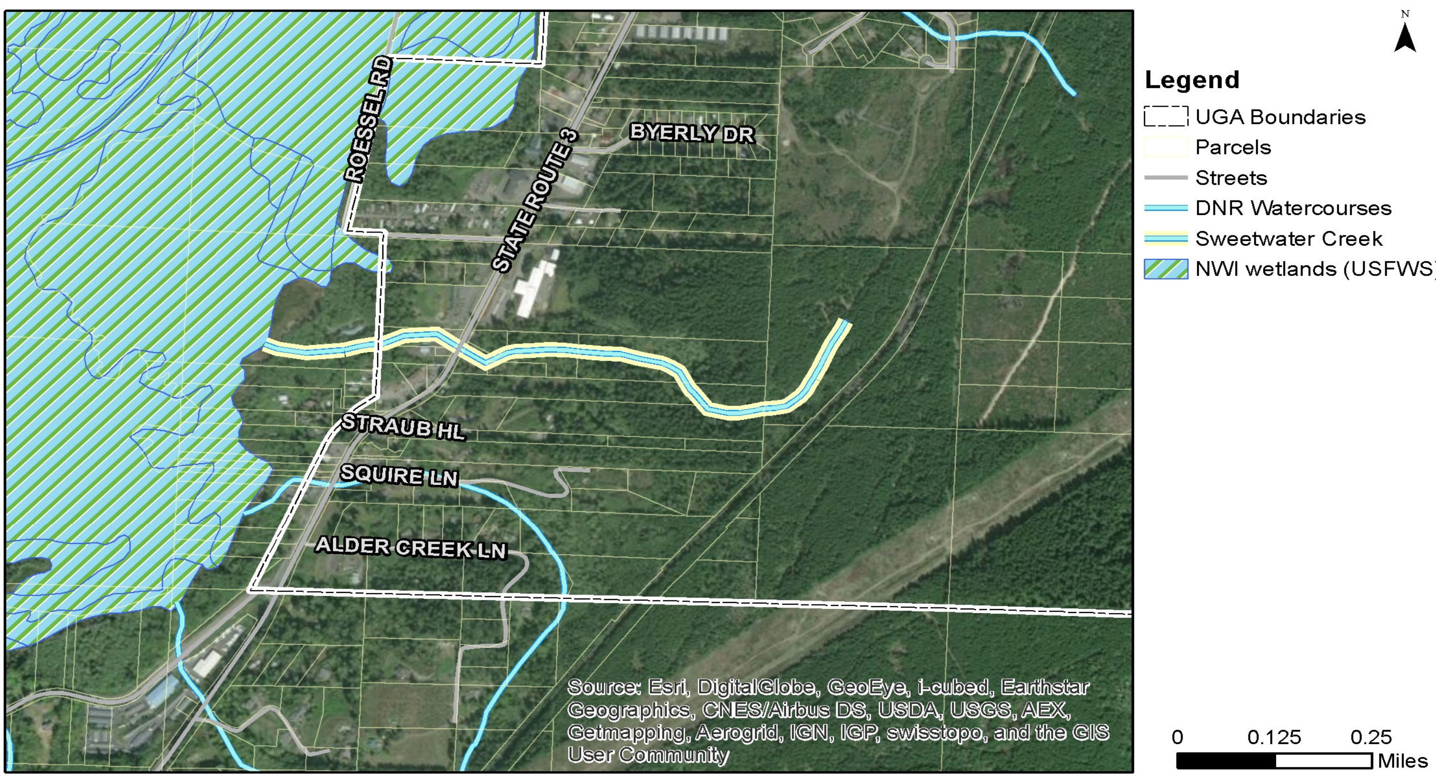
PROJECT SUMMARY

This project is associated with plans for a new community park along Sweetwater Creek that is being spearheaded by HCSEG. Conceptual plans call for the restoration of Sweetwater Creek and associated riparian wetlands, restoration of a historic water wheel and removal of a fish passage barrier, and a new accessible trail with interpretive signage.

PRIORITIZATION

Impaired Infrastructure	STORMWATER		ECOLOGICAL	EDUCATION AND COMMUNITY	
Addresses Existing Infrastructure Issue	**Reduces Water Quantity**	**Improves Water Quality**	**Habitat Creation/ Rehabilitation**	**High Visibility**	**Enhances Public Space**
YES	MED	NONE	HIGH	LOW	NONE

PROJECT MAP



EXISTING CONDITIONS

PHOTOS NEEDED

Caption

Caption

Mason County - Belfair UGA
Capital Improvement Program
Project Summary Sheet

Name:	**Old Belfair Highway Sidewalk Retrofit**
Need:	**Proactive**
Project Type:	**Bioretention retrofit**
Estimated Cost:	**$60,000**

PROJECT SUMMARY

Ditch in ROW of Old Belfair Highway (west side) could be enhanced to improve water quality (e.g., bioretention). County planning future sidewalk improvement that could be leveraged with this retrofit.

PRIORITIZATION

Impaired Infrastructure	STORMWATER		ECOLOGICAL	EDUCATION AND COMMUNITY	
Addresses Existing Infrastructure Issue	Reduces Water Quantity	Improves Water Quality	Habitat Creation/ Rehabilitation	High Visibility	Enhances Public Space
NO	LOW	HIGH	LOW	MED	MED

PROJECT MAP

EXISTING CONDITIONS

Proposed retrofit location looking south.

Proposed retrofit location looking north.

Mason County - Belfair UGA
Capital Improvement Program
Project Summary Sheet

Name:	**William Hunter Park Bioretention (West)**
Need:	**Proactive**
Project Type:	**Bioretention retrofit**
Estimated Cost:	**$54,000**

PROJECT SUMMARY

Runoff from Clifton Lane flows west along the curb and gutter adjacent to William (Bill) Hunter park in downtown Belfair. Two catch basins in Clifton Lane capture this runoff and convey it untreated to the municipal stormwater system, which eventually discharges to the Union River. Through simple pipe modifications and curb cuts, the runoff directed to these catch basins would be routed to a new bioretention facility at the lower or western end of the park. This bioretention facility would be sited in existing green space adjacent to an existing small plaza and sculpture near the intersection of Clifton Lane and State Route 300. One catch basin and the existing connecting pipe would be decommissioned. Signage could be installed to provide education and information on the facility for the public.

PRIORITIZATION

Impaired Infrastructure	STORMWATER		ECOLOGICAL	EDUCATION AND COMMUNITY	
Addresses Existing Infrastructure Issue	Reduces Water Quantity	Improves Water Quality	Habitat Creation/ Rehabilitation	High Visibility	Enhances Public Space
NO	LOW	HIGH	LOW	HIGH	MED

PROJECT MAP

EXISTING CONDITIONS


Proposed retrofit location looking east.


Proposed retrofit location looking west.

