3 May 2005

SR 520 Bridge Replacement and HOV Project Draft EIS

Appendix T

Water Resources

Discipline Report

Washington State Department of Transportation

Sound Transit

U.S. Department of Transportation
Federal Highway Administration

SR 520 Bridge Replacement and HOV Project Draft EIS

Water Resources
Discipline Report

Prepared for

Washington State Department of Transportation
Federal Highway Administration
Sound Transit

Lead Authors

Parametrix, Inc.
CH2M HILL

Consultant Team

Parametrix, Inc.
CH2M HILL
Parsons Brinckerhoff
Michael Minor and Associates

May 3, 2005

Contents

Attachment

List of Exhibits

Acronyms and Abbreviations

AKART	All Known, Available, and Reasonable Technology
BMP	Best Management Practice
CARA	Critical Aquifer Recharge Area
cfs	cubic feet per second
CSO	combined sewer overflow
Draft EIS	Draft Environmental Impact Statement
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
EPM	Environmental Procedures Manual
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
GIS	Geographic Information System
gpm	gallons per minute
HOV	High Occupancy Vehicle
HPA	Hydraulic Project Approval
HRM	Highway Runoff Manual
µg/L	micrograms per liter
mg/L	milligram per liter
MOHAI	Museum of History and Industry
mph	miles per hour
msl	mean sea level
NTU	nephelometric turbidity unit
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
PAH	polycyclic aromatic hydrocarbon
PGIS	pollutant-generating impervious surface
SMMWW	Stormwater Management Manual for Western Washington
SPCC	Spill Prevention Controls and Countermeasures
TESC	Temporary Erosion and Sedimentation Control
TSS	total suspended solids
USGS	U.S. Geological Survey
WQC	Water Quality Criterion
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation

Introduction

What are water resources and why are they considered in this EIS?

This discipline report uses the phrase "water resources" to refer collectively to surface water bodies (e.g., lakes, rivers, and streams), stormwater, and groundwater. The report is divided into two primary sections, one focusing on surface water bodies and the project's stormwater treatment facilities, and the other dedicated to discussion of groundwater and effects of the project on groundwater.

The Clean Water Act (33 USC 1251 et seq.) is the cornerstone of legislation protecting water resources in the United States (EPA 2004b). Passed in 1972, the Clean Water Act responds to widespread public concern about controlling water pollution and protecting America's water bodies (EPA 2004a). The goal of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of our nation's waters (EPA 2004b).

The U.S. Environmental Protection Agency (EPA) is the federal agency responsible for implementing and enforcing the Clean Water Act. In most cases, however, EPA has delegated its authority and implementation duties to state agencies. In Washington state, the Department of Ecology (Ecology) has been authorized by EPA to administer the National Pollutant Discharge Elimination System (NPDES) permit program, as well as the Pretreatment and General Permits programs. Ecology is responsible for managing and protecting Washington state's water resources. In doing so, Ecology has adopted laws that regulate the concentrations of toxic substances allowed in stormwater and surface water bodies, and they have developed manuals detailing approved stormwater treatment and detention procedures.

In addition to the state, the cities and towns in the project area have jurisdiction over water resources, wetlands, and critical areas in the project vicinity. The Washington Department of Fish and Wildlife, National Oceanic and Atmospheric Administration (NOAA) Fisheries, and the U.S. Fish and Wildlife Service also have jurisdiction over water quality as it applies to protecting wetlands and fish and wildlife

What are "water resources"?
As used in this report, the phrase "water resources" refers collectively to surface water bodies (e.g., lakes and streams), stormwater, and groundwater. When the issue under consideration applies to only one element, we will use "surface water bodies," "stormwater," or "groundwater" to identify the specific resource being discussed.

Surface water bodies include lakes, streams, ponds, and wetlands.

Stormwater includes stormwater runoff, snow melt runoff, and surface runoff and drainage [40 CFR 122.26(b)(13)]. Drainage can flow across the ground in open ditches, in pipes, or below the surface as interflow.

Groundwater is water found underground in the saturated zone. The saturated zone is the layer of soil that is soaked, or loaded, to capacity with water.

resources. Regulations related to wetlands and fish and wildlife resources are discussed in Appendix E of this EIS, *Ecosystems Discipline Report*.

Exhibit 1 lists the agencies responsible for protecting surface water resources, describes the policies and regulations these agencies follow, and explains the purpose of the policies. Groundwater regulations are discussed in the *Groundwater* chapter at the end of this report.

Exhibit 1. Agencies that Regulate and Manage Surface Water in the Project Area and their Policies

Agency/ Organization	Policies/Regulations	Purpose/Intent
Ecology	Clean Water Act (33 USC 1251 et seq.)	Establishes the basic structure for regulating discharges of pollutants to receiving waters.
	Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201a)	Sets goals for a water body by designating beneficial uses and assigning water quality criteria to protect those uses.
	Stormwater Management Manual for Western Washington (Ecology 2001)	Provides technical standards and guidance on stormwater management measures to control quantity and quality of stormwater produced by new development and redevelopment.
Washington State Department of Transportation (WSDOT)	Puget Sound Highway Runoff Program (WAC 173-270)	Establishes procedures and water quality criteria for WSDOT's highway runoff program.
	Highway Runoff Manual (WSDOT 2004a)	Directs the planning and design of stormwater management facilities for new and redeveloped Washington state highways and other facilities. Directs the planning and design of stormwater control measures during construction. WSDOT's Highway Runoff Manual is considered to be equivalent to Ecology's Stormwater Management Manual.
	Environmental Procedures Manual (WSDOT 2004b)	Provides guidelines for complying with federal and state environmental laws and regulations for all phases of project delivery.
Seattle, Medina, Hunts Point, Clyde Hill, Yarrow Point, Kirkland, and Bellevue	City and county critical or sensitive areas ordinances that establish allowed uses, mitigation standards, and buffers for streams and lakes	Establishes policies and development guidelines to protect the functions and values of critical areas. All cities and counties in Washington are required by the Growth Management Act to adopt critical area regulations (RCW 36.70A.060).

What are the key points of this report?

Most stormwater generated by SR 520 today is not treated, and flows are not controlled before being discharged. Stormwater would continue to be discharged without treatment or flow control under the No Build Alternative scenarios. Conversely, stormwater would be treated and flows controlled (as required by Ecology to protect small streams) for the 4-Lane and 6-Lane Alternatives.

The Continued Operation Scenario of the No Build Alternative would either maintain existing conditions or further degrade surface water bodies. Traffic would increase, so the quantity of pollutants generated by cars on the SR 520 roadway would increase compared to existing conditions. These pollutants would enter stormwater and be discharged to surface water bodies, which could degrade water quality compared to existing conditions. Water quality would likely improve in the immediate vicinity of the project corridor under the Catastrophic Failure Scenario because vehicles would no longer be able to drive on much of the corridor.

The proposed 4-Lane and 6-Lane Alternatives would increase the amount of land covered by pollutant-generating impervious surfaces in the project area. However, by applying stormwater treatment and flow control in their designs, both build alternatives would meet state and federal water quality regulations, and both alternatives would provide more treatment than is required for stormwater discharging from the Evergreen Point Bridge. In general, both alternatives would maintain existing pollutant loading levels or reduce pollutant loading compared to existing levels because stormwater would be treated prior to discharge. Although pollutant loading would be reduced overall in the project area, the 4-Lane and 6-Lane Alternatives would load more of some kinds of pollutants in specific sub-basins than the No Build Alternative.

The 4-Lane and 6-Lane Alternatives would also affect stormwater discharge rates. Flow control would be included in stormwater treatment facilities discharging to Eastside streams. Reducing discharge flow rates should minimize the effect of each alternative on the physical characteristics of project area streams.

Temporary water quality effects during construction of the 4-Lane and 6-Lane Alternatives would be avoided or minimized through the development and implementation of required erosion control plans, spill control plans, and permit conditions. These plans and permits regulate construction activities on-land and in the water to prevent or limit water quality effects. The installation of bridge anchors and piers during construction could disrupt lake bottom sediments and the organisms living in them. These sediments and organisms would be displaced, and organisms living in these sediments may die. However, these effects would be localized, and these organisms would re-establish communities quickly. Water quality in the immediate vicinity of the in-water construction activities could become turbid (cloudy), though it is unlikely that the water would become turbid enough to reduce lake productivity or directly harm fish and invertebrates.

Permanent effects on groundwater would be negligible. The 4-Lane and 6-Lane Alternatives would increase pollutant-generating impervious surfaces in the project area; however, this increase would not cause a detectable change to groundwater recharge. The increased impervious surface associated with the 4-Lane and 6-Lane Alternatives would have minimal or no effect on groundwater recharge because increases would only be a fraction of the total recharge area of the groundwater system.

Additionally, effects on groundwater used for drinking purposes would be negligible because there is very limited use of groundwater for drinking water in the project area. There is one small drinking water well with four connections located within 500 feet of the project area. In addition, 23 wells are listed within 1 mile of the project area. The current condition, uses, or existence of these wells are unknown. If these wells still exist, they are most likely not used for drinking water because they are located in areas served by municipal drinking water systems.

Groundwater levels in some areas may need to be temporarily lowered during construction so some of the structures can be built in dry conditions. This dewatering could temporarily alter the groundwater flow direction or the volume of groundwater discharge to surface water; however, these effects would be temporary and localized. Water generated during dewatering would be stored either in temporary treatment ponds or in portable steel tanks. Water would be stored for a sufficient amount of time to allow particles to settle, or chemical flocculants could be used to reduce suspended particles before the water is discharged to the stormwater system. Additionally, temporary effects to groundwater used as drinking water in the project area would be negligible because use of groundwater for drinking water is very limited in the project area.

There would be no need to further mitigate or compensate for long-term project effects because all regulatory requirements to address negative effects are included in the designs of both build alternatives. Construction effects would be avoided or minimized by implementing required erosion control plans and spill control plans, and by meeting established permit conditions.

What are the project alternatives?

The SR 520 Bridge Replacement and HOV Project area comprises neighborhoods in Seattle from I-5 to the Lake Washington shore, Lake Washington, and Eastside communities and neighborhoods from the Lake Washington shore to 124th Avenue Northeast just east of I-405. Exhibit 2 shows the general location of the project. Neighborhoods and communities in the project area are:

- Seattle neighborhoods—Portage Bay/Roanoke, North Capitol Hill, Montlake, University District, Laurelhurst, and Madison Park
- Eastside communities and neighborhoods—Medina, Hunts Point, Clyde Hill, Yarrow Point, Kirkland (the Lakeview neighborhood), and Bellevue (the North Bellevue, Bridle Trails, and Bel-Red/Northup neighborhoods)

The SR 520 Bridge Replacement and HOV Project Draft EIS evaluates the following three alternatives and one option:

- No Build Alternative
- 4-Lane Alternative
  - Option with pontoons without capacity to carry future high capacity transit
- 6-Lane Alternative

Each of these alternatives is described below. For more information, see the *Description of Alternatives and Construction Techniques Report* contained in Appendix A of this EIS.

Exhibit 2. Project Vicinity Map

What is the No Build Alternative?

All EISs provide an alternative to assess what would happen to the environment in the future if nothing were done to solve the project's identified problem. This alternative, called the No Build Alternative, means that the existing highway would remain the same as it is today (Exhibit 3). The No Build Alternative provides the basis for measuring and comparing the effects of all of the project's build alternatives.

This project is unique because the existing SR 520 bridges may not remain intact through 2030, the project's design year. The fixed spans of the Portage Bay and Evergreen Point bridges are aging and are vulnerable to earthquakes; the floating portion of the Evergreen Point Bridge is vulnerable to wind and waves.

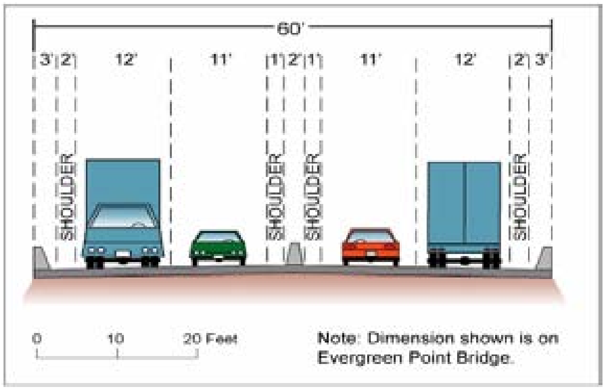


Exhibit 3. No Build Alternative

In 1999, the Washington State Department of Transportation (WSDOT) estimated the remaining service life of the Evergreen Point Bridge to be 20 to 25 years based on the existing structural integrity and the likelihood of severe windstorms. The floating portion of the Evergreen Point Bridge was originally designed for a sustained wind speed of 57.5 miles per hour (mph), and was rehabilitated in 1999 to withstand sustained winds of up to 77 mph. The current WSDOT design standard for bridges is to withstand a sustained wind speed of 92 mph. In order to bring the Evergreen Point Bridge up to current design standards to withstand at least 92 mph winds, the floating portion must be completely replaced.

The fixed structures of the Portage Bay and Evergreen Point bridges do not meet current seismic design standards because the bridge is supported on hollow-core piles. These hollow-core piles were not designed to withstand a large earthquake. They are difficult and cost prohibitive to retrofit to current seismic standards.

If nothing is done to replace the Portage Bay and Evergreen Point bridges, there is a high probability that both structures could fail and become unusable to the public before 2030. WSDOT cannot predict when or how these structures would fail, so it is difficult to determine the actual consequences of doing nothing. To illustrate what could happen, two scenarios representing the extremes of what is possible are evaluated as part of the No Build Alternative. These are the Continued Operation and Catastrophic Failure scenarios.

Under the Continued Operation Scenario, SR 520 would continue to operate as it does today as a 4-lane highway with nonstandard shoulders and without a bicycle/pedestrian path. No new facilities would be added and no existing facilities (including the unused R.H. Thompson Expressway Ramps near the Arboretum) would be removed. WSDOT would continue to maintain SR 520 as it does today. This scenario assumes the Portage Bay and Evergreen Point bridges would remain standing and functional through 2030. No catastrophic events (such as earthquakes or high winds) would be severe enough to cause major damage to the SR 520 bridges. This scenario is the baseline the EIS team used to compare the other alternatives.

In the Catastrophic Failure Scenario, both the Portage Bay and Evergreen Point bridges would be lost due to some type of catastrophic event. Although in a catastrophic event, one bridge might fail while the other stands, this Draft EIS assumes the worst-case scenario—that both bridges would fail. This scenario assumes that both bridges would be seriously damaged and would be unavailable for use by the public for an unspecified length of time.

What is the 4-Lane Alternative?

The 4-Lane Alternative would have four lanes (two general purpose lanes in each direction), the same number of lanes as today (Exhibit 4). SR 520 would be rebuilt from I-5 to Bellevue Way. Both the Portage Bay and Evergreen Point bridges would be replaced. The bridges over SR 520 would also be rebuilt. Roadway shoulders would meet current standards (4-foot inside shoulder and 10-foot outside shoulder). A 14-foot-wide bicycle/pedestrian path would be built along the north side of SR 520 through Montlake, across the Evergreen Point Bridge,

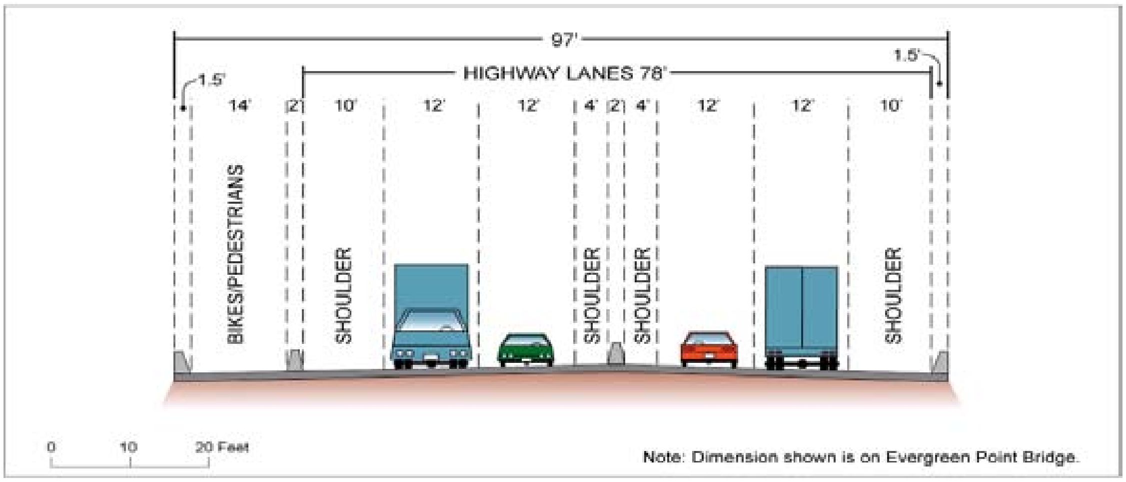


Exhibit 4. 4-Lane Alternative

and along the south side of SR 520 through Medina, Hunts Point, Clyde Hill, and Yarrow Point to 96th Avenue Northeast, connecting to Northeast Points Drive. Sound walls would be built along much of SR 520 in Seattle and the Eastside. This alternative also includes stormwater treatment and electronic toll collection.

The floating bridge pontoons of the Evergreen Point Bridge would be sized to carry future high-capacity transit. An option with smaller pontoons that could not carry future high-capacity transit is also analyzed. The alternative does not include high-capacity transit.

A bridge operations facility would be built underground beneath the east roadway approach to the bridge as part of the new bridge abutment. A dock to moor two boats for maintenance of the Evergreen Point Bridge would be located under the bridge on the east shore of Lake Washington.

A flexible transportation plan would promote alternative modes of travel and increase the efficiency of the system. Programs include intelligent transportation and technology, traffic systems management, vanpools and transit, education and promotion, and land use as demand management.

What is the 6-Lane Alternative?