HERRERA

Mason County - Belfair UGA Capital Improvement Program Project Summary Sheet

Name:	**Roy Boad Road Bioretention**
Need:	**Proactive**
Project Type:	**Bioretention retrofit**
Estimated Cost:	**$535,000**

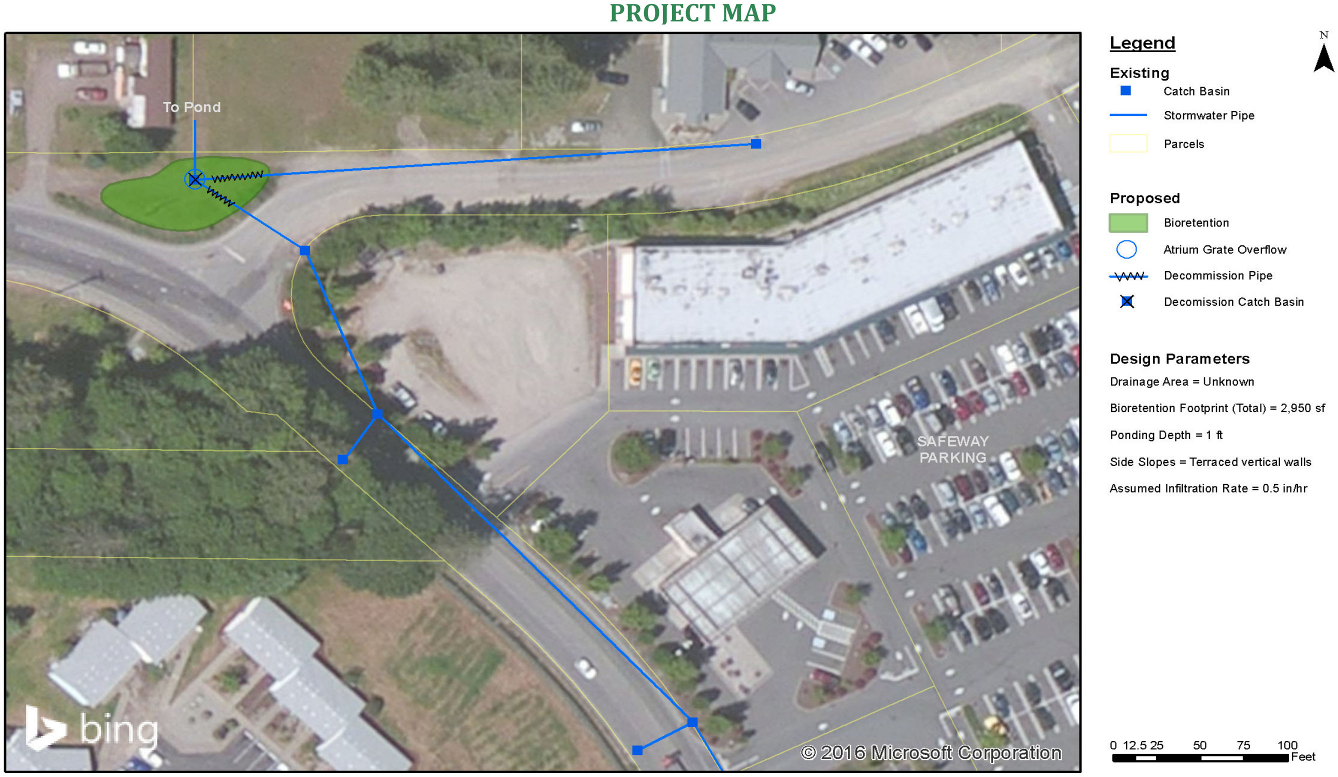
PROJECT SUMMARY

Piped runoff from the Safeway development and Roy Boad Road converge at a catch basin located within a grassy area north of the Roy Boad Road and Clifton Lane intersection within the County ROW. Some overland runoff from Roy Boad Road and Clifton Lane is also directed to this area. This combination of public and private runoff is collectively conveyed to a private stormwater pond to the north. This pond appears to provide flow control, but offers limited water quality improvement. This project would create a large bioretention facility where these flows converge in the ROW to improve water quality upstream of the pond. To intercept piped flow, the facility would need to be 6 to 7 feet deep. A combination of low walls, ornamental fencing, vegetation, and stepped terraces would be used to avoid safety concerns related to public access and to create an aesthetically pleasing facility in this highly visible location.

PRIORITIZATION

Impaired Infrastructure	STORMWATER		ECOLOGICAL	EDUCATION AND COMMUNITY	
Addresses Existing Infrastructure Issue	**Reduces Water Quantity**	**Improves Water Quality**	**Habitat Creation/ Rehabilitation**	**High Visibility**	**Enhances Public Space**
NO	LOW	HIGH	LOW	p	MED

PROJECT MAP



EXISTING CONDITIONS

Proposed retrofit location looking west from Roy Boad Road.

Proposed retrofit location looking east from Clifton Lane.

Mason County - Belfair UGA
Capital Improvement Program
Project Summary Sheet

Name: **William Hunter Park Expansion**
Need: **Proactive**
Project Type: **Wetland/ landscape preservation and enhancement**
Estimated Cost: **$311,000**

PROJECT SUMMARY

A forested wetland covers the southern portion of William (Bill) Hunter park and an adjacent commercial parcel that is mostly undeveloped and currently for sale. The wetland appears to have marginal functionality and would be threatened by any new development on the commercial parcel south of the park. This project entails acquiring the commercial property to expand the park and to preserve the wetland and surrounding landscape, including mature trees. Wetland enhancement work would be conducted to improve wetland function and aesthetics. This could include trash and invasive species removal, native wetland vegetation planting, and targeted regrading if necessary. A boardwalk and interpretive signage could be considered to provide safe public pedestrian access and educational opportunities. The existing dilapidated residential structure on the western edge of the property would be demolished and the footprint would be incorporated into the expanded park landscape.

PRIORITIZATION

Impaired Infrastructure	STORMWATER		ECOLOGICAL	EDUCATION AND COMMUNITY	
Addresses Existing Infrastructure Issue	Reduces Water Quantity	Improves Water Quality	Habitat Creation/ Rehabilitation	High Visibility	Enhances Public Space
NO	NONE	LOW	HIGH	HIGH	HIGH

PROJECT MAP

EXISTING CONDITIONS

Existing park with forested wetland in background.

Forested wetland looking south.

Mason County - Belfair UGA
Capital Improvement Program
Project Summary Sheet

Name:	**William Hunter Park Bioretention (East)**
Need:	**Proactive**
Project Type:	**Bioretention retrofit**
Estimated Cost:	**$42,000**

PROJECT SUMMARY

Runoff from Clifton Lane flows northwest along the curb and gutter west of the Safeway development in downtown Belfair. Several catch basins in Clifton Lane capture this runoff on the west side and convey it to municipal stormwater pipes on the east side of the road. This runoff is untreated and eventually discharges to the Union River. This project would decommission one of the downgradient catch basins and redirect the runoff to a new bioretention facility at the upper or eastern end of William Hunter park. This bioretention facility would be sited in existing green space near a picnic area. Signage could be installed to provide education and information on the facility for the public.

PRIORITIZATION

Impaired Infrastructure	STORMWATER		ECOLOGICAL	EDUCATION AND COMMUNITY	
Addresses Existing Infrastructure Issue	Reduces Water Quantity	Improves Water Quality	Habitat Creation/ Rehabilitation	High Visibility	Enhances Public Space
NO	LOW	HIGH	LOW	HIGH	MED

PROJECT MAP

EXISTING CONDITIONS

Proposed retrofit location looking east.

Proposed retrofit location looking southwest.

Mason County - Belfair UGA **Capital Improvement Program** **Project Summary Sheet**	Name:	**SR300 Linear Bioretention Retrofit (North QFC)**
	Need:	**Proactive**
	Project Type:	**Bioretention retrofit**
	Estimated Cost:	**$36,000**

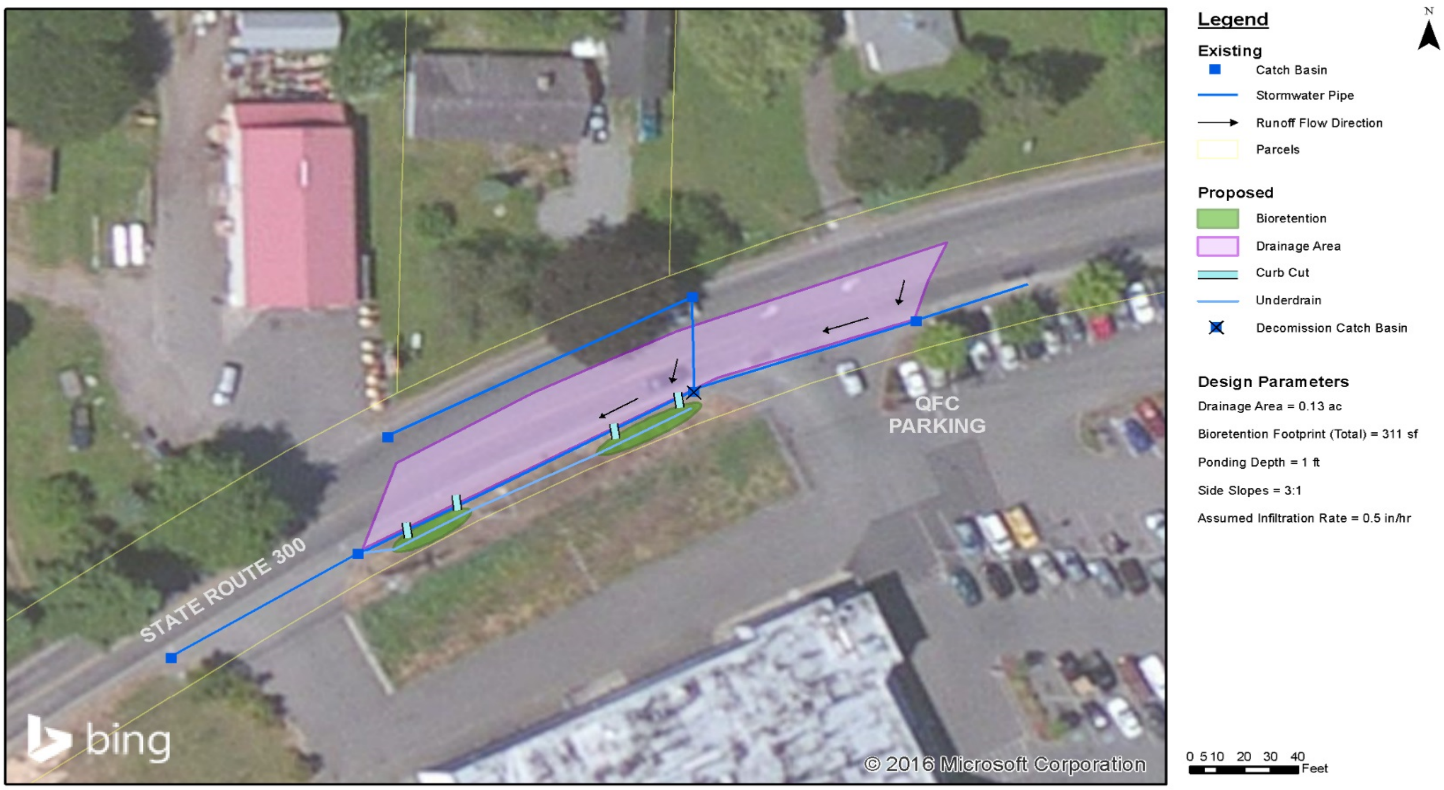
PROJECT SUMMARY

Runoff from SR 300 flows west along the curb and gutter to the north of the QFC development in downtown Belfair. Two catch basins between parking lot entrances capture runoff from SR 300 and convey it untreated to the municipal stormwater system, which eventually discharges to the Union River. Through simple catch basin modifications and curb cuts, the runoff directed to these catch basins would be routed to a new linear bioretention facility installed within the right-of-way north of the QFC development. One catch basin would be decommissioned. Potential utility conflicts (fire hydrant, utility pole) should be investigated before moving into further design. Multiple bioretention cells are proposed to work around utility conflicts.

PRIORITIZATION

Impaired Infrastructure	STORMWATER		ECOLOGICAL	EDUCATION AND COMMUNITY	
Addresses Existing Infrastructure Issue	**Reduces Water Quantity**	**Improves Water Quality**	**Habitat Creation/ Rehabilitation**	**High Visibility**	**Enhances Public Space**
NO	LOW	HIGH	LOW	MED	MED

PROJECT MAP



EXISTING CONDITIONS

Grassy area in ROW could be retrofitted with linear bioretention.

Electrical box indicates utility conflicts may be present.

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Mason County - Belfair UGA Capital Improvement Program Project Summary Sheet

Name:	**SR300 Ditch Improvement**
Need:	**Proactive**
Project Type:	**Ditch retrofit**
Estimated Cost:	**$49,000**

PROJECT SUMMARY

A ditch on the east side of SR300 ROW adjacent to Belfair House Apartments is overgrown, full of organic debris, and overflowing onto the road shoulder. The ditch is located between the road and a berm that holds back a stormwater facility on the Belfair House Apartments property. Seepage of groundwater or wetland water through the berm was observed flowing into the ditch. With this project, the ditch would be enlarged slightly and revegetated to improve capacity and water quality. Seepage through the berm would be investigated further and remediated as needed.

PRIORITIZATION

Impaired Infrastructure	STORMWATER		ECOLOGICAL	EDUCATION AND COMMUNITY	
Addresses Existing Infrastructure Issue	**Reduces Water Quantity**	**Improves Water Quality**	**Habitat Creation/ Rehabilitation**	**High Visibility**	**Enhances Public Space**
YES	LOW	LOW	LOW	LOW	LOW

PROJECT MAP

EXISTING CONDITIONS

Ditch in ROW looking north.

Ditch in ROW looking southwest.