The 6-Lane Alternative would include six lanes (two outer general purpose lanes and one inside HOV lane in each direction; Exhibit 5). SR 520 would be rebuilt from I-5 to 108th Avenue Northeast in Bellevue, with an auxiliary lane added on SR 520 eastbound east of I-405 to 124th Avenue Northeast. Both the Portage Bay and Evergreen Point bridges would be replaced. Bridges over SR 520 would also be rebuilt. Roadway shoulders would meet current standards (10-foot-

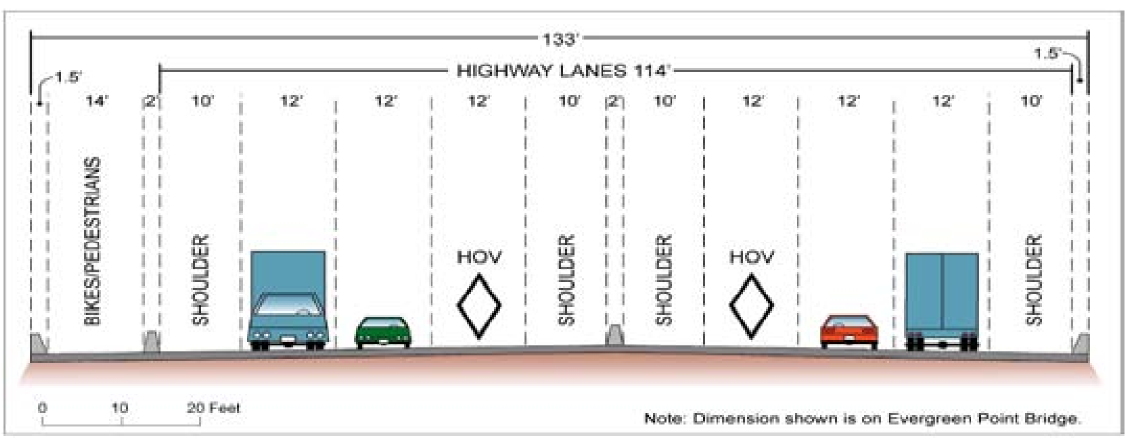


Exhibit 5. 6-Lane Alternative

wide inside shoulder and 10-foot-wide outside shoulder). A 14-foot-wide bicycle/pedestrian path would be built along the north side of SR 520 through Montlake, across the Evergreen Point Bridge, and along the south side of SR 520 through the Eastside to 96th Avenue Northeast, connecting to Northeast Points Drive. Sound walls would be built along much of SR 520 in Seattle and the Eastside. This alternative would also include stormwater treatment and electronic toll collection.

This alternative would also add five 500-foot-long landscaped lids to be built across SR 520 to help reconnect communities. These communities are Roanoke, North Capitol Hill, Portage Bay, Montlake, Medina, Hunts Point, Clyde Hill, and Yarrow Point. The lids are located at 10th Avenue East and Delmar Drive East, Montlake Boulevard, Evergreen Point Road, 84th Avenue Northeast, and 92nd Avenue Northeast.

The floating bridge pontoons of the Evergreen Point Bridge would be sized to carry future high-capacity transit. The alternative does not include high-capacity transit.

A bridge operations facility would be built underground beneath the east roadway approach to the bridge as part of the new bridge abutment. A dock to moor two boats and maintain the Evergreen Point Bridge would be located under the bridge on the east shore of Lake Washington.

A flexible transportation plan would promote alternative modes of travel and increase the efficiency of the system. Programs would include intelligent transportation and technology, traffic systems management, vanpools and transit, education and promotion, and land use as demand management.

This Page Intentionally Left Blank

Surface Water Bodies and Stormwater Treatment

This chapter is divided into several sections. In the *Affected Environment* section we discuss the existing state of the project area's water bodies and the lack of stormwater treatment facilities to treat stormwater running off the current SR 520 roadway in the project area. Then, in *Treating the Project's Stormwater*, we discuss the stormwater treatment facilities proposed for the 4-Lane and 6-Lane Alternatives. The next section, *Potential Effects of the Project on Surface Water Bodies*, discusses the project's effects on surface water bodies. We conclude with a discussion about mitigation.

Affected Environment

What information was collected to identify surface water bodies and existing stormwater facilities?

The water resources discipline team identified surface water resources in the project area by collecting and reviewing maps and government reports. We combined several maps using geographic information system (GIS) software to create a single project base map that incorporated the following data:

- Streams
- Lakes
- Wetlands
- Wetland buffers
- Soil types
- Floodplains
- Floodways
- Culverts
- Sub-basin and watershed boundaries

We consulted with various state and local agencies to obtain other important information about project area surface water resources and stormwater. Local agencies identified existing flooding problems in the project area. Water quality information came from Ecology's 303(d) list and Washington state's

What is the Ecology 303(d) list?
The 303(d) list identifies surface water body segments (lakes, streams, and ponds) with degraded water quality. Ecology assembles available water quality data and publishes this list, as required under Section 303(d) of the federal Clean Water Act (40 CFR 130.7, as revised July 1, 2003).

What is the Ecology 305(b) Report?
Ecology prepares the Section 305(b) Report to inform the U.S. Congress and the public about the current condition of the state's waters. This report describes the status of *all* waters in the state, while the 303(d) list reports only the *impaired* waters in the state.

Water Quality Assessment Report (also called the 305[b] Report). King County provided water and sediment quality data for Lake Union and Lake Washington (King County 2004).

WSDOT provided information about the existing stormwater system on SR 520. We also consulted with project team members, WSDOT, Sound Transit, and other agencies to obtain information about hazardous materials, edges of existing pavement lines, and the quantity and quality of treated stormwater from the existing highway within the project area.

What surface water bodies are present in the project area?

The following surface water bodies are located in the project area:

- Surface water bodies in the Seattle project area include Lake Union and Portage Bay. These water bodies are located in heavily developed basins (more than 50 percent impervious surface).
- Lake Washington
- Surface water bodies in the Eastside project area include Fairweather Creek, Cozy Cove Creek, an unnamed tributary to Yarrow Bay, Yarrow Creek (including the east and west tributaries), and the West Tributary of Kelsey Creek. These water bodies are located in developed suburban areas where impervious surfaces cover 27 to 42 percent of the stream basins.

Water flows through the project area (Exhibit 6):

- In surface water bodies such as streams, ponds, wetlands, and lakes
- Across the surface as stormwater runoff, where it flows directly to surface water bodies or is conveyed to surface water bodies in open ditches or drainage pipes
- Below ground in soil and/or in the groundwater

Although surface water bodies, stormwater, and groundwater are typically managed and regulated independently, they are interconnected and interdependent. Exhibit 6 shows how stormwater runoff can percolate into soil and become groundwater, and how groundwater can move into and out of surface water bodies.

How does impervious surface affect surface water resources?
Impervious surfaces such as rooftops, sidewalks, roads, parking lots, and compacted urban soils prevent rain from infiltrating soils as it would naturally. These barriers shift more water into creeks and lakes, and can increase the transport of pollutants from land to adjoining surface waters.

How do state agencies regulate increases in impervious surface?
Current state regulations require new and redeveloping construction projects to treat stormwater and sometimes control the flow of stormwater from existing and new impervious surfaces.

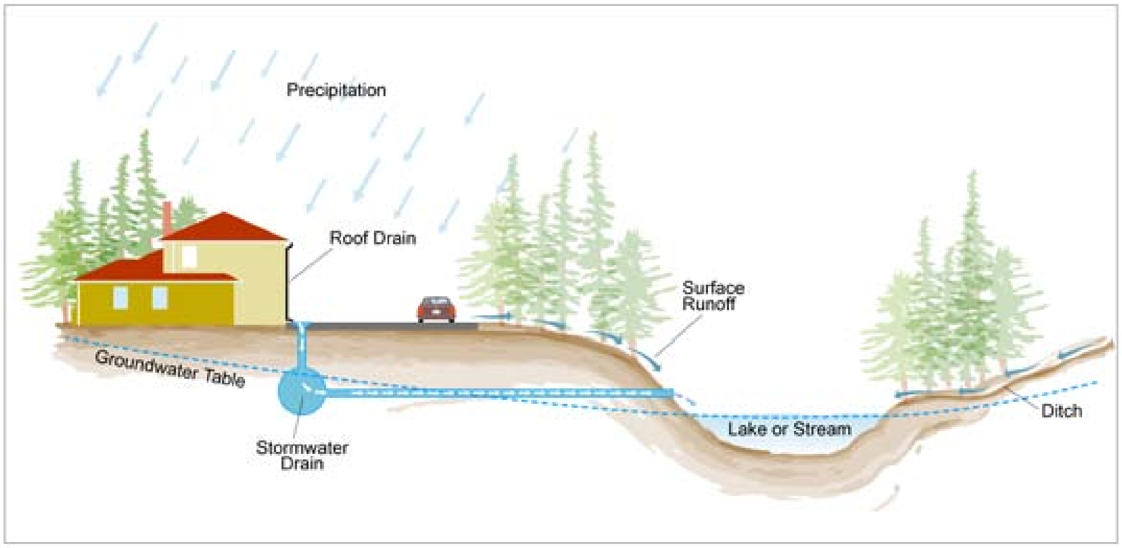


Exhibit 6. Pathways for Water Moving through the Project Area

General Background Information

The project area is located entirely in Water Resource Inventory Area 08 (WRIA 8) (Exhibit 7), the most heavily developed of the 15 WRIAs directly bordering the Puget Sound. As shown in Exhibit 7, WRIA 8 is divided into two watersheds—Lake Washington/Cedar and Sammamish. The project area lies within the Lake Washington/Cedar watershed, the more highly developed of the two watersheds. These two watersheds are further divided into a number of smaller basins.

The Seattle project area is a highly urbanized area that is densely developed with commercial, industrial, residential, and transportation land uses. The Eastside project area contains both urbanized and suburban areas that are less developed than Seattle. Exhibit 8 shows the developed and undeveloped areas located within WRIA 8. Urbanization overlays the natural landscape with impervious surfaces made up of sidewalks, streets, parking lots, and buildings. These impervious surfaces prevent rain from percolating into the ground and alter the distribution and movement of surface water and groundwater.

Urbanization and its associated impervious surfaces alter water flows in a watershed by:

- Lowering stream summer minimum flows (known as base flows)
- Raising stream winter maximum flows (known as peak flows)
- Lowering groundwater levels

It can also lead to more rapid increases and decreases (termed “flashiness”) in stream flow rates and the frequency and extent of flooding when it rains. Researchers have documented a decline in the quality of aquatic habitat in urban streams. Degraded aquatic habitats have been associated with a decline in the numbers and types of fish and invertebrates in these streams (Booth 1989, Booth and Jackson 1997, Karr and Chu 1999, Kleindl 1995). When the flow of water is modified by increases in impervious surface, the result is:

- Changed streamside conditions (such as increased streambank erosion and loss of riparian vegetation, which shades streams and helps to filter out stormwater pollutants)
- Reduced structural complexity and stability of stream channels

New impervious surface can further affect water resources by accumulating and retaining pollutants, which can then be transported by stormwater runoff to surface water bodies and to groundwater. A range of pollutants and sources are present in both urban and suburban areas, such as sediments from development and new construction; oil, grease, and chemicals from vehicles; nutrients and pesticides from turf management and gardening; viruses and bacteria from failing septic systems; road salts; and heavy metals from automobile tire and brake wear (EPA 2004d). Sediments and solids constitute the largest volume of pollutant loads to receiving waters in urban areas. Impervious surfaces that accumulate and retain pollutants are called pollutant-generating impervious surfaces (PGIS). PGIS can adversely affect the quality of water resources because of:

Pollutant-Generating Impervious Surfaces (PGIS) are impervious surfaces that are a source of pollutants in stormwater runoff. Project area PGIS includes roadways that receive direct rainfall or the run-on or blow-in of rainfall.

- Increased fertilizer amounts that lower dissolved oxygen levels in water bodies
- Increased turbidity that limits algal productivity and harms fish and aquatic insects
- Increased levels of metals, pesticides, and oil and greases that harm fish, aquatic insects, and algae
- Increased sickness in people who swim and boat in these areas due to increased levels of bacteria and viruses

Automobile, truck, and bus traffic traveling on SR 520 impervious surfaces would likely generate only a small subset of this list of potential stormwater constituents. Vehicles could act as sources of metal (e.g., copper , zinc, and cadmium from brake and tire wear), hydrocarbons (e.g., oil and grease from leaky engines and polycyclic aromatic hydrocarbons [PAHs] from engine exhaust), and total

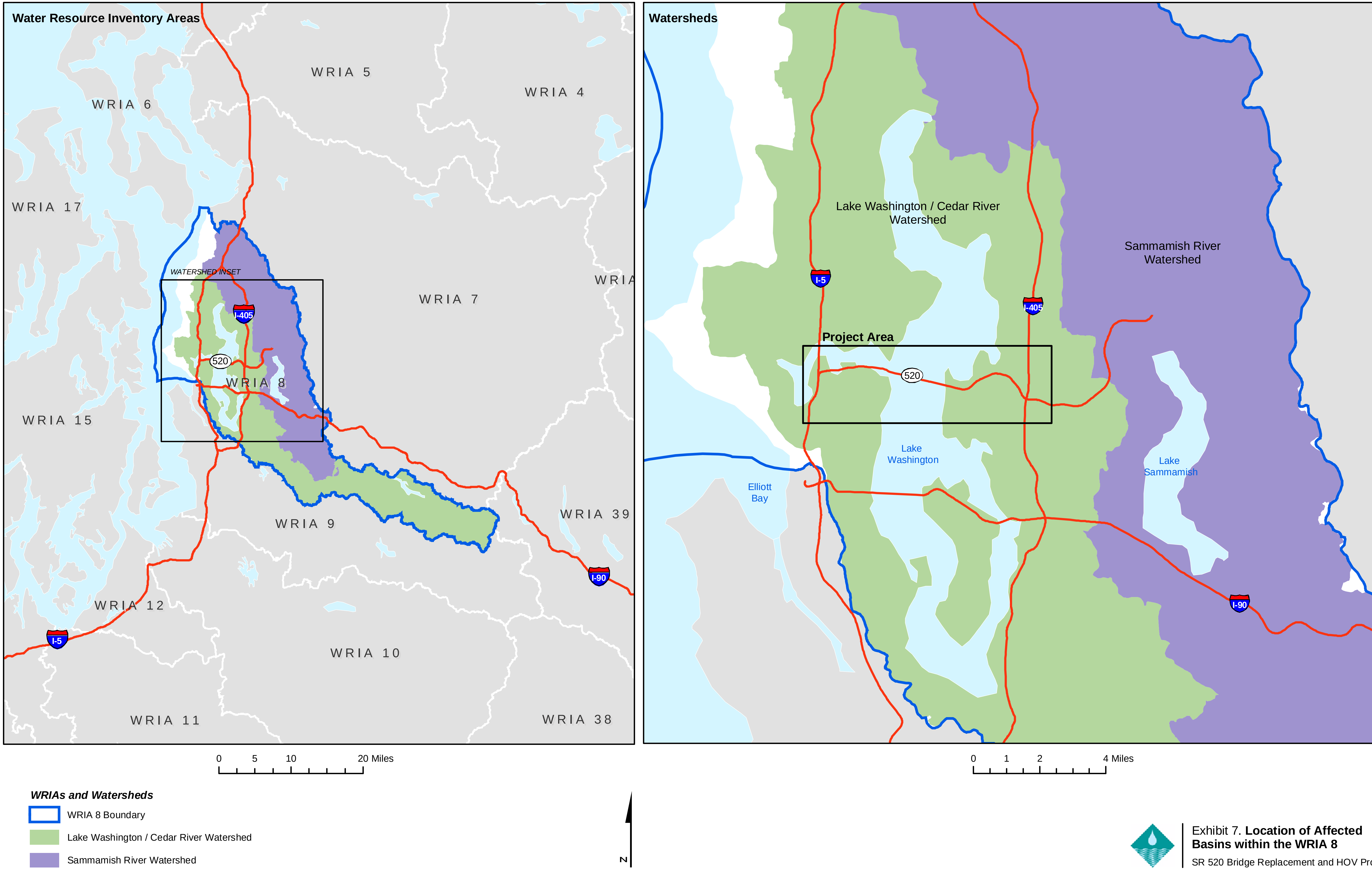
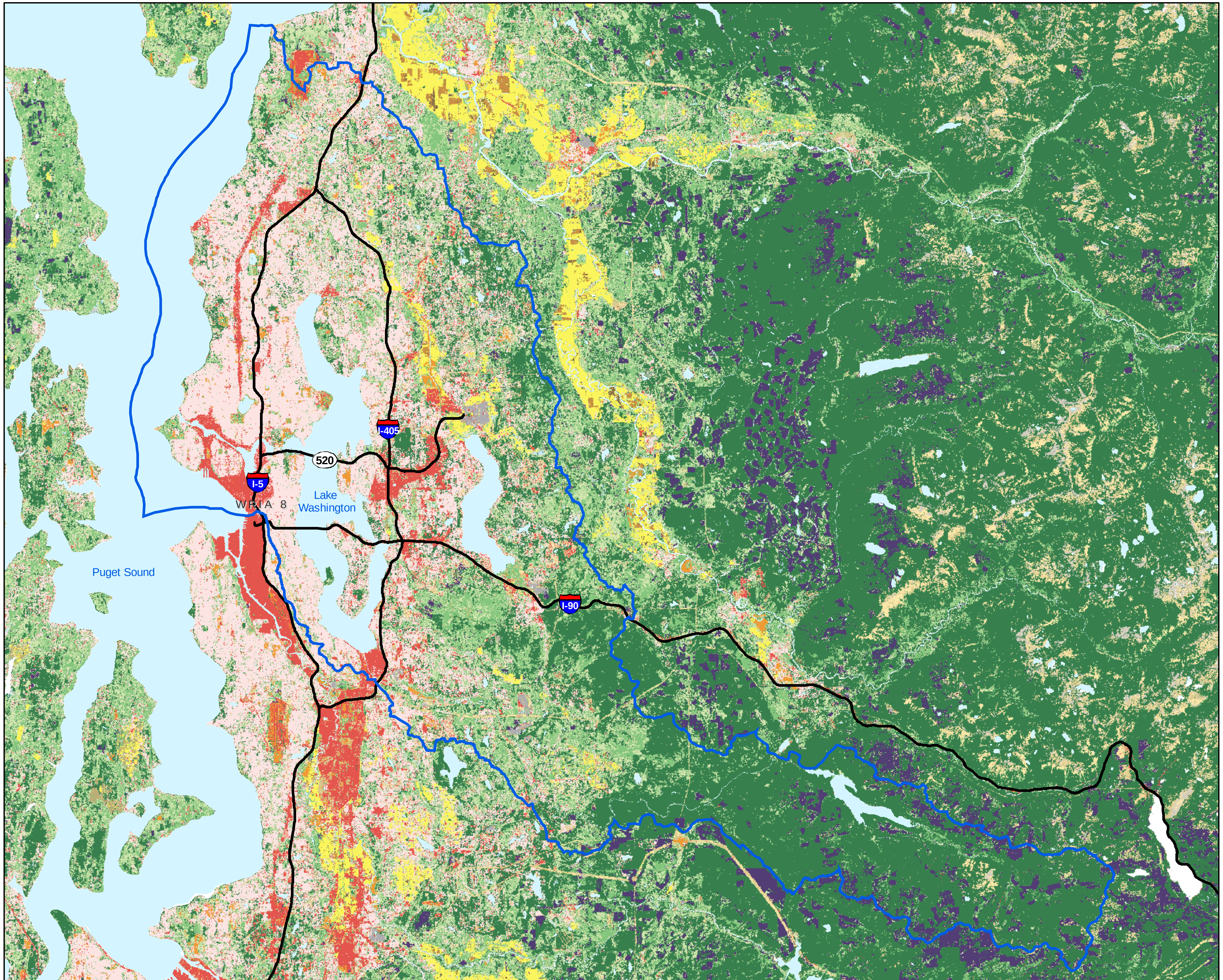


Exhibit 7. **Location of Affected Basins within the WRIA 8**

SR 520 Bridge Replacement and HOV Project



WRIA 8

Land Cover Classification

- Low Intensity Residental
- High Intensity Residental
- Commerical/Industrial/Transportation
- Bare Rock/Sand/Clay
- Quarries/Strip Mines/Gravel Pits
- Transitional
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrubland
- Orchards/Vineyards
- Grasslands/Herbaceous
- Pasture/Hay
- Row Crops
- Small Grains
- Fallow
- Urban/Recreational Grasses
- Woody Wetlands
- Emergent Herbaceous Wetlands

Source: USGS (1992) National Land Cover Dataset.

N

0 1 2 4 6 8 Miles

Exhibit 8. **Land Cover within the SR 520 Project Area**

SR 520 Bridge Replacement and HOV Project

suspended solids (TSS) (from dirt on car exteriors and tires, and brake and tire wear particles).

Seattle Surface Water Bodies

Seattle surface water bodies potentially affected by the project include portions of the Lake Washington Ship Canal system and part of the western shoreline of Lake Washington.

Lake Washington Ship Canal

The Lake Washington Ship Canal system is an 8.6-mile-long manmade navigable waterway connecting Puget Sound to Lake Washington in Seattle (Exhibits 9 and 10). The Lake Washington Ship Canal system includes the following interconnected waterways:

- Shilshole Bay
- Hiram M. Chittenden Locks (Ballard Locks)
- Salmon Bay
- Salmon Bay Waterway
- Fremont Cut
- Lake Union
- Portage Bay
- Montlake Cut
- Union Bay on the edge of Lake Washington

The project area includes Lake Union, Portage Bay, the Montlake Cut, and the western shoreline of Lake Washington.

What is a floodplain?
Land adjacent to water bodies that can regularly be inundated by floodwater is called a floodplain. The Federal Emergency Management Agency (FEMA) regulates flood hazards within a 100-year floodplain (the area adjoining a river, stream, or watercourse covered by water in a 100-year flood).

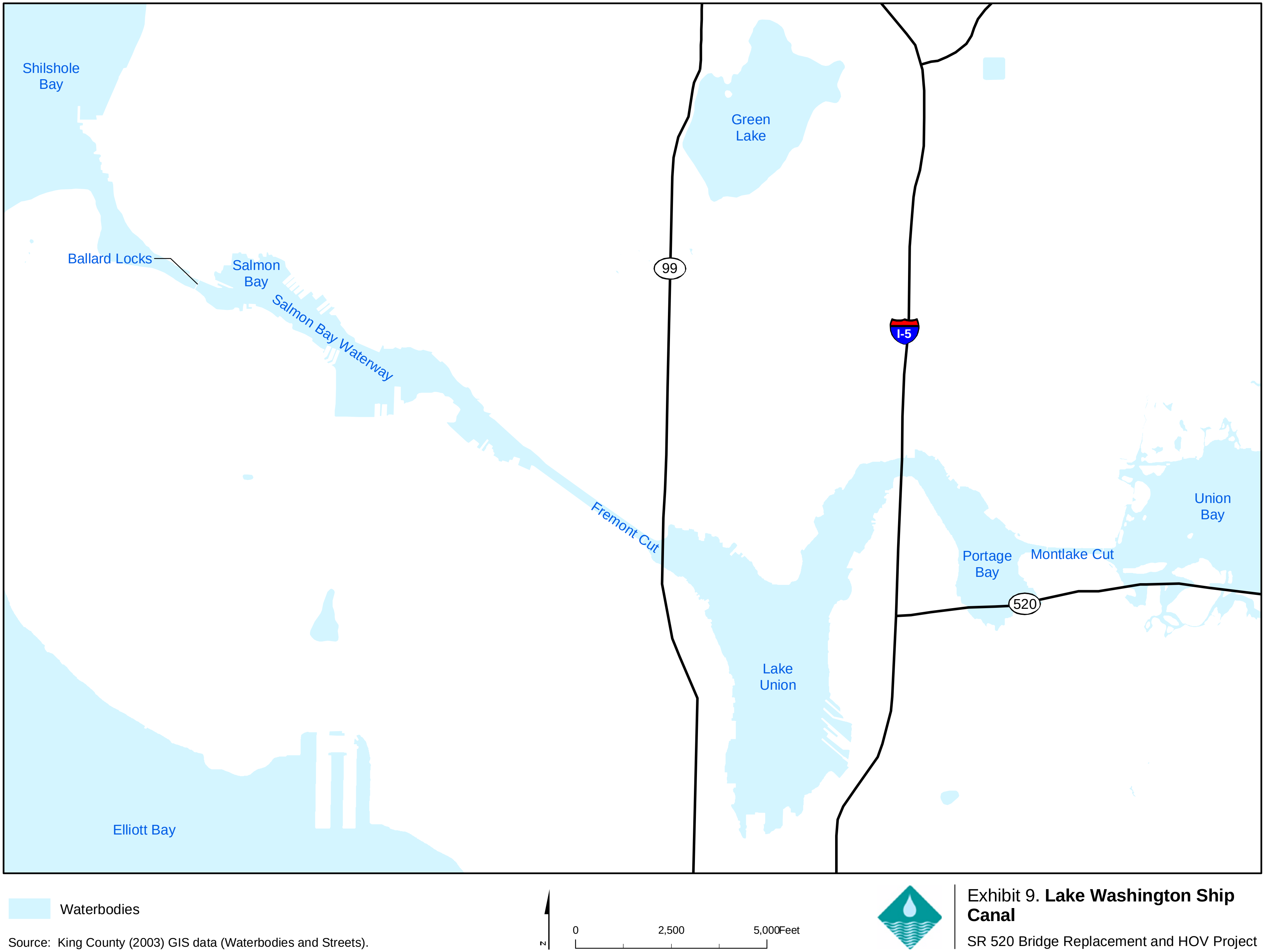
What is a 100-year flood?
A 100-year flood is not a flood that occurs every 100 years. A 100-year flood is a flood so large it has a 1 percent chance of occurring in any given year. The term “100-year” is a measure of the size of the flood, not how often it occurs. Several 100-year floods can occur within the same year or within a few years. A 100-year flood occurs on average once every 100 years.

Why are floodplains discussed in this section?
Existing floodplain conditions are discussed to document the floodplain resources located in the project area and determine project effects. Natural floodplains in the SR 520 project corridor are essentially nonexistent, so no effects are expected.

Lake Union and Portage Bay

Lake Union and Portage Bay represent a transitional area between the marine water of Puget Sound and the freshwater of Lake Washington. These waters are critical passageways that provide rearing habitat for migrating salmon.

Approximately 63 percent of the land around Lake Union and Portage Bay is made up of impervious surface. Lake Union and Portage Bay receive most of the stormwater draining from the densely developed surrounding low and high intensity residential and commercial/ industrial and transportation land uses.



Source: King County (2003) GIS data (Waterbodies and Streets).

Exhibit 9. **Lake Washington Ship Canal**

SR 520 Bridge Replacement and HOV Project

File Path: P:\Parametrix\168395\180171 SR 520 Bridge Replacement\GIS\Layouts\WaterResources\Ship_Canal.mxd

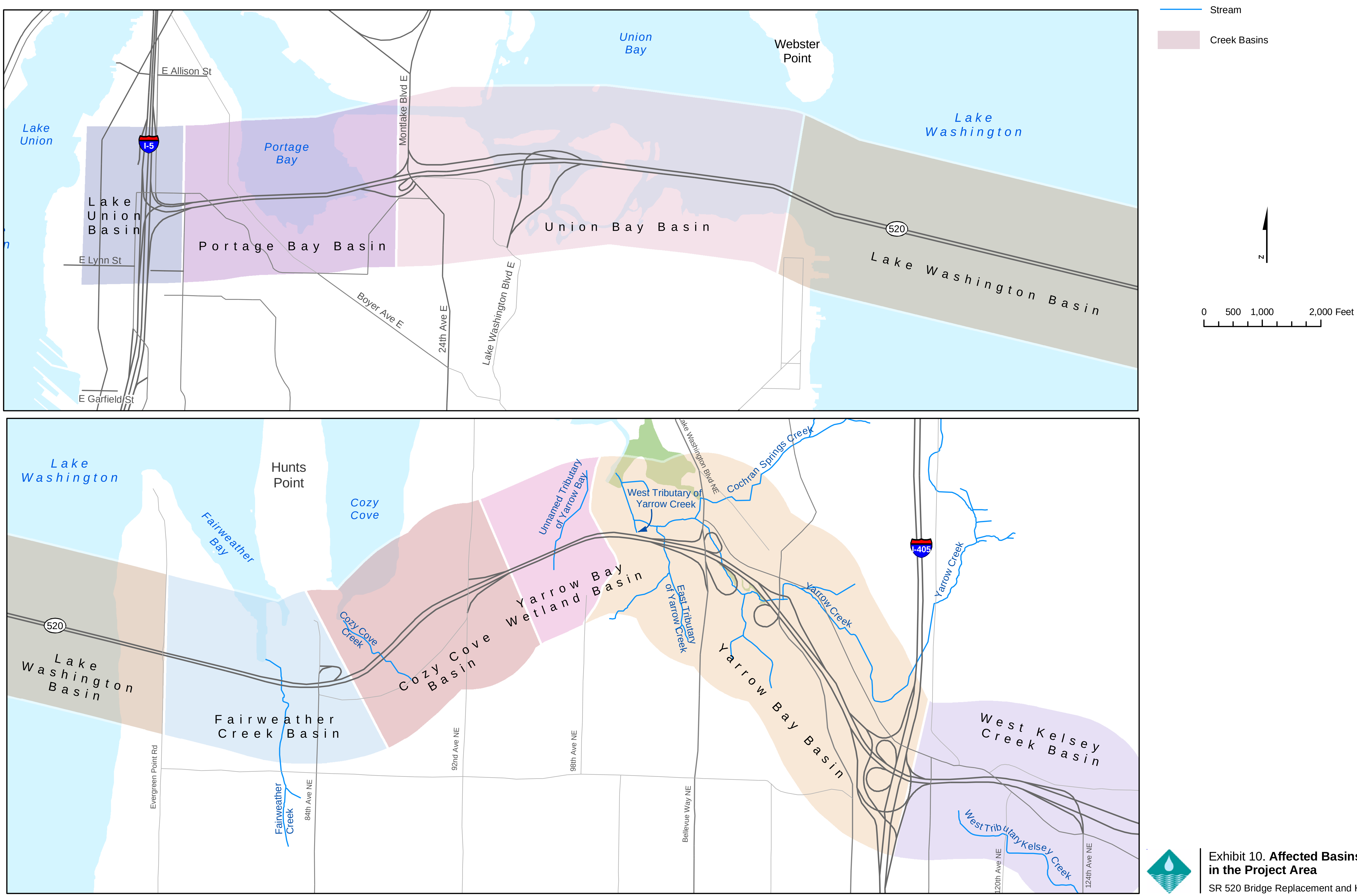


Exhibit 10. **Affected Basins Located in the Project Area**

SR 520 Bridge Replacement and HOV Project

Seattle Floodplains

The floodplain for Lake Union and Portage Bay is effectively nonexistent because (1) the banks are heavily armored with riprap and (2) water levels are controlled by the U.S. Army Corps of Engineers to prevent flooding and allow navigation and commerce.

Lake Washington

Lake Washington is the second largest natural lake in the state, with a surface area of 21,500 acres and a watershed of 472 square miles. Overall, almost two-thirds of the land use in the Lake Washington watershed has been converted to residential, commercial, or industrial uses (King County 2004); this refers only to the mix of land uses and not the amount of impervious surface.

Beginning of the water-level adjustment between Lake Washington and Lake Union in 1916 (printed with permission from the Museum of History and Industry, Seattle, Washington).

Historically, Lake Washington drained to the south through the Black River to the Duwamish River and Puget Sound. In 1912, the Cedar River was diverted from the Duwamish River into Lake Washington. Construction of the Lake Washington Ship Canal system in 1916 diverted Lake Washington's outlet to Shilshole Bay (Chrzastowski 1983).

The Cedar River currently comprises over half the inflow to Lake Washington. The Sammamish River at the northern end of Lake Washington and numerous smaller tributaries make up the remaining lake inflow (King County 2004).

Lake Washington Floodplains

The Lake Washington floodplain is a narrow fringe of land controlled and maintained by the U.S. Army Corps of Engineers at the Ballard Locks. The Corps of Engineers maintains daily lake elevations to within 0.01 foot. The summer high-water level is 22.0 feet mean sea level (msl); the lake is lowered approximately 2 feet during the winter to minimize shoreline erosion and property damage and to allow dock and other facility maintenance (Chrzastowski 1983; Corps of Engineers 2004a,b).

Eastside Surface Water Bodies

Eastside surface water bodies potentially affected by the project include the shoreline of Lake Washington under the east highrise, Fairweather Bay (part of Lake Washington), and several streams (Exhibit 11):

- Fairweather Creek
- Cozy Cove Creek
- Unnamed Tributary to Yarrow Bay
- Yarrow Creek (includes West and East Tributaries of Yarrow Bay)
- West Tributary of Kelsey Creek

As shown in Exhibit 12, between 27 and 42 percent of the Eastside basins are covered by impervious surface. Exhibit 13 shows how much total impervious surface is located within each of the Eastside basins and the total amount of impervious surfaces associated with the project.

Fairweather Creek (Fairweather Creek Basin)

Fairweather Creek drains a small, urban residential basin (approximately 600 acres) that discharges north into Fairweather Bay, which is part of Lake Washington (Exhibit 11). The 1.4-mile-long stream is rock-lined in places and its banks are nearly vertical (4 to 6 feet high and higher) for much of its length (Anderson et al. 2001). The stream originates at the Overlake Golf Course ponds where drainage from the Medina and Clyde Hill communities is collected. These ponds function as stormwater flow control facilities that reduce flooding downstream. Beginning at the golf course ponds, Fairweather Creek passes through four culverts (including one under SR 520) before entering Lake Washington at Fairweather Bay.

During a 2-year storm event, flow rates in Fairweather Creek have been estimated to reach 36 cubic feet per second (cfs) under existing basin conditions (Anderson et al. 2001). By comparison, the historic 2-year flow was estimated to be 15 cfs (Anderson et al. 2001). This doubling of the 2-year storm event peak flow in Fairweather Creek is a consequence of the extensive development that has occurred in the upper portions of this basin. The extensive development has likely reduced the overall habitat quality of Fairweather Creek for the aquatic community.