Mason County - Belfair UGA
Capital Improvement Program
Project Summary Sheet

Name:	**SR300 Linear Bioretention Retrofit (East QFC)**
Need:	**Proactive**
Project Type:	**Bioretention retrofit**
Estimated Cost:	**$309,000**

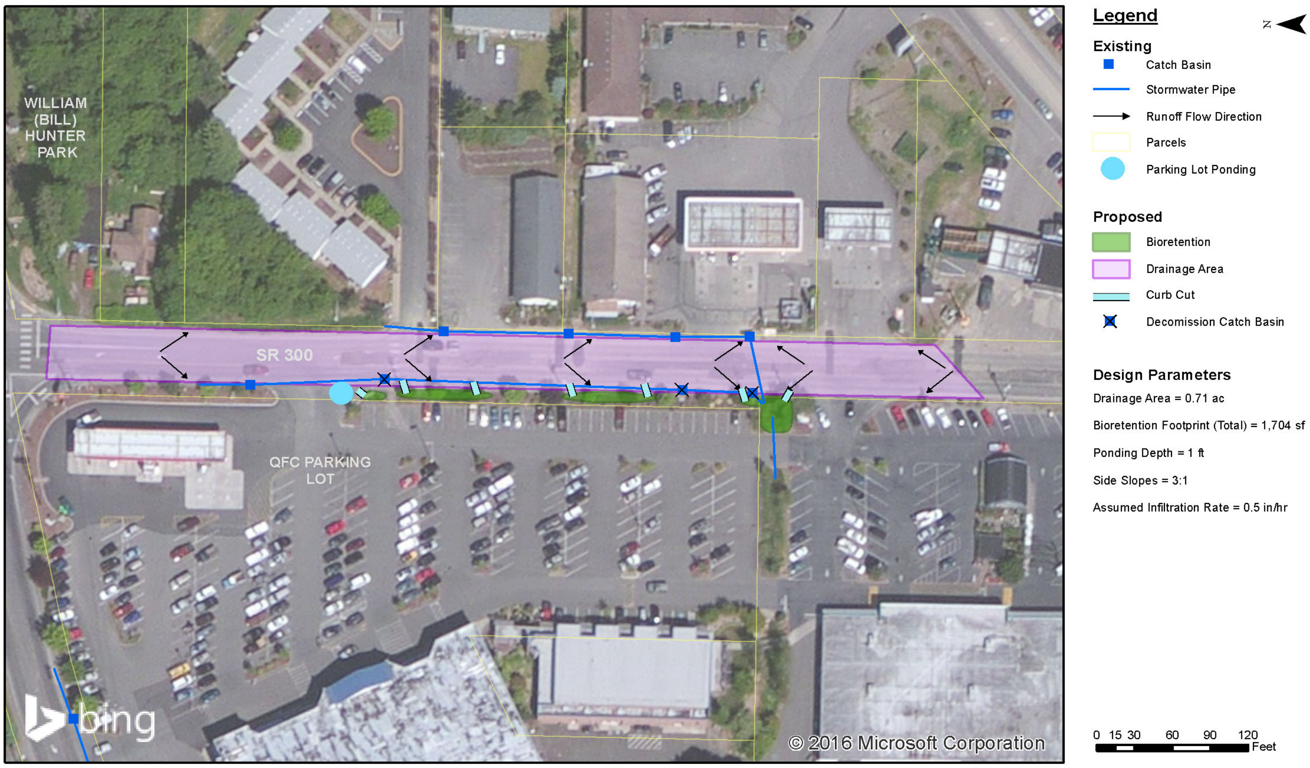
PROJECT SUMMARY

A poorly placed surface inlet is located in the middle of the curb lane of SR300 in front of the QFC development. As a result, ponding/flooding routinely occurs at the adjacent driveway entrance to the QFC parking lot. In addition, runoff from SR300 further downgradient from this point is collected from both sides of the street and conveyed untreated to the Union River. This project would decommission the misplaced surface inlet and route flow intended for this inlet, along with two additional downgradient catch basins, to a series of long linear bioretention facilities in the SR300 ROW in front of the QFC development. The ROW is sparsely vegetated with low quality shrubs and some mature trees. A larger bioretention facility would also be placed at the point where runoff collected from both sides of SR300 converge (southeast corner of QFC parking lot).

PRIORITIZATION

Impaired Infrastructure	STORMWATER		ECOLOGICAL	EDUCATION AND COMMUNITY	
Addresses Existing Infrastructure Issue	**Reduces Water Quantity**	**Improves Water Quality**	**Habitat Creation/ Rehabilitation**	**High Visibility**	**Enhances Public Space**
YES	LOW	HIGH	LOW	MED	MED

PROJECT MAP



EXISTING CONDITIONS


Poorly placed surface inlet in curb lane.


Ponding at QFC parking lot entrance.


Proposed retrofit location looking north.

APPENDIX E

Old Belfair Highway Predesign Report

HERRERA

DRAFT
PREDESIGN REPORT

OLD BELFAIR HIGHWAY
STORMWATER RETROFIT PROJECT
MASON COUNTY, WASHINGTON

Prepared for
Mason County Public Works

Prepared by
Herrera Environmental Consultants, Inc.

HERRERA

Note:
Some pages in this document have been purposely skipped or blank pages inserted so that this document will copy correctly when duplexed.

PREDESIGN REPORT

Old Belfair Highway Stormwater Retrofit Project Mason County, Washington

Prepared for
Mason County Public Works
100 W. Public Works Drive
Shelton, WA 98584

Prepared by
Herrera Environmental Consultants, Inc.
2200 Sixth Avenue, Suite 1100
Seattle, Washington 98121
Telephone: 206-441-9080

DRAFT
October 20, 2017

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Appendix B - Cost Estimate

FIGURES

Figure 1. Project area for the Old Belfair Highway Stormwater Retrofit, Belfair, Washington. 3
Figure 2. Proposed Old Belfair Highway Stormwater Retrofit. 5
Figure 3. Typical Bioretention Cross-Section. 6

ENGINEERS' STAMPS

This preliminary design report has been prepared under the supervision of the professional engineers registered in Washington State whose seals appear below.

Kristen Matsumura, PE October 20, 2017

Brian E. Busiek, PE October 20, 2017

Introduction

Mason County and Herrera Environmental Consultants (Herrera) worked in partnership with the Washington Department of Ecology (Ecology), Mason Conservation District (MCD) and the Hood Canal Salmon Enhancement Group (HCSEG) to develop a basin plan for the City of Belfair Urban Growth Area (UGA). The plan provides a pathway forward for development and redevelopment of the UGA that ensures sound stormwater management and policies that are protective of the region's natural resources. This includes decisions about the regulatory requirements that will govern future development and redevelopment projects and the necessary programs and capital projects that will be needed to help mitigate flooding and protect water quality and environmental health in the UGA.

The basin plan included consideration of 16 capital projects that were qualitatively evaluated based on stormwater, ecological, education and community, and economic metrics. Herrera prepared this preliminary design report for one of the priority capital projects along Old Belfair Highway. This project would be implemented in conjunction with a County sidewalk improvement project and would provide stormwater runoff treatment for the roadway. This project would retrofit an existing stormwater ditch with a bioretention system to provide water quality treatment and infiltration of stormwater in a high traffic location in downtown Belfair.

Basin Description

The Belfair UGA spans approximately 2,400 acres to the northeast of the eastern terminus of Hood Canal's lower arm. The UGA is bound to the west by the Union River, and to the east by hills that act as the watershed divide between Hood Canal and Case Inlet.