Cozy Cove Creek (Cozy Cove Creek Basin)

Cozy Cove Creek is a short, small stream (approximately 0.4 mile long) that drains from Medina north into Cozy Cove, which is part of Lake Washington near Hunts Point (Exhibit 11). The stream flows through residential neighborhoods, with landscaped lawns immediately

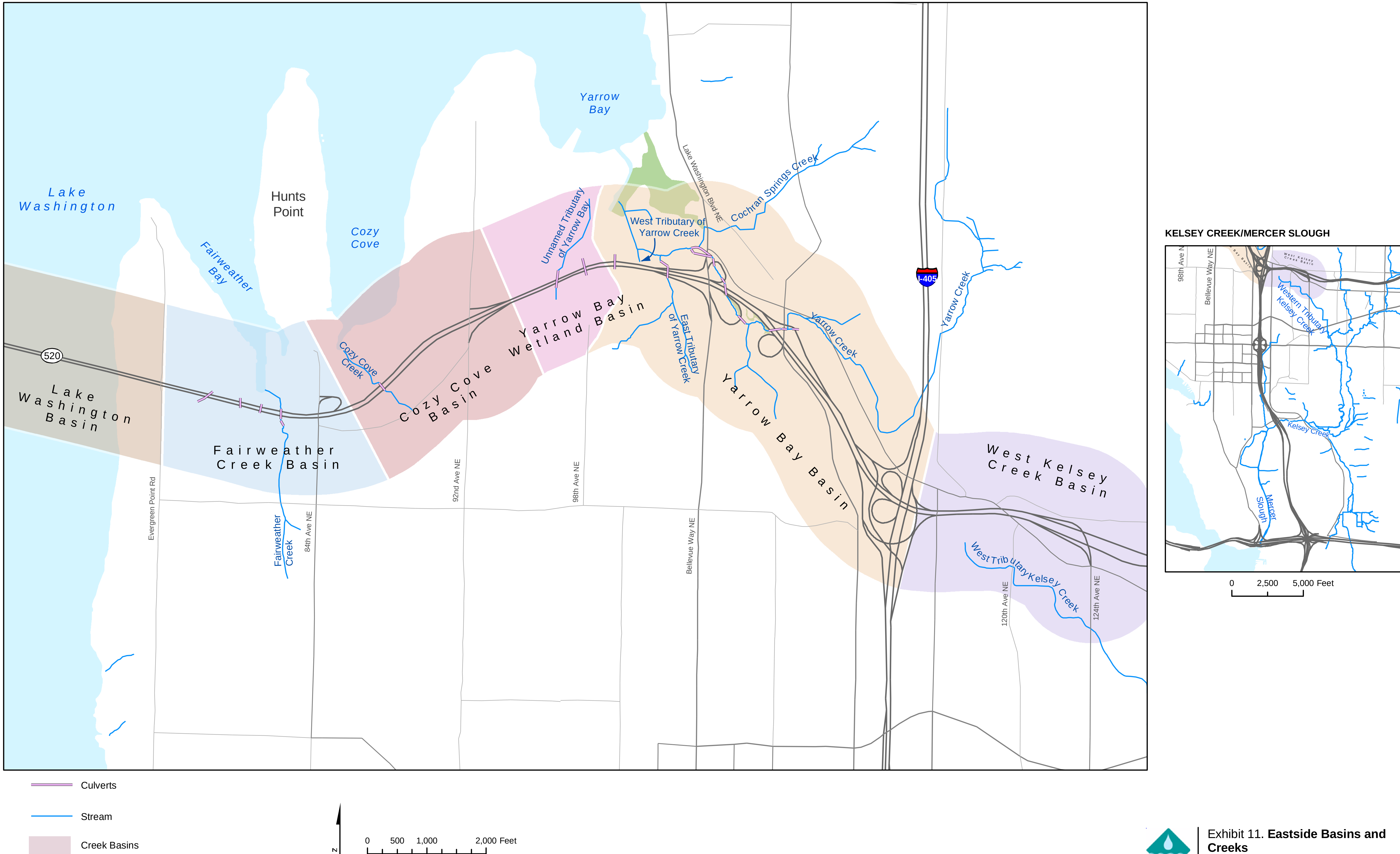


Exhibit 11. **Eastside Basins and Creeks**

SR 520 Bridge Replacement and HOV Project

File Path: P:\Parametrix\168395\180171 SR 520 Bridge Replacement\GIS\Layouts\WaterResources\Eastside_Basins_Creek.mxd

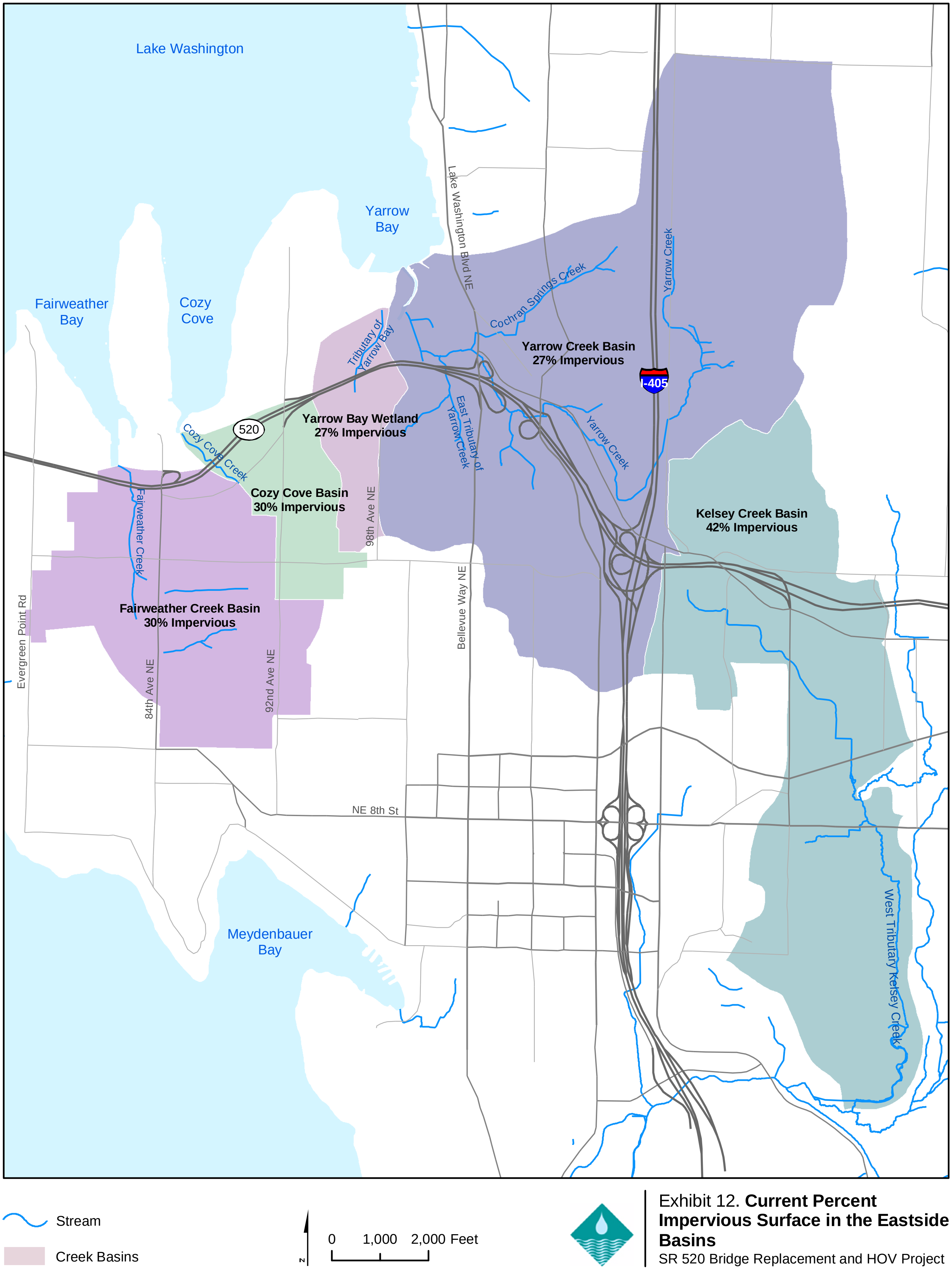


Exhibit 12. **Current Percent Impervious Surface in the Eastside Basins**

SR 520 Bridge Replacement and HOV Project

Exhibit 13. Basin and Impervious Surface Area on the Eastside

Basin	Total Basin (acre)	Current Basin Impervious Surface (acre)	Existing SR 520 Impervious Surface (acre)	Current Basin-Wide Percent Impervious Surface
Fairweather Creek	538.9	162.8	13.8	30%
Cozy Cove Creek	176.4	52.5	9.8	30%
Yarrow Bay Wetland	134.5	35.9	3.5	27%
Yarrow Creek	1,666.2	446.0	6.6	27%
West Tributary of Kelsey Creek	1,001.9	416.7	1.4	42%

adjacent to the stream. The stream crosses under SR 520 and continues approximately 1,000 feet north before entering the cove. The water resources discipline team did not find any information documenting the effects of basin urbanization on Cozy Cove Creek flow rates or aquatic habitat quality. Based on the level of basin development, however, we assumed that the stream hydrology would be comparable to other similarly sized urban streams in Puget Sound lowland basins (Booth 1989, Booth and Jackson 1997), meaning that current peak flows for Cozy Cove Creek would be higher than predevelopment levels.

Unnamed Tributary to Yarrow Bay (Yarrow Bay Wetland Basin)

This stream originates from storm drainage in Clyde Hill, crosses under SR 520, flows 0.6 mile down a steep, wooded ravine, discharging into the Yarrow Bay wetland (Exhibit 11). The water resources discipline team did not find any information documenting the effects of basin urbanization on flow rates or aquatic habitat quality for this unnamed tributary. As stated for Cozy Cove Creek, we assumed that the current peak flows for this unnamed tributary to Yarrow Bay would be higher than predevelopment levels because of the extensive amount of development in the basin.

Yarrow Creek (located in the Yarrow Bay Basin)

Yarrow Creek is approximately 3.5 miles long. This stream originates in Bridle Trails Park and the surrounding residential area. The stream, which drains approximately 1,667 acres, flows south along the I-405 corridor (Exhibit 11). In the project area, the stream flows in roadside ditches along Northup Way (northern SR 520 frontage road) and twice under SR 520 in pipes. A portion of the stream flows through an open channel located in the cloverleaf interchange located at the Lake Washington Boulevard off-ramp. From its headwaters to the mouth, Yarrow Creek crosses several municipal boundaries including Yarrow Point, Kirkland, and Bellevue. Cochran Springs Creek, a small tributary located in this watershed, originates west of I-405 in a small wetland and flows west through the Yarrow Bay wetland complex into Yarrow Creek just upstream of the mouth.

Development in the upper watershed is primarily residential. As the stream crosses under I-405 into the middle watershed, land use is dominated by commercial facilities. The lower watershed contains multifamily residential housing and the Yarrow Bay wetland. The water resources discipline team did not find any studies reporting discharge rates for this stream. As with the other basins, we assumed

that the current peak flows for Yarrow Creek would likely be higher than predevelopment levels because of the extensive amount of development in the basin.

West Tributary of Kelsey Creek (Kelsey Creek Basin)

The West Tributary of Kelsey Creek is located in the Kelsey Creek Basin, one of four sub-basins collectively comprising the Mercer Slough Basin. The West Tributary of Kelsey Creek originates southeast of the intersection of I-405 and SR 520 in Bellevue, flows southerly to the confluence with the mainstem of Kelsey Creek, and eventually discharges into Lake Washington just north of the I-90 East Channel Bridge (Exhibit 11).

The stream flows through a combination of open stream/ditch reaches and pipes. The estimated length of open channel of the West Tributary is 2.8 miles (14,585 feet). Land use in the Kelsey Creek basin is mainly single-family residential, with other major uses including public streets, industrial, and open space/parks. The water resources discipline team did not find any information documenting the effects of basin urbanization on flow rates or aquatic habitat quality. As with the other basins, the water resources discipline team assumed that the current peak flows of the West Tributary of Kelsey Creek would likely be higher than predevelopment levels because of the extensive amount of development in the basin.

Eastside Floodplains

The Federal Emergency Management Agency (FEMA) flood rate insurance map for the Eastside does not show any 100-year floodplains associated with Fairweather Creek, Cozy Cove Creek, or the West Tributary of Kelsey Creek. Fairweather Creek and its historical floodplain are currently disconnected because the stream is confined by high, steep banks along much of its length (Anderson et al. 2001).

The FEMA flood insurance rate map for Yarrow Creek shows no floodplains for the section of stream located in the project area. This same map shows 100-year floodplains associated with the upper reaches of Yarrow Creek between I-405 and Northeast 39th Street and at the mouth of Yarrow Creek, where numerous small, unnamed drainages flow into Lake Washington. The area around the mouth of Yarrow Creek has also been identified as a wetland (wetland YBN-1; see Appendix E, *Ecosystems Discipline Report*, for more information).

What is the quality of surface water bodies in the project area?

The overall quality of surface water bodies in the project area is summarized below, and discussed in greater detail in the following sections.

- Surface water bodies in the Seattle project area receive urban runoff from roadways, commercial and industrial neighborhoods, residential areas, and combined sewer overflows (CSOs).
- Ecology has designated Lake Union as an impaired water body because of sediment contamination; it also exceeds the water quality criteria for dieldrin, a pesticide.
- Lake Washington water quality is improved over recent historic conditions. Water quality is high for most parameters, but the lake is still listed by Ecology as impaired because of bacterial contamination.
- Ecology has listed most of the Eastside project area streams as impaired because of temperature and bacterial contamination.

What are Combined Sewer Overflows (CSOs)?

Combined sewers carry sewage in the same pipe as stormwater. During normal storm events, the combined sewers convey sewage and stormwater to wastewater treatment plants, where the water is treated and discharged. During heavy rainfall, the combination of sewage and stormwater sometimes exceeds the capacity of pipe and the wastewater treatment plant. When this occurs, the combined sewage and stormwater will overflow and discharge into a nearby lake or stream without being treated.

Seattle Surface Water Quality

Surface water quality in Lake Union and Portage Bay is influenced by:

- Freshwater inflows from Lake Washington
- Saltwater inflows from Puget Sound through the Ballard Locks
- CSOs
- Storm drains from the surrounding urbanized watershed
- Roof drains
- Boat discharges

The water in Lake Union is completely replaced about once a week during high water flows (King County 2004), a fairly high flushing rate (Ecology 2004b). High flushing rates can lower nutrient levels by reducing algal growth rates, leading to clearer water and better light penetration (Ecology 2004b). High flushing rates can also act to reduce pollutant concentrations in the water column.

Potential pollutant sources include roads, commercial and industrial neighborhoods, residential areas, and CSOs. The shores of Lake Union and Portage Bay are completely lined by marinas, houseboat moorage, commercial docks and dry-docks, and industries.

The combination of freshwater and salt water in Lake Union affects the amount of oxygen in this lake. During the summer months—July, August, and September—a layer of water with very low dissolved oxygen (approximately 1 milligram per liter [mg/L]) and increased salinity forms along the bottom of Lake Union (Hansen et al. 1994). The layer of water at the bottom of the lake has a higher density than the warm water at the top of the lake because it is a mixture of freshwater and marine water. As a result, the higher density water concentrates at the bottom of the lake and does not mix with the lower density warm water closer to the surface of the lake to any great extent during the summer (CH2M HILL 1999). This combination of low dissolved oxygen and increased salinity would be stressful to most invertebrates living in Lake Union sediments, and make the lower parts of the lake unhealthy for water column invertebrates and fish.

Ecology has placed Lake Union on its 303(d) list because it exceeds the water quality criteria for dieldrin (a pesticide) and sediment bioassays (meaning that test organisms placed in these sediments did not survive or grow well) (Ecology 2004a). Past studies have shown that concentrations of some metals and some PAHs are twice as high in Lake Union sediments as in Lake Washington sediments (Cubbage 1992). King County has monitored surface water chemistry annually in Portage Bay since 1998 (King County

Why is oxygen important for a healthy lake?
Healthy lake systems provide aquatic animals and plants with high levels of dissolved oxygen, low levels of salt (salinity), and a range of moderate temperatures. The colder the temperature and the lower the salt content, the more dissolved oxygen the water can hold, expressed in units of milligrams per liter (mg/L).

How much oxygen is needed?
Above 6 mg/L dissolved oxygen, most aquatic plants and animals have plenty of oxygen. When the level of dissolved oxygen is low (below 3 mg/L), the water is called hypoxic. If all of the dissolved oxygen is used up (below 0.5 mg/L), the water is called anoxic. Under hypoxic conditions, many aquatic plants and animals may not survive.

What are polycyclic aromatic hydrocarbons (PAHs)?
PAHs are a group of cancer-causing chemicals formed when organic substances do not completely burn. Typical substances that can form PAHs include coal, oil, gas, wood, garbage, tobacco, and meat.

2004). Most of the water quality parameters measured (e.g., pH, dissolved oxygen, and conductivity) were within acceptable ranges, except for temperature. Temperatures at 3.28 feet below the surface consistently reached approximately 68°F or higher each August between 1998 and 2002 (King County 2004). A comparative study of Lake Union and Portage Bay sediments conducted in 1992 found that metal concentrations in Portage Bay sediments were consistently lower than those measured in Lake Union (Cubbage 1992), and did not exceed national and international freshwater sediment guidelines.

Lake Washington Surface Water Quality

The water in Lake Washington is replaced about every 3 years (Emery et. al. 1973), which is about half of its historical replacement rate (Chrzastowski 1983). This replacement time accelerated when the Lake Washington Ship Canal system was built and the Cedar River was diverted into the lake.

Before 1968, Lake Washington experienced high levels of algal growth, with corresponding drops in oxygen level (termed eutrophication), which were stimulated by direct discharges of treated sewage (Edmondson 1991, King County 2001). Metro began diverting sewage from the lake between 1963 and 1967, and water quality quickly improved, particularly with respect to nutrient levels, transparency, and associated nuisance blue-green algae (Edmondson 1991).

What is eutrophication?
A major challenge facing Puget Sound lowland lakes is algal growth associated with increased fertilizer inputs from surrounding urban neighborhoods. High nutrient concentrations stimulate blooms of algae, clouding the water and blocking sunlight, leading to decreases in dissolved oxygen.

This process is called **eutrophication**.

The water in Lake Washington is considered high quality for most parameters important to fish, wildlife, and human uses (dissolved oxygen, temperature, pH, conductivity, metals, and nutrients). However, Lake Washington is on the Ecology 303(d) list of impaired water bodies because it exceeds the fecal coliform criterion (Ecology 2004a). Potential pollutant sources include those typical of urbanized basins such as residential, commercial, and industrial neighborhoods and roads.

What are fecal coliforms?
Fecal coliforms are bacteria present in human and animal feces, such as wildlife species that use the lake. These bacteria can indicate the potential presence of harmful bacteria and virus.

Eastside Surface Water Quality

Fairweather Creek

Fairweather Creek was placed on the Ecology 303(d) list because it exceeds the fecal coliform and temperature water quality criteria (Ecology 2004a). Metro sampled water quality in 1988 and between 1990 and 1993. The sampling showed that high temperature violations occurred during the summer low-flow months when the stream was nearly dry (King County 1994). Metro also measured exceedances of fecal coliform and dissolved oxygen water quality criteria (Metro 1989), as well as elevated levels of copper, zinc, and nickel in sediments located at the mouth of the stream (King County 1994).

A study by The Watershed Company also showed water quality to be poor in Fairweather Creek during the summer (the study was limited to the summer). Ammonia levels exceeded the state standard and were higher than levels acceptable for raising farmed salmon. For salmon, the creek's manganese and iron levels were unacceptably high, dissolved oxygen levels were marginal to low, and temperature levels were higher than ideal during summer low flows and acceptable during summer high flows. The Watershed Company also noted a lack of stream shading and stream channel complexity, and a prevalence of nonnative and invasive vegetation along the stream corridor (Anderson et al. 2001). Potential stormwater pollutant sources in this basin, in addition to SR 520, include residential neighborhoods, a golf course, and local roads.

Cozy Cove Creek

Little is known about the water quality of Cozy Cove Creek or the unnamed tributary that discharges directly to Yarrow Bay. Neither stream was rated in the 303(d) water quality classification system. Residential development has affected Cozy Cove Creek, which has been channelized and contained within riprapped banks. The stream receives runoff from landscaped lawns, residential streets, and SR 520. The unnamed tributary also drains stormwater from a residential neighborhood and SR 520, but has a well-developed forested riparian corridor north of SR 520.

The banks of channelized streams are frequently riprapped. **Riprap** is a lining of large stones and boulders intended to reduce undercutting and stabilize stream banks. Riprap reduces the habitat complexity of the stream channel and confines it, which increases the velocity of the stream flow. Increased stream flow velocity causes erosion and scouring. Riprapping stream banks can adversely affect juvenile salmon (Knudsen and Dilley 1987).

Forested riparian corridors provide shade to adjacent creeks, lowering stream temperatures compared to similar unshaded streams. Riparian vegetation also acts to clean stormwater, lowering pollutant concentrations discharged to streams and lakes.

Yarrow Creek

Yarrow Creek is on the Ecology 303(d) list because it exceeds the fecal coliform water quality criterion (Ecology 2004a). Between 1990 and 1993, Metro measured high nitrate concentrations (associated with the use of fertilizers) in this stream (King County 1994). Metro also measured two exceedances of the fecal coliform water quality criterion between 1988 and 1989, as well as high levels of nitrate, nickel, chromium, and lead (Metro 1989). Sources of metals in this basin are primarily residential neighborhoods and roads, while fecal coliform sources include pets and ongoing horse and cattle pasturing upstream of I-405 near Bridle Trails State Park.

West Tributary of Kelsey Creek

The West Tributary of Kelsey Creek is on the Ecology 303(d) list because it exceeds the temperature and fecal coliform water quality criteria (Ecology 2004a). Between 1998 and 2002, 10 percent of water samples collected by King County exceeded the Washington state temperature water quality criterion, with exceedances occurring each year. During the same testing period, King County data also showed that the fecal coliform water quality criterion was exceeded in 57 percent of the samples collected, with exceedances occurring in all years. Potential pollutant sources in this basin primarily include residential neighborhoods, roads, and industrial activities.

How is stormwater managed in the project area?

Overall, stormwater management in the project area takes place as follows:

- Most stormwater runoff discharged from SR 520 is not treated before it is discharged. Stormwater draining to the West Tributary of Kelsey Creek is the only part of the project area where stormwater is treated and flows are controlled prior to discharge.
- Stormwater runoff in the Seattle project area discharges directly to major water bodies such as Lake Union and Lake Washington.
- Stormwater runoff from the existing Portage Bay Bridge and Evergreen Point Bridge discharge directly to Portage Bay and Lake Washington, respectively.
- Stormwater runoff in the Eastside project area discharges to either Lake Washington or a series of small streams.

The following sections describe in detail how stormwater runoff is managed in the Seattle, Lake Washington, and Eastside project areas.

Seattle

In the Seattle project area, stormwater runoff from SR 520 is not treated before it is discharged. The SR 520 corridor crosses a heavily urbanized area of Seattle, where little of the natural stormwater drainage patterns remain. Most stormwater in this area is diverted into channels and conveyance systems that transport stormwater directly to Lake Union and Portage Bay.

The drainage system in the project area consists primarily of storm drains and bridge drains on the elevated bridge structures, which discharge untreated stormwater directly to major water bodies such as Lake Union and Portage Bay. Stormwater from I-5 between East Lynn Street and the Lake Washington Ship Canal Bridge (which includes the I-5/SR 520 Interchange) is conveyed north in storm drains to East Allison Street, where it flows west to an outfall in Lake Union (Exhibit 14). An existing 30-foot-deep stormwater pump station located between the southbound and express lanes just south of the Roanoke bridge over SR 520 pumps stormwater into the storm drain system conveyed to East Allison Street.

Stormwater from the section of SR 520 between approximately 10th Avenue East and Montlake Boulevard is conveyed in storm drains and discharged to two outfalls in Portage Bay—one under the SR 520 structure at Boyer Avenue East and the other under the Montlake Boulevard eastbound off-ramp. The Portage Bay Bridge discharges directly into Portage Bay (Exhibit 14).

Lake Washington

None of the stormwater runoff from the Lake Washington project area is treated before it is discharged. Stormwater from SR 520 between Montlake Boulevard and Union Bay is conveyed in storm drains that flow east, discharging to an outfall in Union Bay, located near the R.H. Thompson Expressway Ramps next to the Lake Washington Boulevard Interchange (Exhibit 14). Stormwater on the west approach to the Evergreen Point Bridge discharges from numerous bridge drains directly into Union Bay. There are no constructed drainage systems where SR 520 crosses Foster Island. Stormwater from the floating bridge deck is conveyed into bridge drains that discharge directly into Lake Washington.

Eastside

In the Eastside project area, the West Tributary of Kelsey Creek is the only basin that receives treated stormwater from SR 520. Untreated stormwater from the remainder of the project area is discharged to various tributary streams or wetlands before reaching Lake Washington, the major receiving water body.

Fairweather Creek Basin

Stormwater from SR 520 discharges in storm drains and curb openings at multiple locations, eventually flowing into Fairweather Bay. There are four primary discharge locations from SR 520—Fairweather Park, 80th Avenue Northeast, a culvert under SR 520 at the tip of Fairweather Bay, and Fairweather Creek (Exhibit 14).

At Fairweather Park, a culvert beneath SR 520 conveys flows to a diversion structure near Medina. Low flows are conveyed though Fairweather Park to a steep ravine; high flows are conveyed around the park and down a storm drain under 80th Avenue Northeast to Fairweather Bay. This outfall is located on residential property at the end of Northeast 32nd Street in Hunts Point. The third discharge location is a pipeline at the tip of Fairweather Bay between residential properties. The easterly discharge location is Fairweather Creek, which crosses under SR 520 just west of the Northeast 84th Street ramp. The creek flows northwesterly a short distance through residential properties to Fairweather Bay.

Cozy Cove Creek Basin

Stormwater from SR 520 between the 84th Avenue Northeast interchange and the 92nd Avenue Northeast interchange is conveyed west along SR 520 in curbs and ditches. It is discharged primarily to Cozy Cove Creek, which crosses under the highway east of 84th Avenue Northeast (Exhibit 14). Scuppers (openings for drainage in a wall or curb) along the centerline barrier are necessary because no storm drains exist here. Stormwater from this part of SR 520 is not currently treated.

Yarrow Bay Wetland and Yarrow Bay Basins

Between 92nd Avenue Northeast and 108th Avenue Northeast, the SR 520 drainage system consists of ditches, storm drains, and bioswales that discharge to Yarrow Creek and its tributaries (Exhibit 14). Two bioswales, one on either side of SR 520, provide basic water quality treatment for stormwater. There are several places where stormwater is discharged into Yarrow Bay and Yarrow Creek in this basin. A 36-inch culvert just east of 92nd Avenue Northeast (a tributary to Yarrow Bay) discharges its flows north down a steep slope into the Yarrow Bay wetland. Farther east near the end of Northeast 35th Street, a 24-inch culvert also discharges flows north into the wetland.

A **bioswale** is landscape designed to act as a water filter. A bioswale is generally a low-gradient, open channel with vegetative cover that slows water flow.

West Kelsey Creek Basin

Stormwater from SR 520 east of I-405 is conveyed in storm drains and discharged at 120th Avenue Northeast. From there, it flows south in city storm drains to Kelsey Creek, eventually reaching Lake Washington through Mercer Slough (Exhibit 14). An existing large

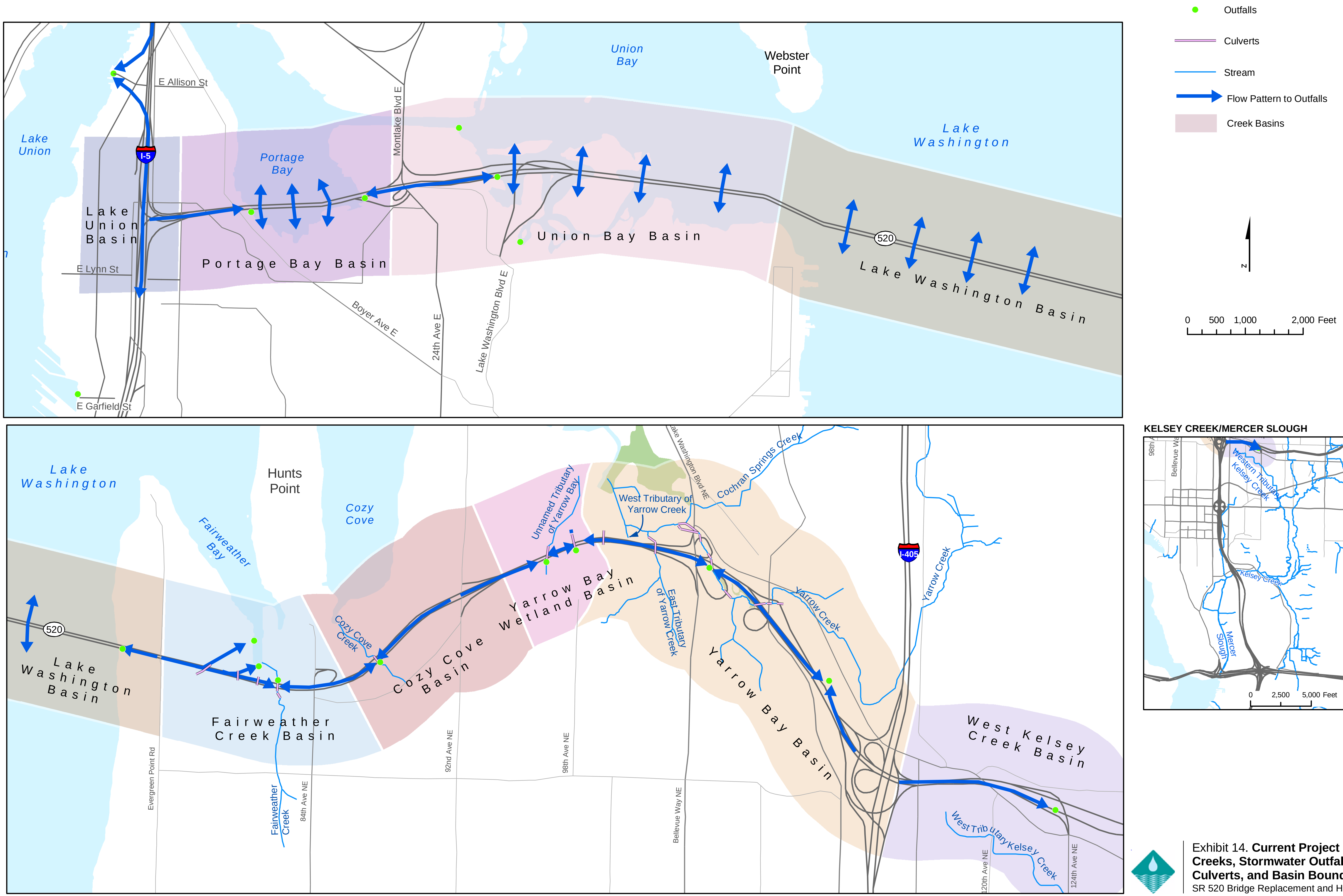


Exhibit 14. **Current Project Area Creeks, Stormwater Outfalls, Culverts, and Basin Boundaries**
SR 520 Bridge Replacement and HOV Project

water quality and detention vault under the eastbound 124th Avenue Northeast off-ramp shoulder and roadside currently provides water quality treatment for roadway stormwater. There is also a bioswale along this part of SR 520 that provides water quality treatment for stormwater from the highway.

Treating the Project's Stormwater

How do Ecology's stormwater regulations affect the design of the stormwater system for this project?

Ecology requires stormwater from all new PGIS to be treated before it is discharged. In addition, Ecology often requires stormwater flows to be controlled (detained) before they are treated and discharged. Exhibit 15 describes how Ecology's regulations apply to the design of stormwater systems for road projects in general, and to the SR 520 Bridge Replacement and HOV Project specifically.

Exhibit 15. How Ecology's Stormwater Regulations Apply to Road Projects

If…	Then	How does this apply to the SR 520 Bridge Replacement and HOV Project?
If a project proposes to add new impervious surfaces…	Stormwater from the new impervious surface area must be treated. In addition, stormwater flow control measures may be required.	This project must build and maintain stormwater treatment and required flow control facilities in areas where new impervious surfaces are proposed.
If a project proposes to retrofit existing impervious surfaces where stormwater is not treated and flows are not controlled…	A project must build a system to treat stormwater from the existing impervious surface area. In addition, flow control measures may be required.	This project must build and maintain stormwater treatment and required flow control facilities in areas where existing impervious surfaces are going to be replaced.

Ecology's *Stormwater Management Manual for Western Washington* (Ecology 2001) describes how project proponents must design stormwater systems that meet the water quality criteria. WSDOT implements this guidance on transportation projects by using the *Highway Runoff Manual* (HRM) to design stormwater systems to meet Ecology's regulations (WSDOT 2004a). WSDOT's manual has been approved by Ecology and is considered to be equivalent to the 2001 Stormwater Management Manual.

How have engineers designed the stormwater treatment facilities system for this project?

Project engineers have designed the stormwater treatment facilities proposed for the project using WSDOT's HRM. The HRM specifies:

- The level of treatment and flow control required to protect surface water bodies located in Washington
- Approaches that engineers must use when they design stormwater systems
- Stormwater treatment and flow control methods and technologies that can be used to meet water quality criteria (typically called Best Management Practices, or BMPs)

What are Best Management Practices (BMPs)?
BMPs are practices and treatment technologies or methods that can be used to meet water quality criteria. There are many different types of BMPs. Some are treatment technologies such as wet vaults and stormwater treatment wetlands. Others are maintenance measures that can be implemented as part of a project, such as sweeping streets of debris. Some BMPs are permanent features of a project; others can be temporary measures employed during construction.

How do stormwater treatment and flow control facilities work?

There are several types of systems for stormwater treatment and flow control facilities. The following is a description of these systems and how they would treat water prior to discharge. Exhibit 16 shows the use of these four treatment options for this project.

Exhibit 16. **Stormwater Treatment and Flow Control Requirements for Project Area Basins**

Water Quality Treatment and Flow Control Requirements	Applicable Project Area Basins
Water Quality – Basic Treatment Flow Control – None	Lake Union Basin Portage Bay West Lake Washington Fairweather Bay West
Water Quality – Basic Treatment Flow Control – Provided	West Tributary of Kelsey Creek
Water Quality – Enhanced Treatment Flow Control – None	Yarrow Bay Wetland Portage Bay East Union Bay
Water Quality – Enhanced Treatment Flow Control – Provided	Fairweather Bay East Cozy Cove Yarrow Creek

Basic Water Quality Treatment Without Flow Control

This type of system deposits sediment on the bottom of a vault or pond (Exhibit 17). Many pollutants are bound to sediments, so removing the sediments can reduce the level of pollutants contained in stormwater.

The polluted sediments are frequently cleaned out from the bottom of the vault or pond. For this treatment combination, the inflow rate is equal to the outflow rate, which means that flows are not controlled.

Basic Water Quality Treatment with Flow Control

This type of system removes pollutants bound to sediments from stormwater and temporarily stores stormwater to control the outflow rate relative to the inflow rate (Exhibit 18).

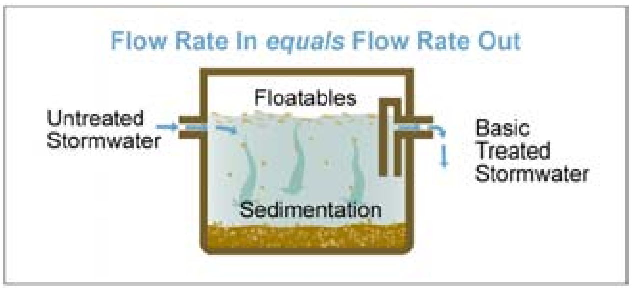


Exhibit 17. Schematic Profile of a Basic Water Quality Treatment Facility

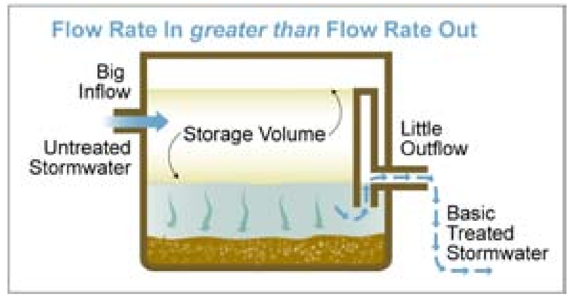


Exhibit 18. Schematic Profile of a Basic Water Quality Treatment Facility with a Flow Control

Enhanced Water Quality Treatment Without Flow Control

This type of system removes pollutants bound to sediments from stormwater and dissolved pollutants by passing the stormwater through a treatment filter, pond, or wetland before it is discharged (Exhibit 19). For this project, this type of system is planned only for stormwater draining to the Yarrow Bay wetland.