The Union River and Hood Canal are the major waterbodies that lie within or adjacent to (and are affected by) the UGA. The Union River is one of the more significant rivers that flow into Hood Canal and provides the largest source of water to the lower arm of the canal. The Union River is impaired by bacteria, dissolved oxygen, and temperature levels that exceed the state water quality standard.

There are many small streams within the Belfair UGA that provide important habitat for fish and wildlife. Four named streams discharge to the Union River with watersheds that are entirely or almost entirely within the UGA. These include; Irene, Belfair, Mindy, and Viola Creeks. This proposed project is located within the Irene Creek subbasin. See Figure 1.

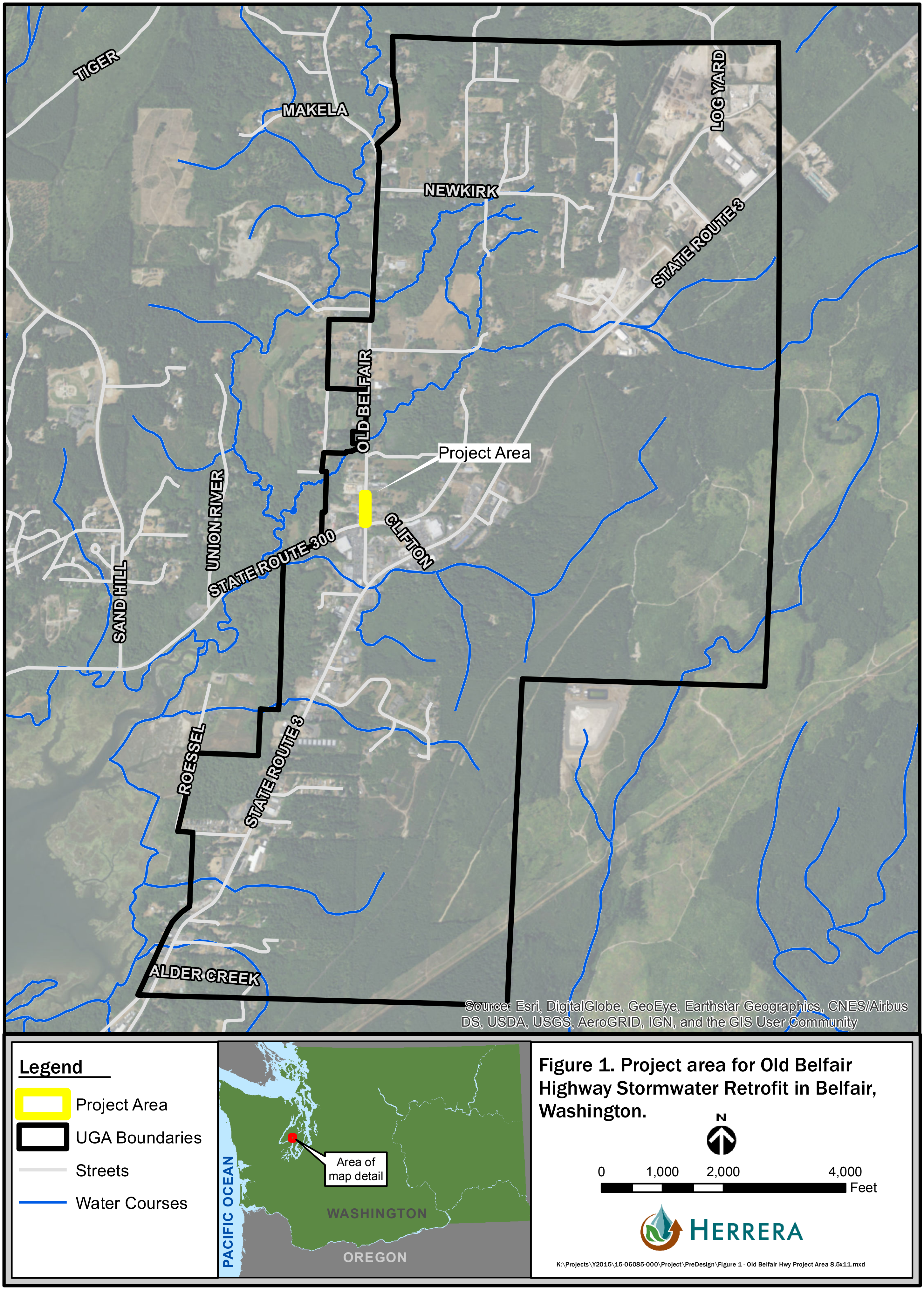


Figure 1. Project area for Old Belfair Highway Stormwater Retrofit in Belfair, Washington.

OVERALL GOAL

The overall goal of the retrofit project is to provide water quality treatment of roadway runoff in the Belfair UGA. Additional goals include public education and involvement, and reduction of flow rates to Irene Creek.

SITE DESCRIPTION

The project site is located along Old Belfair Highway north of the intersection with State Route 300 and Old Clifton Road. State Route 300, through downtown Belfair, has an average annual daily traffic count ranging between 10,000 and 19,000 vehicles. It is expected that Old Belfair Highway experiences a significant portion of this traffic.

Old Belfair Highway is crowned such that half of the roadway drains west into a roadside drainage system. The drainage system is comprised of ditches, catch basins, and pipes which ultimately drain to a 30-inch culvert that travels west between two parcels to Irene Creek. The ditch system also conveys flow from a private stormwater pond located east of Old Belfair Highway.

Land use in the area along Old Belfair Highway is primarily commercial. The drainage area a facility would treat is comprised of approximately 11,000 square feet (0.25 acre) of impervious roadway.

PROJECT DESCRIPTION AND DESIGN ANALYSIS

This project focuses on a 450-foot length of Old Belfair Highway north of the intersection with State Route 300 where a sidewalk improvement project is currently planned. In concert with sidewalk construction, two bioretention cells would be installed to manage runoff from 11,000 square feet of roadway surface. The right-of-way along Old Belfair Highway is wide enough on the west side of the road to allow a six-foot sidewalk and multiple linear bioretention facilities located within the existing ditch systems. The bioretention facilities would be located between the sidewalk and the roadway. Trench drains will be installed along the existing driveways to direct road runoff to the bioretention facilities and away from private parcels.

MGS Flood was used to estimate the portion of runoff that can be treated and attenuated within the footprint allotted between the proposed sidewalks and roadway. The modeling report is included in Appendix A.

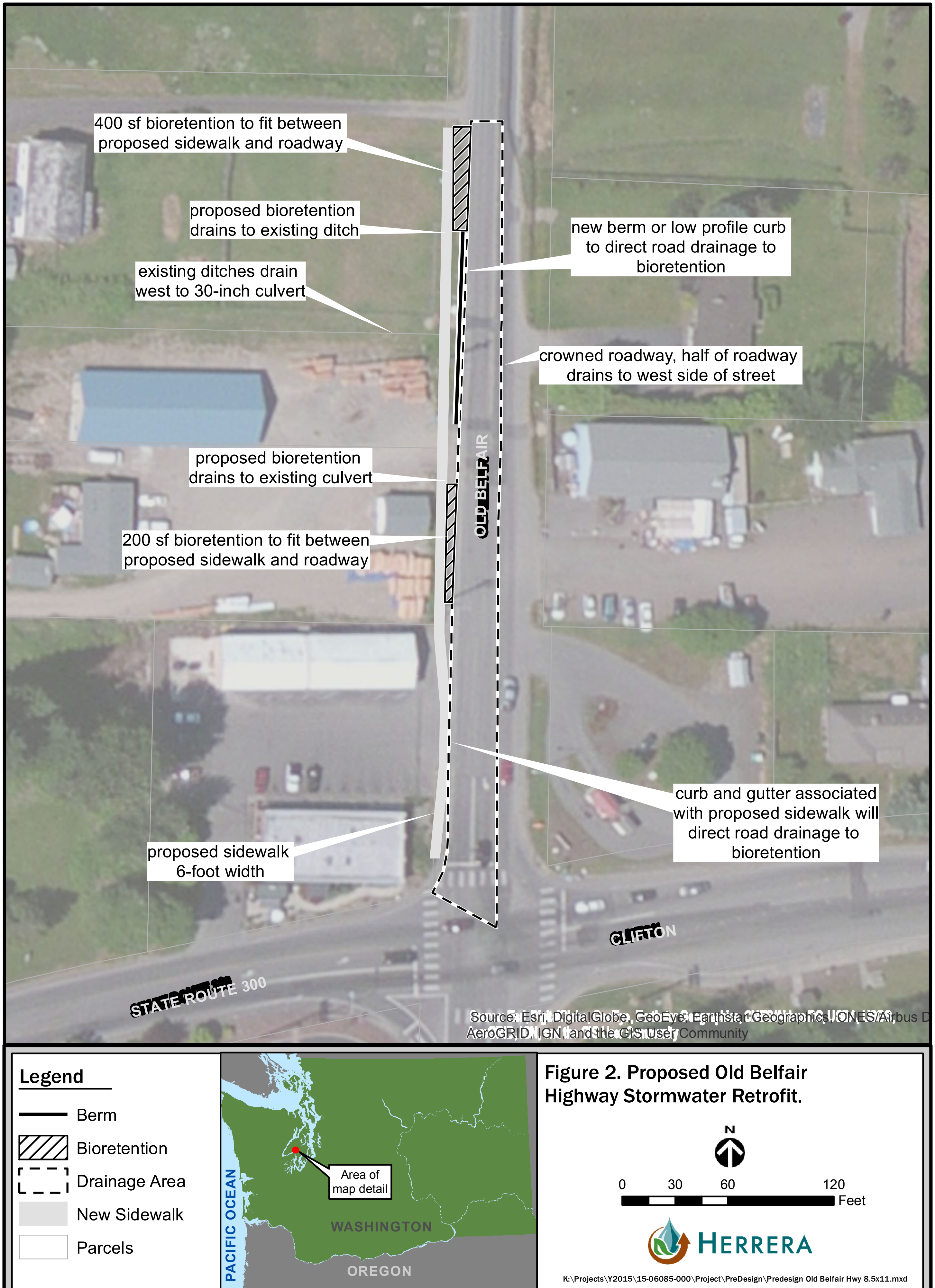
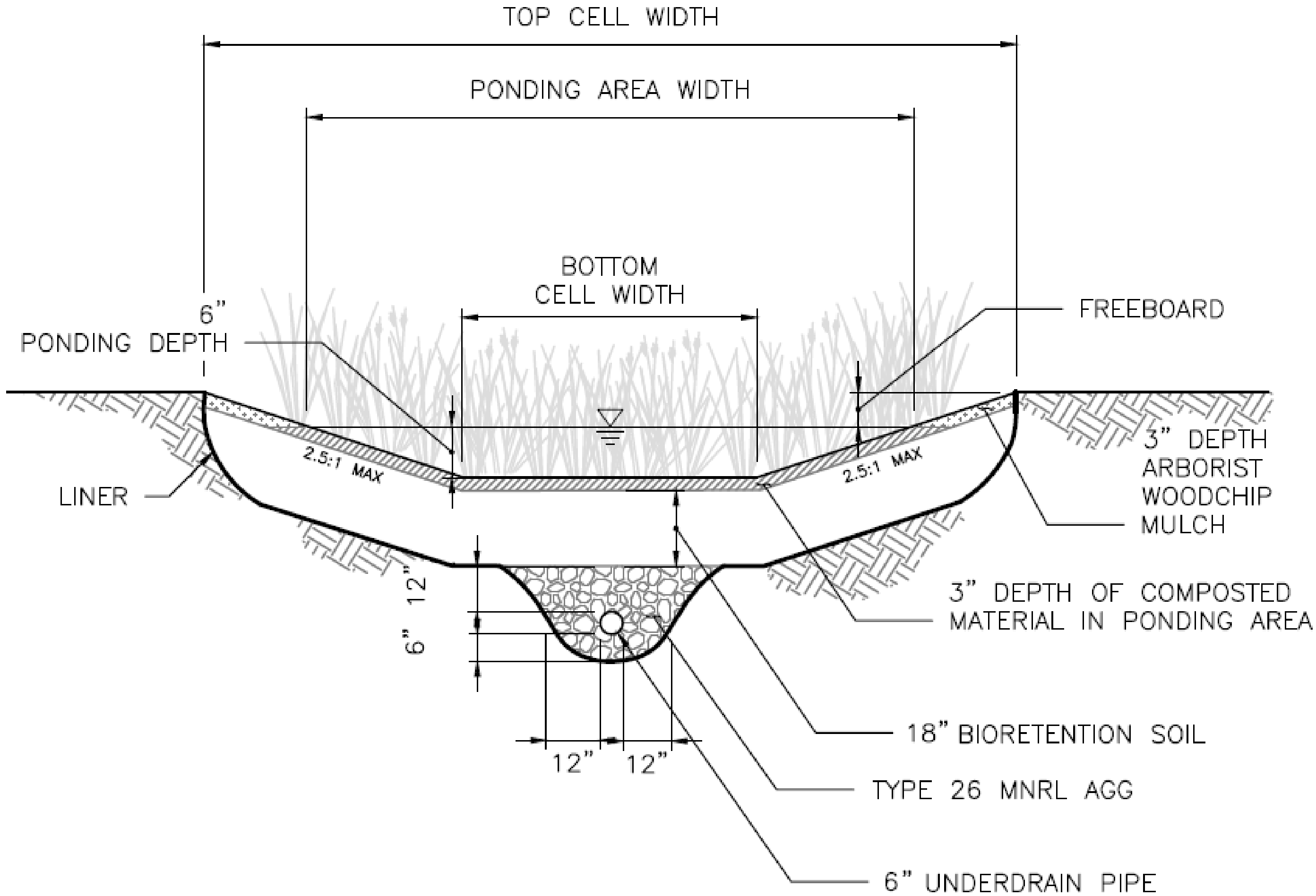


Figure 2. Proposed Old Belfair Highway Stormwater Retrofit.

Figure 3. Typical Bioretention Cross-Section.