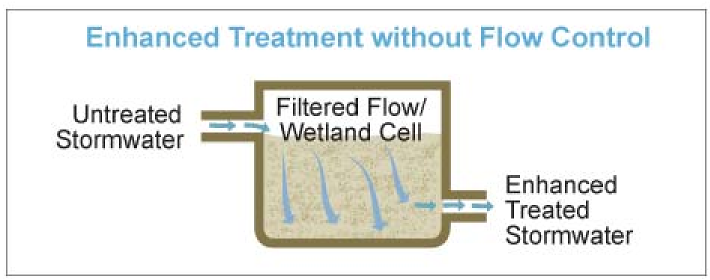


Exhibit 19. Schematic Profile of an Enhanced Water Quality Treatment Facility

Enhanced Water Quality Treatment With Flow Control

This type of system removes pollutants bound to sediments from stormwater, and it removes some dissolved pollutants by passing the stormwater through an additional treatment filter, pond, or wetland before it is discharged (Exhibit 20). This system also temporarily stores the stormwater to control flow rates.

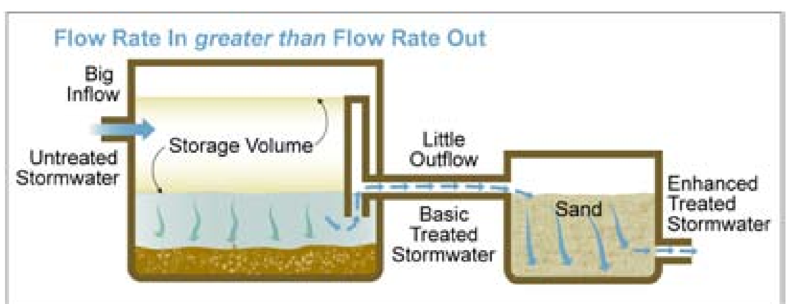


Exhibit 20. Schematic Profile of an Enhanced Water Quality Treatment Facility with Flow Control

What are basic and enhanced stormwater treatment BMPs?
Basic and enhanced stormwater treatment BMPs are different types of BMPs that have been designated in the *Highway Runoff Manual* to treat stormwater (see page 2-17, Chapter 2 of the HRM [WSDOT 2004a]).

- **Basic treatment BMPs** remove pollutants such as metals, suspended solids, and nutrients from contaminated stormwater. The HRM performance goal for basic treatment BMPs is 80 percent removal of total suspended solids (WSDOT 2004a).
- **Enhanced treatment BMPs** are designed to achieve greater removal of dissolved metals than basic treatment. In addition to removing 80 percent total suspended solids, the HRM performance goal for enhanced treatment is 50 percent removal of dissolved copper and zinc for influent concentrations, ranging from 0.003 to 0.2 mg/L for dissolved copper and 0.02 to 0.3 mg/L for dissolved zinc (WSDOT 2004a).

While these families of BMPs have different performance goals for the stormwater they are designed to treat, the intent of treatment is the same—to produce stormwater discharges that comply with state and federal water quality criteria.

What level of water quality treatment and flow control is required?

The HRM establishes the level of water quality treatment (basic or enhanced) required for a project. It also identifies if and where flow controls are required. Using the guidelines provided in the HRM, the 4-Lane and 6-Lane Alternatives would construct four combinations of flow control and water quality treatment facilities, as shown in Exhibit 16.

The HRM specifies that Lake Union, Portage Bay, and Lake Washington are exempt from any flow control requirements (see page 2-22, Table 2-5 in WSDOT 2004a) because the elevation or flow patterns of these water bodies would not be affected by changes in stormwater discharge patterns. Flow control would only be required for sub-basins in Seattle that drain to the city's storm drains/CSOs (Stormwater, Grading, and Drainage Control Code, Seattle Municipal Code 22.800-22.808). In the Eastside project area, all direct discharges to streams would require flow control facilities (WSDOT 2004a).

The **Water Quality Design Storm** is defined in the *Stormwater Management Manual for Western Washington* (WSDOT 2004a) as "a 24-hour storm with a 6-month return frequency (also known as the 6-month, 24-hour storm)." The Design Storm is used to calculate the size and capacity of flow control and stormwater treatment BMPs needed to effectively treat the volume of stormwater generated during such an event.

Stormwater in Lake Union, Portage Bay, and Lake Washington would require basic treatment BMPs (see Table 2-2 in WSDOT 2004a). In the Eastside project area, direct discharges to streams would require installing enhanced treatment facilities for both the 4-Lane and 6-Lane Alternatives (WSDOT 2004a).

How are the sizes of stormwater treatment and flow control facilities determined?

After establishing the type of treatment (basic or enhanced) system, engineers determined the size of the facilities based on the expected volume of stormwater that would be generated by what is termed the

Water Quality Design Storm. The Water Quality Design Storm Volume is defined as "the volume of runoff predicted from a 6-month, 24-hour storm. Facilities such as wetpools are sized based on the volume of runoff produced by the water quality design storm" (WSDOT 2004a). The total volume of stormwater runoff is a function of the Water Quality Design Storm designated for the project area, and the amount of impervious surface on which rain falls. For this project, engineers determined the size of the individual treatment and flow control facilities based on the volume of water generated during the Water Quality Design Storm for each individual section of the project area.

How are the types of stormwater treatment and flow control facilities determined?

The HRM presents two approaches to designing a system that complies with federal and state water quality regulations. These approaches are called the *presumptive approach* and the *demonstrative approach*. Both approaches "are based on best available science and result from existing federal and state laws that require stormwater treatment systems to be properly designed, constructed, maintained and operated" (page 1-3, WSDOT 2004a).

In the HRM, the presumptive approach specifies a menu of BMPs that engineers can use to design a stormwater system to meet Ecology's stormwater regulations. The HRM provides information to guide engineers in the "the proper selection, design, construction, implementation, operation, and maintenance of BMPs" (pages 1-3 and 1-4, WSDOT 2004a). "Projects that follow the stormwater BMPs contained in [the HRM] are presumed to have satisfied [the] demonstration requirement and do not need to provide technical justification to support the selection of BMPs" (page 1-3, WSDOT 2004a).

Alternatively, engineers can design stormwater systems using stormwater BMPs and management approaches that are not included in the HRM. This approach is called the demonstrative approach. The approach can be used if it can be:

1. [d]emonstrate[ed] that the project will not adversely impact water quality by collecting and providing appropriate supporting data to show that the alternative approach protects water quality and satisfies state and federal water quality laws; and by

2. satisfying the technology-based requirements of state and federal law (page 1-3, WSDOT 2004a).

Based on this guidance from the HRM, the project engineers on the design team followed the presumptive approach to design the flow control and stormwater treatment facilities for the Seattle and Eastside project areas. However, project engineers determined that standard BMPs specified under the presumptive approach would not work with the unique features of the Evergreen Point Bridge, and instead followed the demonstrative approach to design a stormwater treatment system for the floating portion of the bridge.

The engineering team conducted an All Known, Available, and Reasonable Technology (AKART) analysis to evaluate the universe of possible stormwater BMPs that could be used on the Evergreen Point Bridge (CH2M HILL et al. 2002). They found that typical BMPs (such as vaults) that store large amounts of stormwater could threaten the structural integrity of the bridge, possibly causing sections of the floating bridge to sink. Treating stormwater on barges or other structures moored alongside the floating portion of the bridge would pose a threat to the bridge during storms because the structures could break loose or dislodge bridge anchors. Additionally, pumping stormwater flows off the bridge to an offsite location was not considered to be reliable due to mechanical requirements, maintenance, and experience on the I-90 floating bridge (CH2M HILL et al. 2003). The *AKART and Water Quality Studies for an SR 520 Replacement Floating Bridge Report* (CH2M HILL et al. 2002) is incorporated here by reference.

What is an AKART Analysis?
AKART stands for **A**ll **K**nown, **A**vailable, and **R**easonable **T**echnology. AKART represents the most current methodology and technology that may reasonably be required for preventing, controlling, or minimizing pollutants associated with a discharge. An AKART analysis identifies the universe of possible BMPs that could reasonably be used for stormwater treatment on a project.

Exhibit 21 identifies the steps followed to determine how the project would affect surface water resources using the presumptive and demonstrative approaches.

What are the proposed stormwater treatment facilities for the 4-Lane and 6-Lane Alternatives?

For the proposed project, project engineers selected each BMP based on space constraints and discharge location. The engineers also sized the treatment facilities to meet the HRM requirements for each build alternative. Generally, the stormwater treatment facilities would be in approximately the same locations for both the 4-Lane and 6-Lane Alternatives, although the 6-Lane

Protecting water quality beyond HRM requirements.
In the Seattle project area, stormwater discharges to portions of Portage Bay and the Union Bay area would meet guidelines for enhanced treatment. This means that stormwater discharges from these areas would receive more treatment than the HRM requires.

Exhibit 21. Steps Involved in Applying the Presumptive and Demonstrative Approach for this Project

Steps followed to apply the presumptive approach for this project	
1)	Identify the surface water bodies receiving stormwater and the associated level(s) of flow control and water quality treatment required by the HRM.
2)	Determine the total area of PGIS and the Water Quality Design Storm for the project area. With that information, determine the appropriate size and location for required treatment and flow control facilities.
3)	Identify the types and combinations of flow control and water quality treatment BMPs to be used from the flowcharts provided in the HRM. Evaluate feasibility, location constraints, and costs.
4)	Presume that the project has demonstrated compliance with state and federal water quality criteria based on the HRM guidance (WSDOT 2004a).
Steps followed to apply the demonstrative approach for this project	
1)	Identify the surface water bodies receiving stormwater and the associated level(s) of flow control and water quality treatment required by the HRM.
2)	Conduct AKART analysis to determine the types of BMPs that can be used. The BMPs can come from the HRM, or they can be new or innovative emerging technologies
3)	Develop an approach to demonstrate that stormwater discharges will meet relevant state and federal water quality criteria.
4)	Demonstrate that stormwater discharges will meet relevant state and federal water quality criteria.

Alternative facilities are larger. The discussion below covers both build alternatives and notes where there are different locations for the 4-Lane and 6-Lane Alternative treatment facilities.

The SR 520 Bridge Replacement and HOV Project *Preliminary Stormwater Management Report* (CH2M HILL and Parametrix 2004) is incorporated here by reference. The report includes a basin by basin description of the proposed stormwater treatment facilities, as well as preliminary design drawings, and is summarized below. A map with the locations of the facilities discussed below is provided as Exhibit 22. Each treatment facility has a distinct designation on the map (e.g., CC-1); these designations are included in parentheses in the discussion below to assist the reader in finding the facility on the map.

According to the *Highway Runoff Manual* (WSDOT 2004a), **emerging technologies** are technologies that have not been evaluated using approved protocols, but for which preliminary data indicate that they may provide a desirable level of stormwater pollutant removal. Ecology has defined three categories of emerging technologies:

- Modifications to public domain practices (such as modifications to biofiltration)
- Swales, wet ponds, infiltration trenches, and others
- Proprietary (vendor-supplied) products
- Nonproprietary experimental designs based on established science and engineering principles (for which supporting literature exists). These include approaches that may not have been formally applied to roadway stormwater treatment, but have a basis in other disciplines (industrial wastewater, municipal wastewater, agricultural drainage, and others).

Seattle Stormwater Treatment Facilities

In the Lake Union basin, project engineers selected emerging technology BMPs to treat stormwater quality. The specific BMP would be chosen from BMPs available at the time of final design. Regardless of the BMP selected, it would meet the HRM's requirements for basic treatment. A space-efficient underground facility would be located on the I-5 roadside between the southbound and express lanes at approximately East Louisa Street in the existing right-of-way (LU-1). It would treat the portion of the SR 520 mainline west of 10th Avenue East and the I-5 flyover ramp that the project would add.

In the Portage Bay basin, the project would construct a water quality wet vault under the Portage Bay Bridge between Boyer Avenue East and the shoreline to provide basic stormwater treatment (PB-1). The vault could be an open-top structure located in existing right-of-way and would discharge to an existing outfall location under the bridge. Exhibit 17 illustrates how wet vaults treat stormwater. A stormwater treatment wetland would be located between SR 520, the Montlake Boulevard eastbound off-ramp, and the shoreline of Portage Bay (PB-2).

A stormwater treatment wetland in South King County

The stormwater treatment wetland discussed above would be one of four stormwater treatment wetlands proposed for the project. These wetlands would be designed to resemble natural wetlands, so they would blend into the surrounding landscape.

Exhibit 23 shows how a stormwater treatment wetland would work. Stormwater treatment wetlands are considered an enhanced treatment BMP because they remove some of the dissolved metals from stormwater, in addition to removing total suspended solids (TSS). Exhibit 23 shows how stormwater treatment wetlands provide enhanced treatment by using multiple cells and wetland vegetation. The first cell is a presettling cell that collects sediment and pollutants. After treatment in the first cell, water flows into the wetland cell, where the combined biological action of plants and bacteria, along with settling, biofiltration, biodegradation, and

What are Total Suspended Solids (TSS)?
Total suspended solids are all the solid particles in water that cannot pass through a filter. Field data show that most TSS particles are very small (less than 125 microns in diameter) (Ecology 2004c). To meet Ecology's stormwater regulations, all treatment facilities must remove 80 percent of the TSS associated with stormwater. Most pollutants found in stormwater are attached to the sediment particles, though there are some dissolved in the water column.

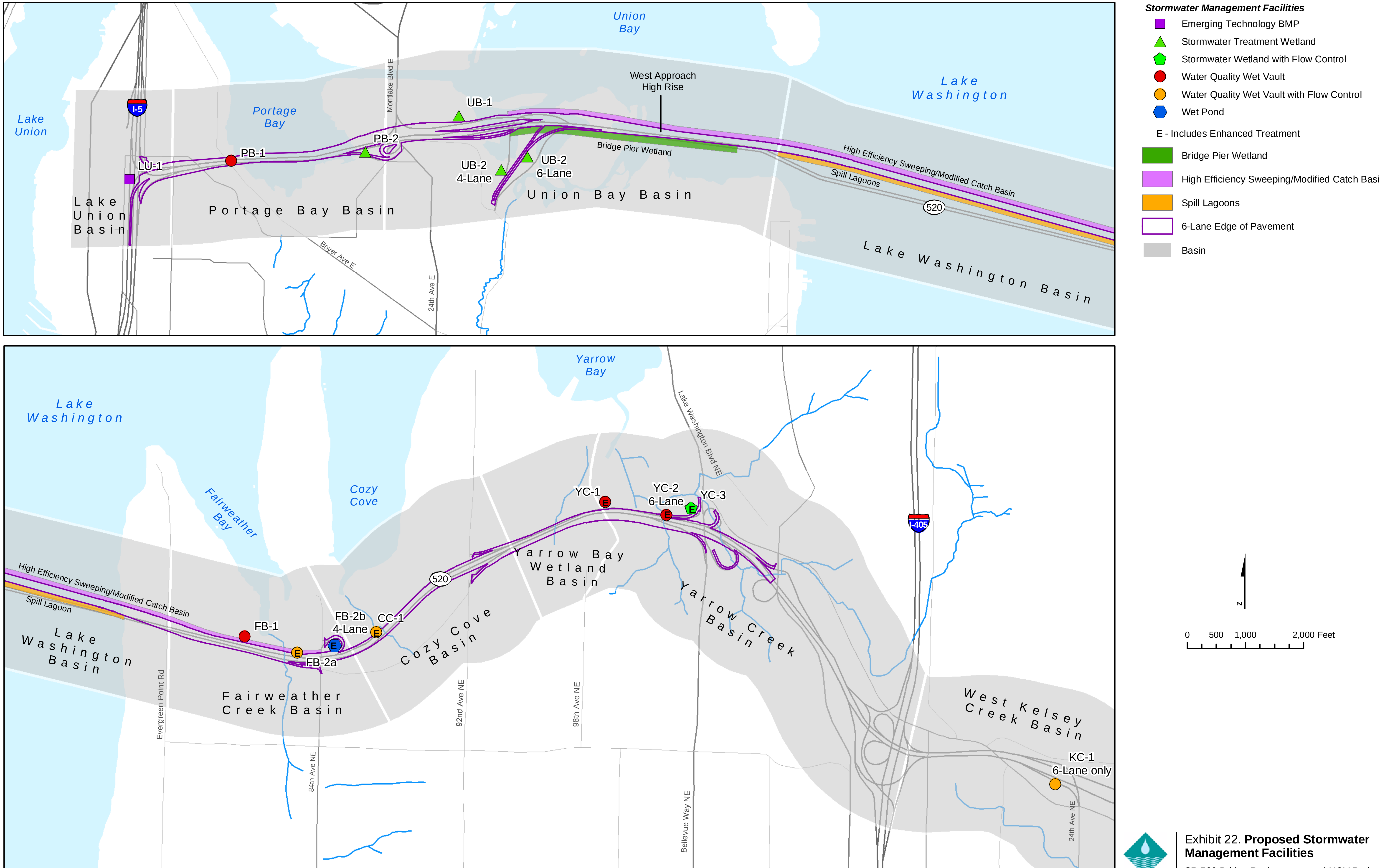
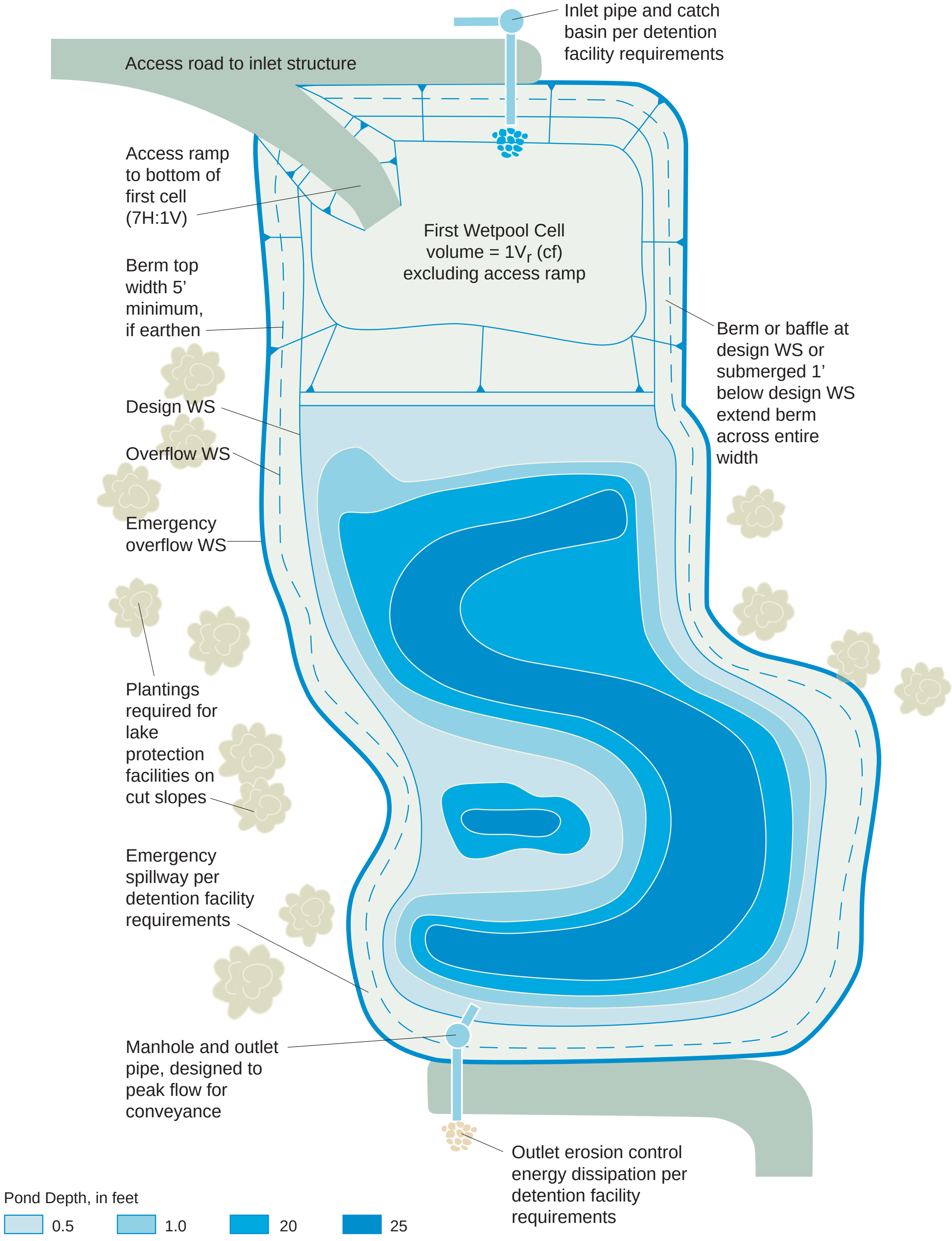