PROJECT SELECTION AND ALTERNATIVES CONSIDERATION

This project was selected from among 16 capital projects considered in the Belfair UGA 2018 Basin Plan. The Old Belfair Highway retrofit project was chosen as a high priority and selected for further design because it could be coupled with another planned project and because it would be a highly visible project at a relatively low project cost. In addition to treating stormwater, the project would help provide public education and enhance aesthetics.

Three types of treatment facilities were considered for the project: StormFilter® cartridges media filter drain (MFD), and bioretention. Each is discussed below.

The StormFilter® cartridge system would require installation of a manhole vault to house the treatment media cartridges. It would also need more than 2 feet of head between the inlet and outlet of the system, which is not available without significant site grading and extension of the outlet pipe several hundred feet off the site.

An MFD would provide filtration of runoff through a media filter drain mix. An MFD can use an underdrain to maximize treatment capacity and minimize prolonged ponding. However, MFDs require shallow side slopes of less than 5 percent, which would result in a large total facility footprint. An MFD would also likely conflict with existing utilities in the planter strip, would diminish site aesthetics, and would provide relatively little public education value.

A bioretention system would provide infiltration and filtration through a treatment media within a smaller and shallower overall footprint than an MFD system or a StormFilter system. It would also be more aesthetically pleasing and would demonstrate to the public that stormwater facilities can beautify the landscape while achieving stormwater treatment goals. For these reasons, bioretention was determined to be the best treatment option for the Old Belfair Highway project.

WATER QUALITY BENEFITS

The bioretention facilities provide both runoff treatment and flow control. The proposed facilities will meet Ecology's runoff treatment requirement by treating over 91 percent of long-term runoff volume from the adjacent 11,000 square feet of contributing area. Treatment is achieved via filtration through the bioretention media. As a conservative measure, it was assumed that native soil infiltration capacity is very low, so the facility would have a relatively low capacity to infiltrate runoff. Given this assumption, the facilities were designed with an underdrain. As such, the systems will provide a flow control benefit, but will not meet Ecology's flow control requirement for new development/redevelopment.

Minimum Requirements - Quantifying the Facility Benefit

Per guidelines laid out in the Design Deliverables for Stormwater Projects with Ecology Funding (Ecology 2016b), a runoff treatment ratio was developed for the project.

Runoff Treatment Ratio

Runoff treatment BMPs are analyzed based on the following equation:

$$\text{Ratio}_{\text{WRT-1}} = \frac{\text{Design flowrate or volume for proposed retrofit treatment BMP}}{\text{Design flow rate or volume to meet new/redevelopment criteria}}$$

$$\text{If Ratio}_{\text{WRT-1}} > 1\text{, then set Ratio}_{\text{WRT-1}} = 1$$

$$\text{Area}_{\text{WRT-1}} = \text{Ratio}_{\text{WRT-1}} \times \text{Contributing Basin Area}$$

The proposed design treatment volume of the bioretention system is 1.07 acre-feet per year. The design flow rate required to meet new/redevelopment criteria (91 percent of long-term runoff volume) is 0.99 acre-feet. The ratio of the proposed design flowrate to the required design flowrate is greater than 1, so the equivalent new/redevelopment area is equal to the total contributing basin area of 0.25 acre.

Flow Control Ratio

As noted in the previous section, the facilities will not meet Ecology's flow control requirement for new development/redevelopment due to the presence of an underdrain. If geotechnical testing during the design process indicates that soil infiltration capacity is sufficient, then it may be possible to eliminate or modify the underdrain to allow the systems to meet flow control requirements.

COST ESTIMATE

A preliminary construction cost estimate (Appendix B) was prepared based on experience with projects of a similar scale and in similar site settings, and assuming a contractor would be hired to carry out the construction. Except where otherwise noted, the cost estimate was developed using the following considerations:

- This project is expected to be constructed in concert with the Old Belfair Highway sidewalk installation project. As such, there are potentially overlapping costs such as mobilization, traffic control, erosion and sediment control, etc. that have already been accounted for in the sidewalk installation design. The cost estimate for the stormwater retrofit was prepared to only account for these costs over and above the sidewalk project so that there was no duplication of costs.

- Construction bid items were based on Washington State Department of Transportation (WSDOT) standard specifications where applicable, including material, construction requirements, measurement, and payment.

- Line item unit prices used in the construction cost estimate were developed with sound engineering judgment and were derived from a combination of applicable sources, including contractor bid tabs from similar past projects; prices compiled by WSDOT and Seattle Public Utilities; quotes from vendors; cost estimating guides (e.g., RS Means and The Guide); and site-specific understanding of probable contractor staging, access, and other project-specific requirements and constraints that would affect contractor bids for the project.

- Mason County sales tax of 8.5 percent was applied to the construction cost.

Allied costs (project management, survey, geotechnical analyses, design, permitting, property acquisition, and construction management) were developed by applying the following assumptions:

- County would hire a consultant to perform the survey, geotechnical analysis, design, and permitting.

- County would manage the project for a cost equal to 10 percent of the construction cost and would perform construction management for a cost equal to 10 percent of the construction cost.

- Costs for survey, design, and permitting are based on experience with design and permitting for similar projects, and knowledge of site-specific job complexities and challenges. In some cases, professional judgment was used to estimate allied costs as a percentage of construction costs.

- No easements will be required for the project.

- A 10 percent contractor bid overrun allowance and 5 percent change order allowance is included in the cost estimate, along with an estimated cost for utility protection and relocation during construction. However, no contingency was included because the Ecology grant requirements do not allow for a contingency.

The total planning-level cost of the retrofit project, including survey, design, construction, and other miscellaneous costs, is estimated to be approximately $60,000. Itemized costs are included in Appendix B.

Commitment to Long-Term Operations and Maintenance

Water quality performance of the installed bioretention system will be maintained in accordance with requirements identified in the 2012 Ecology Manual, as amended in 2014. During maintenance visits, County staff will perform all required maintenance activities. The performance of the facilities will be monitored by observing them during storm events or simulated storm events (i.e. flow provided by hydrants or water truck). The mulch and media will be replaced, as needed, by County staff.

The proposed water quality treatment system incorporates green techniques (i.e., plants and soil) to improve water quality treatment performance. It is a passive system that does not require energy input other than for routine maintenance.

Project Success

Success of the project will be linked to effective filtration and infiltration of stormwater runoff as observed during future storm events. Project success will be measured with: 1) written records of observations of facility function and condition during scheduled maintenance activities, and 2) field visits during rain events to observe flow through the bioretention system to ensure flow is not bypassing the facilities. If warranted, project maintenance activities and frequencies will be adjusted to ensure the facilities are functioning per the design.

Over the long term, the County can use the recorded observations of facility function and condition during scheduled maintenance to develop recommendations for facility operations and maintenance. Those recommendations can be distributed among County design engineers and maintenance staff to inform them of bioretention facility function and maintenance requirements. County personnel can then apply their knowledge on future stormwater projects in Mason County.

Implementation Recommendations

Infiltration testing will be conducted during the design phase of the project to determine native infiltration rates. If the native infiltration capacity is found to be sufficient, then the underdrains may be eliminated or modified to allow the systems to meet flow control requirements.