Exhibit 22. **Proposed Stormwater Management Facilities**

SR 520 Bridge Replacement and HOV Project



WS = water surface
Vr = volume of runoff
cf = cubic feet

Exhibit 23. **Example of a Stormwater Treatment Wetland**

SR 520 Bridge Replacement and HOV Project

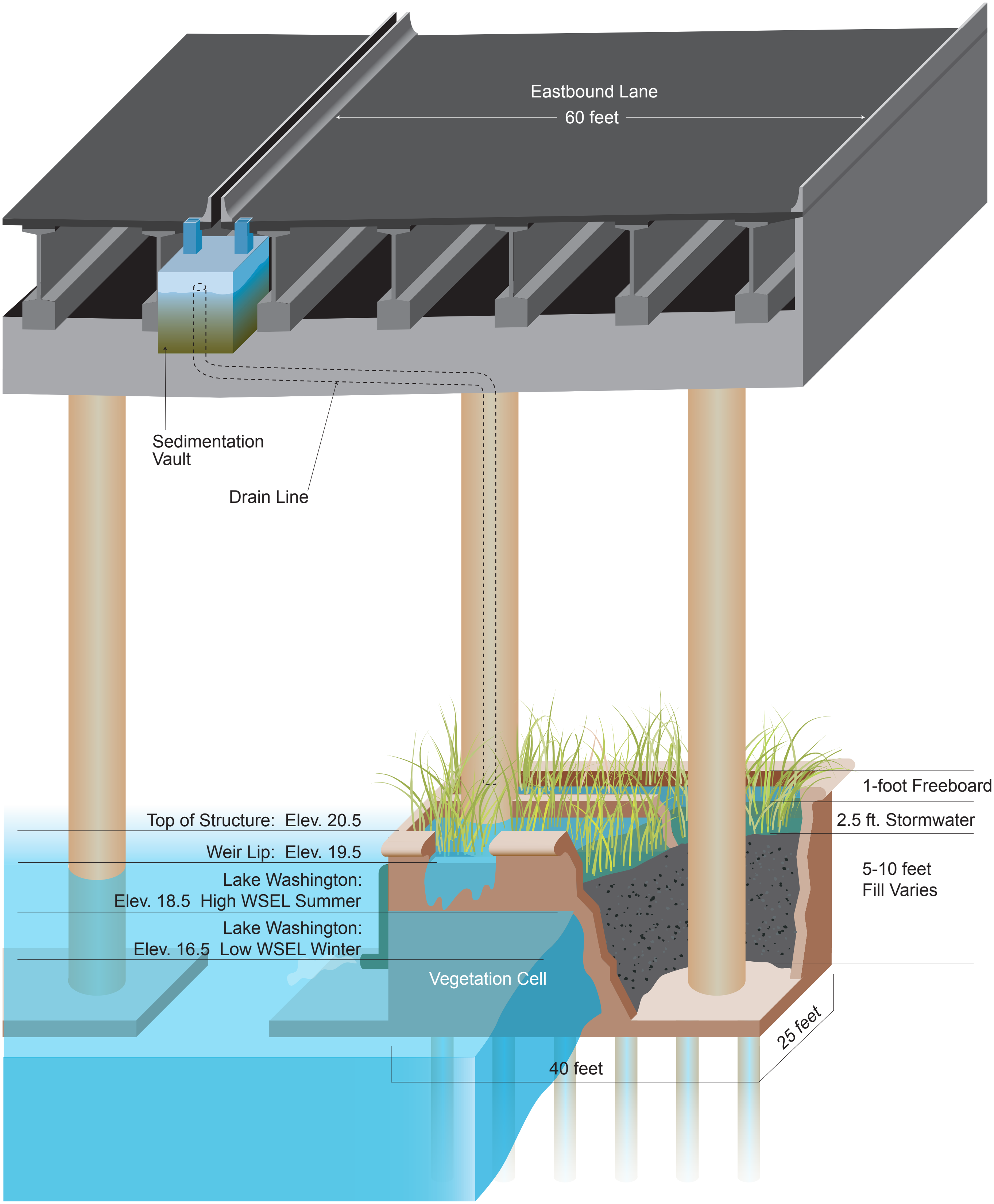
Not To Scale

180171.ag.a5.02_WR_Ex23_ConstrWetland_5apr05.ai bioaccumulation, provide further treatment for dissolved metals and other pollutants. Stormwater discharged from the wetland is assumed to meet the 80 percent TSS removal goal and the 50 percent removal goal for copper and zinc.

In the Union Bay basin, stormwater would be treated at a number of stormwater treatment wetlands. Run-off from SR 520 between Montlake Boulevard and approximately the R.H. Thompson peninsula would be conveyed in new storm drains to a stormwater treatment wetland in McCurdy and East Montlake Parks (where the MOHAI parking lot is currently located) (UB-1). Treated discharges from the wetland would be conveyed north to a new outfall or an existing city outfall in the Montlake Cut. If the existing outfall were used, it would likely have to be upgraded with a larger pipe.

Another stormwater treatment wetland in the Union Bay basin would be located in existing right-of-way on the peninsula where the current Lake Washington Boulevard ramps are located. The wetland would treat stormwater from the elevated Lake Washington Boulevard ramps (UB-2).

Also in the Union Bay basin, 14 or 15 bridge column wetlands would be integrated into the design and construction of the bridge columns (Exhibit 24). These wetlands would have the same standard components and functions as a typical stormwater treatment wetland but would have a nontraditional location. The bridge column wetlands would be constructed inside cofferdams that are used to dewater the column footings during construction. Rather than removing the cofferdams after the columns are built, a stormwater treatment wetland would be created inside the cofferdam (CH2M HILL et al. 2003). Stormwater runoff from approximately the R.H Thomson peninsula to just east of Foster Island would first be treated in sediment chambers (larger than typical catch basins) located just below the roadway at the columns. The sediment cells would remove most of the sediment. The runoff would then be conveyed to the stormwater treatment wetlands located at the base of the columns on the south side of the bridge for additional removal of dissolved metals and TSS. Finally, discharges would flow into submerged outfalls at each column. In addition to this treatment, the bridge approach would be cleaned with a high-efficiency vacuum sweeper on a scheduled basis to collect pollutants from the roadway before they can get into the stormwater.



WSEL = Water Surface Elevation

Note: Elevation is based on North American Vertical Datum 1988 (NAVD88).

Exhibit 24. **Stormwater Treatment Wetland at Bridge Column**

SR 520 Bridge Replacement and HOV Project

Lake Washington Stormwater Treatment Facilities

The proposed floating portion of the Evergreen Point Bridge consists of a column-supported bridge deck on elevated pontoons. Traditional stormwater treatment strategies are difficult and/or structurally infeasible on the floating bridge. Based on the AKART analysis discussed in a previous section, WSDOT's proposed treatment strategy is a sequence of treatments, including, in order of treatment:

1. High efficiency sweeping of the bridge deck
2. Modified catch basins with oil traps (larger capacity than standard sumps and oil traps) to collect sediment and oil
3. Spill lagoons located in the enclosed space between the main pontoons and cross-pontoons

Exhibits 25, 26, and 27 show what the spill lagoons would look like and how they would work. The spill lagoons would be located between sets of paired pontoons. Stormwater would flow across the road surface on the bridge to the inside gutter, and then move down the gutter and through grated inlets into the modified catch basins and ultimately discharge to the spill control lagoons.

The 3-foot-wide lagoon for the 4-Lane Alternative and the 6-foot-wide lagoon for the 6-Lane Alternative (Exhibits 26 and 27) would serve two purposes. The first would be to provide containment for any spilled hydrophobic materials such as oil and other petroleum products, as well as any oil and grease accumulating on the bridge pavement from the normal operation of vehicles crossing the bridge. The second purpose of the spill lagoon would be to mix and diffuse water-soluble pollutants, such as metals in stormwater (Exhibits 25, 26, and 27). This mixing process would be aided by ambient lake currents that would continue to cause turbulent mixing and diffusion as the stormwater disperses from each discharge pipe (Exhibit 25).

Eastside Stormwater Treatment Facilities

Two facilities would be located in the Fairweather Bay basin (Medina and Hunts Point). A wet vault would be located between the roadway slope and the 80th Avenue Northeast cul-de-sac to treat flows from the west portion of the basin (FB-1). The vault would discharge flows to the storm drain in 80th Avenue Northeast and then to Fairweather Bay. The storm drain and outfall at Fairweather Bay would likely need upgrading due to the increased flow rates.

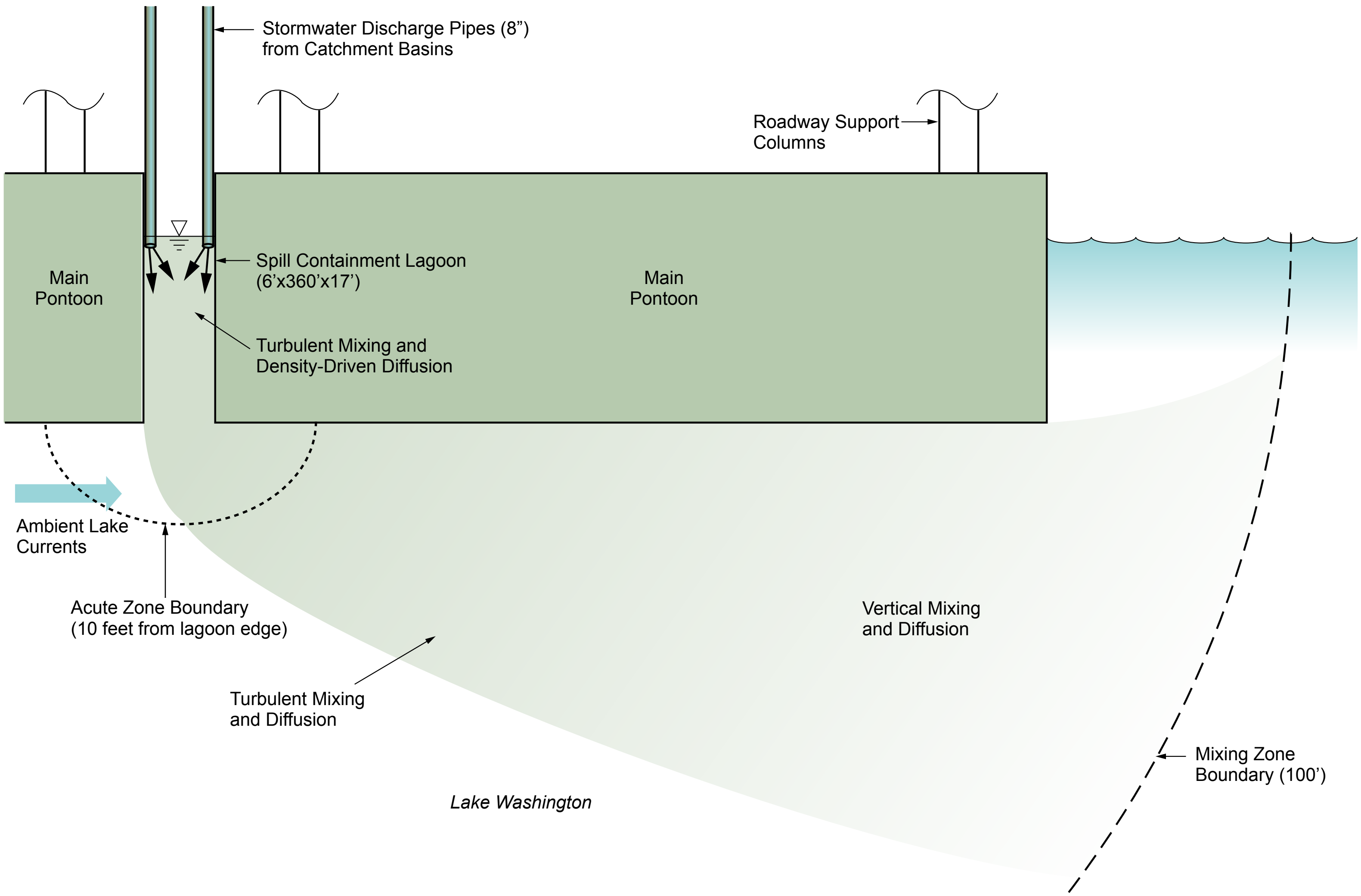
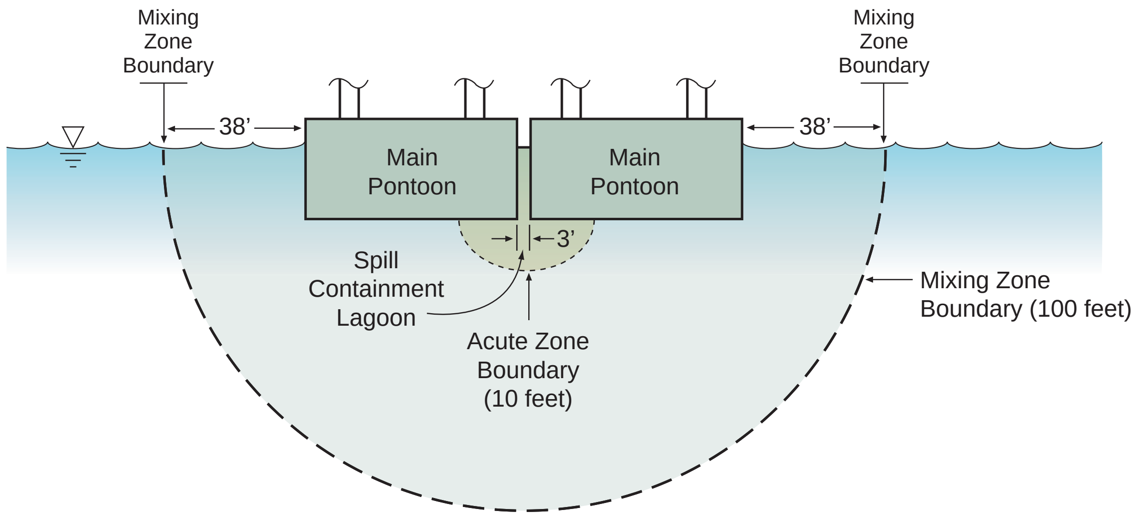


Exhibit 25. **Schematic Representation of Stormwater Mixing Processes for Floating Bridge**