Some utilities are visible above ground in the project area, but the presence and location of underground utilities is not known. Underground utilities should be located and surveyed prior to design. Potholing may be needed in areas where utilities are within the potential footprint of the proposed stormwater facility and cost for potholing is included in the cost estimate.

This report has been written to facilitate completing the grant application for the Ecology Stormwater Financial Assistance Program and preparation of the design report required for projects funded under that program. The information in this report, particularly water quality benefits and cost, will need to be updated as the design is developed, prior to submission of the design report to Ecology.

REFERENCES

Ecology. 2014. 2012 Stormwater Management Manual for Western Washington, as Amended in December 2014. Publication Number 14-10-055. Washington State Department of Ecology, Water Quality Program, Olympia, Washington. December.

Ecology. 2016b. Design Deliverables for Stormwater Projects with Ecology Funding. Washington State Department of Ecology. Olympia, Washington.

APPENDIX A

Modeling Report

MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.40
Program License Number: 200210002
Project Simulation Performed on: 10/19/2017 1:19 PM
Report Generation Date: 10/19/2017 1:56 PM

Input File Name: 2017-09-26 old belfair hwy.fld
Project Name:
Analysis Title:
Comments:

PRECIPITATION INPUT

Computational Time Step (Minutes): 5

Puget West 56 Climate

Extended Precipitation Time Series Selected
Climatic Region Number: 0

Full Period of Record Available used for Routing
Precipitation Station : 95005605 Puget West 56 in_5min 10/01/1939-10/01/2097
Evaporation Station : 951056 Puget West 56 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

*********************** WATERSHED DEFINITION ***********************

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.258	0.250
Area of Links that Include Precip/Evap (acres)	0.000	0.008
Total (acres)	0.258	0.258

----------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

	-------Area (Acres) --------
Till Forest	0.258
Subbasin Total	0.258

---------------------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

	-------Area (Acres) --------
Impervious	0.250
--	
Subbasin Total	0.250

Developed Scenario - 0.25 acres impervious contributing area

**************************** LINK DATA *******************************

---------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

---------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

--
Link Name: New Bio Lnk1
Link Type: Bioretention Facility
Downstream Link: None

0.5' ponding depth

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.50
Storage Depth (ft) : 0.50
Bottom Length (ft) : 70.0
Bottom Width (ft) : 5.0
Side Slopes (ft/ft) : L1= 3.00 L2= 3.00 W1= 3.00 W2= 3.00
Bottom Area (sq-ft) : 350.
Area at Riser Crest El (sq-ft) : 584.
(acres) : 0.013
Volume at Riser Crest (cu-ft) : 390.
(ac-ft) : 0.009

Bioretention bottom area = 70' x 5'

Sideslopes 3:1

Infiltration on Bottom and Sideslopes Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 3.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.10

Underdrain Present
Orifice NOT Present in Under Drain

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 12.00

Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

----------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 1
Number of Links: 0

----------------------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1
Number of Links: 1

**************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

Model Element	Recharge Amount (ac-ft)
Subbasin: Subbasin 1	58.596
Total:	58.596

Total Post Developed Recharge During Simulation

Model Element	Recharge Amount (ac-ft)
Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	0.000
Total:	0.000

Total Predevelopment Recharge is Greater than Post Developed
Average Recharge Per Year, (Number of Years= 158)
Predeveloped: 0.371 ac-ft/year, Post Developed: 0.000 ac-ft/year

**************Water Quality Facility Data ***************

----------------------SCENARIO: PREDEVELOPED

Number of Links: 0

----------------------SCENARIO: POSTDEVELOPED

Number of Links: 1

********** Link: New Bio Lnk1 **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 166.53
Inflow Volume Including PPT-Evap (ac-ft): 172.31
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 169.58, 98.41%
Primary Outflow To Downstream System (ac-ft): 172.49
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 98.41%

98.41% long term runoff filtered through bioretention soil media

**************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Developed peak flows downstream of bioretention

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	1.364E-02	2-Year	0.111
5-Year	2.406E-02	5-Year	0.171
10-Year	3.481E-02	10-Year	0.187
25-Year	4.328E-02	25-Year	0.220
50-Year	5.222E-02	50-Year	0.259
100-Year	5.539E-02	100-Year	0.339
200-Year	9.006E-02	200-Year	0.358

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

Does not provide flow control

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than 0%): 545.4% FAIL
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than 0%): 3698.7% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0% FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 100.0% FAIL

FLOW DURATION DESIGN CRITERIA: FAIL

Does not meet LID duration standard

****** LID Duration Performance ******
Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 4.3% FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 545.4% FAIL

LID DURATION DESIGN CRITERIA: FAIL

APPENDIX B

Cost Estimate

Engineering Construction Cost Estimate for Pre-Design

Project Name: **Old Belfair Highway Water Quality Treatment**
Project Number: **15-06085-000**
Client: **Mason County**

QA Review
Completed/Updated By: Kristen Matsumura
Last Updated On: 9/27/2017
Approved By: Brian Busiek
Approved On: 10/20/2017

Item No.	Spec Section	Item Description	Qty	Unit	Unit Cost	Total Cost
		General Requirements				
1		Mobilization	1	L.S.	$ 2,000.00	$ 2,000
2		Erosion/Water Pollution Control	1	L.S.	$ 1,000.00	$ 1,000
3		Project Temporary Traffic Control	1	L.S.	$ 1,000.00	$ 1,000
4		Utility Protection and Relocation	1	L.S.	$ 3,000.00	$ 3,000
		Roadwork				
5		Clearing and Grubbing and Roadside Cleanup	1	L.S.	$ 500.00	$ 500
6		Structural Excavation Class B	55	C.Y.	$ 40.00	$ 2,200
7		HMA for Berms	4	Ton	$ 77.00	$ 310
		Drainage and Sewers				
8		6" Underdrain Pipe	160	L.F.	$ 15.00	$ 2,400
9		12" Atrium Overflow Drain	2	Each	$ 1,500.00	$ 3,000
10		Connection to Existing Structures	2	Each	$ 700.00	$ 1,400
11		Drainage Rock	12	C.Y.	$ 40.00	$ 480
		Miscellaneous Construction				
12		Mulching	6	C.Y.	$ 30.00	$ 180
13		Bioretention Soil Media	40	C.Y.	$ 60.00	$ 2,400
14		Plantings for Bioretention	600	S.F.	$ 3.00	$ 1,800
		Construction Subtotal				**$ 21,700**
		Contractor Bid Overrun Allowance	10%			$ 2,170
		Subtotal (with bid overrun allowance)				$ 23,870
		Tax *	8.5%			$ 2,030
		Total (with Tax)**				**$ 26,000**

* Total tax has been rounded to the nearest $10.
** Total has been rounded to two significant figures.

Task 1 - Grant Project Administration / Management	$ 3,000
Task 2 - Survey and Geotechnical	$ 7,000
Task 3 - Design Plans And Specifications, Environmental Review, And Permitting	$ 15,000
Task 4 - Construction Management	$ 3,000
Task 5 - Construction	$ 26,000
Task 6 - Change Orders	$ 1,000
Project Total	**$ 60,000**