SR 520 Bridge Replacement and HOV Project

4-Lane Alternative



6-Lane Alternative

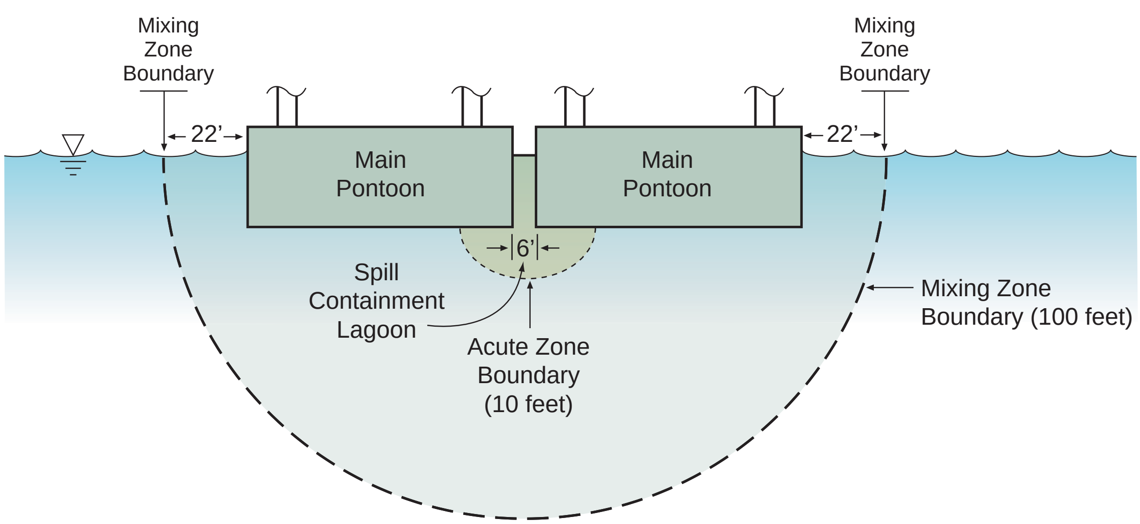
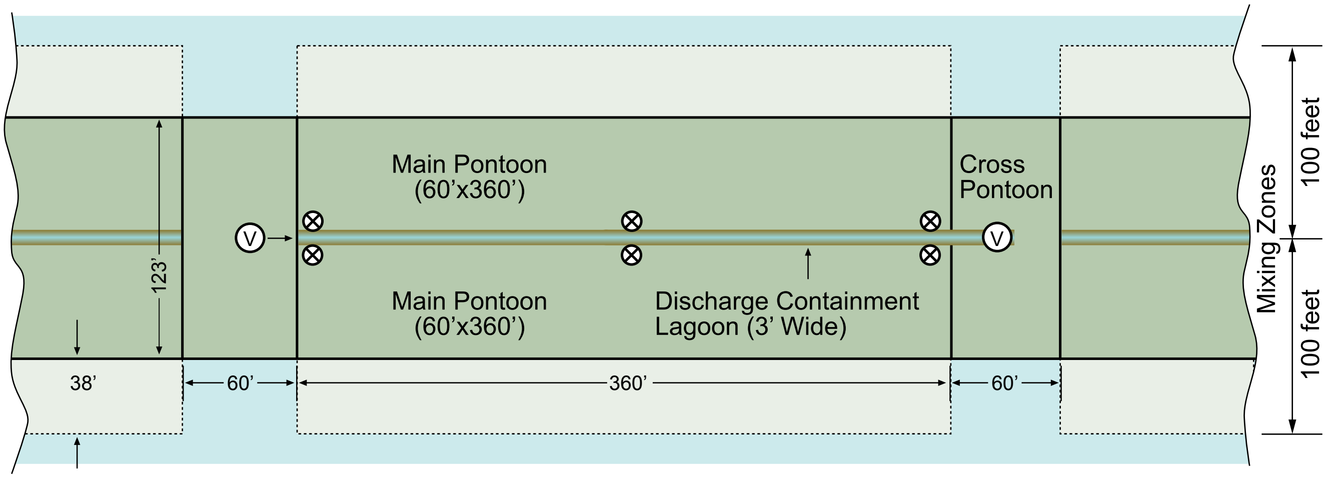


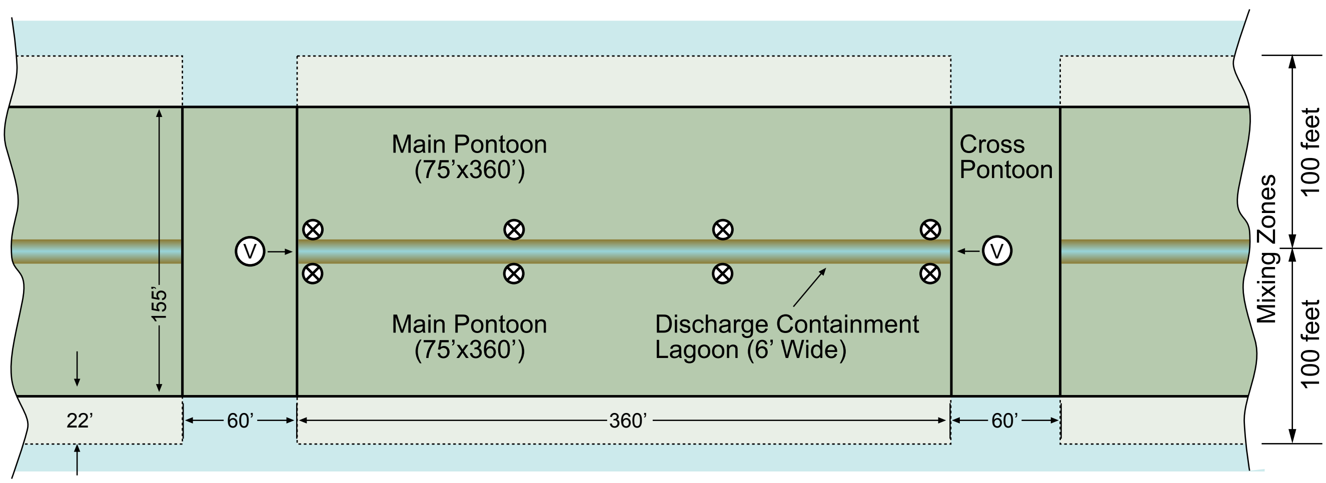
Exhibit 26. **Schematic Section View of Proposed Mixing Zone Boundaries for Build Alternatives**

SR 520 Bridge Replacement and HOV Project

4-Lane Alternative



6-Lane Alternative



LEGEND

- ⊗ Catch Basin and 8”Ø Vertical Discharge Pipe
- Ⓥ Vault Discharge Pipe (12”)
- Mixing Zone Region extending beyond bridge
- Mixing Zone Boundary (100 feet from center)

Exhibit 27. **Schematic Plan View of Stormwater System Configurations and Mixing Zone Boundaries for Bridge Alternatives**

SR 520 Bridge Replacement and HOV Project

For the 4-Lane Alternative, a wet pond would be located inside the loop ramp at the 84th Avenue Northeast westbound on-ramp (FB-2b). Treated flows would discharge to the west beneath the proposed bicycle/pedestrian path. In addition, an underground detention vault would be located under the trail just east of Fairweather Creek. For the 6-Lane Alternative, the loop ramp is an impractical location for a facility because of the lid; therefore, enhanced treatment and flow control would be provided in a vault near the outfall to the creek (FB-2a). Treated and detained flows would discharge to an upgraded outfall at Fairweather Creek.

In the Cozy Cove basin (Hunts Point and Yarrow Point), flow control and wet vaults with an enhanced treatment BMP would be located under the existing Points Loop Trail and the proposed bicycle/ pedestrian path (CC-1). Treated and detained stormwater would then flow to Cozy Cove Creek.

In the Yarrow Bay basin (Kirkland and Bellevue), new and existing storm drains would convey runoff to three stormwater treatment facilities. A wet vault with an enhanced treatment BMP would be located on the shoulder of Northeast Points Drive and treat flows into the Yarrow Bay wetland (YC-1). An upgraded outfall would accommodate increased flows, dissipate erosive velocities, and spread flows into the wetlands. Flows to an existing 36-inch culvert near 92nd Avenue Northeast would be eliminated or reduced to alleviate existing downstream erosion.

Another wet vault with enhanced treatment is proposed under the enforcement area[1] on the westbound on-ramp from Lake Washington Boulevard (only for the 6-Lane Alternative) (YC-2). The treated stormwater would flow into the east tributary of Yarrow Creek.

Also in the Yarrow Bay basin, a stormwater treatment wetland with flow control would be located between SR 520, Lake Washington Boulevard, and Northeast Point Drive (YC-3). This site is currently occupied by a commercial building and an espresso stand. The wetland would discharge to both the east tributary and mainstem of Yarrow Creek.

[1] A place where vehicles may be stopped for ticketing by law enforcement. It also may be used as an observation point and for emergency refuge.

The 6-Lane Alternative, which extends farther east than the 4-Lane Alternative, would have one additional stormwater facility located in the West Kelsey Creek basin (Bellevue). An existing water quality and detention vault under the eastbound 124th Avenue Northeast off-ramp shoulder would be expanded (KC-1).

Potential Effects of the Project

What methods were used to evaluate effects on surface water bodies?

The water resources discipline team used WSDOT- and Ecology-approved methods to evaluate effects on surface water bodies. WSDOT's approved methods for evaluating effects on surface water resources are described in WSDOT's *Environmental Procedures Manual* (2004b) and Highway Runoff Manual (HRM) (2004a). The Environmental Procedures Manual provides guidance to ensure compliance with federal, state, and local laws during the planning, design, construction, and maintenance of WSDOT road projects. The HRM is the manual used by WSDOT to design stormwater systems that meet Ecology's water quality standards.

In addition, we evaluated temporary effects to surface water during construction. These effects were evaluated by determining construction actions that may disturb soil and in-water sediments and by evaluating the potential for accidental spills of hazardous materials.

How would the project permanently affect surface water bodies?

Seattle

No Build Alternative

Surface water quality in Lake Union, Portage Bay, and the west side of Lake Washington would be either unchanged or further degraded under the Continued Operation Scenario. Surface water quality would likely improve under the Catastrophic Failure Scenario.

Under the Continued Operation Scenario, stormwater from the highway discharging to Lake Union, Portage Bay, and the west side of Lake Washington would continue to be untreated. Planning level forecasts conducted as part of this project estimated that traffic levels between the I-5/SR 520 interchange and the Montlake interchange would increase 5 percent over existing levels between 2002 and 2030, which could increase future pollutant loading to SR 520 roadways. Surface water effects under this scenario would be the same as for existing conditions, where water resources affected by discharges of untreated stormwater or water quality could slightly degrade due to predicted increased pollutant loading.

Under the Catastrophic Failure Scenario, loss of the Portage Bay Bridge and Evergreen Point Bridge would eliminate automobile traffic and associated pollutant loading in the Seattle project area past the Montlake interchange. (The exact closure locations are unknown under this scenario.) Pollutant loading would decrease because automobiles would no longer be able to use this part of the project area. Pollutant loading would presumably shift to other parts of the highway system, such as I-90, I-5, SR 522, and I-405.

Predictions of future pollutant loading presented here are based on the assumption that the composition of automobile brakes and tires (the sources of copper and zinc loading to pavement) will not change between now and 2030.

A coalition of brake pad manufacturers and environmental groups are currently evaluating the **contribution of copper from brake pads to stormwater** (Brake Pad Partnership 2004). If their study concludes that brake pads are an important source of copper, the manufacturers have agreed to voluntarily reformulate their products.

4-Lane Alternative

In the Seattle project area, the 4-Lane Alternative would construct a stormwater system that would reduce pollutant loading to stormwater discharged to Lake Union, Portage Bay, and Union Bay compared to existing conditions. Stormwater discharges from these areas are presumed to meet water quality criteria according to the HRM. Stormwater discharges to a portion of Portage Bay and Union Bay would receive enhanced treatment that would exceed the minimum level of treatment required by the HRM.

The 4-Lane Alternative (CH2M HILL and Parametrix 2004) would increase the total area of PGIS by 8.3 acres, and in the individual basins as follows:

- 0.4 acre in the Lake Union Basin
- 1.0 acre in the west part of the Portage Bay Basin
- 3.1 acres in the east part of Portage Bay Basin
- 3.4 acres in the west part of Union Bay Basin
- 0.4 acre in the east portion of the Union Bay Basin

Vehicles would deposit pollutants (such as copper and zinc from tire and brake wear and oil and grease from engines and combustion products) onto the roadway. The water resources discipline team determined pollutant loads to the roadways using the Federal Highway Administration (FHWA) pollutant loading model included in WSDOT's Environmental Procedures Manual (WSDOT 2004b). We calculated pollutant loads to surface water bodies by applying BMP removal efficiencies (Exhibit 28) to the roadway pollutant loads developed using the FHWA model (Exhibit 29).

Exhibit 28. **BMP Percent Removal Efficiencies Used to Calculate Pollutant Loads to Project Area Surface Water Bodies.**

BMP	Copper	Zinc	TSS	Source
Stormwater Wetland	60%	60%	80%	WSDOT (2004b)[a]
Wet Vault	20%	20%	60%	WSDOT (2004b)[a]
Emerging Technology	49%	88%	86%	Filtering Practices (Winer 2000)[b]

[a]This analysis used the minimum pollutant removal efficiencies provided in the Environmental Procedures Manual to represent the removal efficiency for each stormwater pollutant. We determined that Design 3 of the extended detention pond reported in Table 6, Exhibit 431-4B, page 10 of 12, best represented stormwater wetlands. We used Design 4, Wet Ponds, from this same table to represent wet vault percent removal efficiencies.
[b]The *National Pollutant Performance Database for Stormwater Treatment Practices* presented BMP removal efficiencies as medians plus or minus 1 standard deviation. We chose to use these median percent removal efficiencies in this analysis.

Exhibit 29. **Pollutant Loads to the Seattle Project Area Surface Water Bodies**

	Mean Pollutant Loads per Rain Event (pounds/event)			Annual Pollutant Loads (pounds/year)		
Basins	**Copper**	**Zinc**	**TSS**	**Copper**	**Zinc**	**TSS**
No Build Alternative – Continued Operation Scenario (No Stormwater Treatment)						
Lake Union	0.007	0.042	30.7	0.620	3.663	2660.0
Portage Bay West	0.005	0.029	21.2	0.429	2.536	1841.5
Portage Bay East	0.008	0.044	32.3	0.652	3.851	2796.4
Union Bay 1	0.014	0.083	60.6	1.224	7.232	5251.8
Union Bay 2	0.005	0.031	22.8	0.461	2.724	1977.9
4-Lane Alternative (BMP Removal Efficiencies Applied)						
Lake Union	0.004	0.006	4.7	0.349	0.485	410.6
Portage Bay West	0.006	0.033	12.0	0.483	2.855	1036.7
Portage Bay East	0.005	0.032	11.5	0.464	2.743	995.8
Union Bay 1	0.008	0.048	17.5	0.706	4.170	1514.2
Union Bay 2	0.002	0.014	5.2	0.210	1.240	450.2
6-Lane Alternative (BMP Removal Efficiencies Applied)						
Lake Union	0.005	0.007	5.7	0.422	0.586	496.5
Portage Bay West[a]	0.005	0.029	10.4	0.420	2.480	900.3
Portage Bay East	0.008	0.046	16.5	0.668	3.945	1432.3
Union Bay 1	0.012	0.069	25.2	1.017	6.011	2182.6
Union Bay 2	0.002	0.015	5.3	0.216	1.277	463.8

Note: Blue shading indicates pollutant loads are same or less than No Build Alternative.

[a] Estimated pollutant loadings for Portage Bay West are smaller than the 4-Lane Alternative because of the landscaped lids included in the 6-Lane Alternative design. These landscaped lids are not considered pollutant-generating.

Pollutant removal efficiencies were taken from WSDOT's Environmental Procedures Manual (WSDOT 2004b) for the stormwater treatment wetland and wet vault BMPs that would be constructed in the Seattle and Eastside areas of the project (Exhibit 28). Because the Environmental Procedures Manual does not provide pollutant removal efficiencies for emerging technologies, the water resource discipline team used removal efficiencies for the types of BMPs reported in EPA's *National Pollutant Performance Database for Stormwater Treatment Practices* (Winer 2000). These values were used to calculate pollutant mass loading in the Eastside project area, where emerging technology BMPs are proposed (Exhibit 28).

The 4-Lane Alternative would increase the area of PGIS in the Seattle project area. Because the project would implement water quality BMPs to treat and remove pollutants, however, net pollutant loads to receiving water bodies would be reduced compared to existing conditions, except in Portage Bay west where loading of copper and zinc under the 4-Lane Alternative would increase by 13 percent compared to the No Build Alternative (Exhibit 29). The discharge of TSS under the 4-Lane Alternative would decrease to all Seattle water resources that receive project area stormwater. Exhibit 22 shows the demarcation of the areas listed in Exhibit 29, as well as the location and type of BMPs proposed for the entire project area.

6-Lane Alternative

The stormwater treatment system proposed under the 6-Lane Alternative would decrease pollutant loading to Lake Union, Portage Bay west, and Union Bay compared to the No Build Alternative (Exhibit 29). Loading of copper and zinc to Portage Bay east under the 6-Lane Alternative would increase by approximately 2 percent compared to the No Build Alternative. Stormwater discharges to parts of Portage Bay and Union Bay would receive enhanced treatment, which would be a higher level of treatment than is required by the HRM.

The effects of the 6-Lane Alternative on surface water would be similar to the 4-Lane Alternative (CH2M HILL et al. 2002, 2003). The main difference is that the 6-Lane Alternative would create more PGIS than the 4-Lane Alternative because the highway would include two additional lanes. While the volume of stormwater and the mass of pollutants would differ between the 4-Lane and 6-Lane Alternatives, the treated stormwater is presumed to comply with the water quality regulations according to WSDOT's HRM (WSDOT 2004a). Also, it is likely that the pollutant loading estimates for the 6-Lane Alternative are overstated because of the estimating method we used.

The 6-Lane Alternative would increase the total amount of impervious surface by 12.9 acres, and the individual basins as follows:

- 1.3 acres in the Lake Union basin
- –1.7 acres in the west part of the Portage Bay basin
- 6.3 acres in the east part of the Portage Bay basin
- 6.6 acres in the west part of the Union Bay basin
- 0.4 acre in the east part of the Union Bay basin

The amount of impervious surface in the west part of the Portage Bay basin would decrease by 1.7 acres from existing conditions because of the landscaped lids that would cover part of the existing and expanded SR 520 roadway in this area. The landscaped portion of the lids would not be a PGIS and therefore would not contribute polluted stormwater to the basin.

Automobile traffic under the 6-Lane Alternative would load more pollutants annually to the Seattle project area than the 4-Lane Alternative, according to the FHWA method contained in the Environmental Procedures Manual (Exhibit 29). The exception to this pattern would be Portage Bay west, where the 6-Lane Alternative would load 13 percent less copper, zinc, and TSS than the 4-Lane Alternative.

4-Lane and 6-Lane Alternatives Best Management Practice Treatments

Exhibit 30 identifies BMPs proposed for SR 520 in the Seattle project area and compares the proposed BMPs with the treatment requirements of the HRM. (Note that flow control is not required by the HRM in the Seattle project area.)

The 6-Lane Alternative would use the same combinations of BMPs described for the 4-Lane Alternative, though they would be larger to handle the increased stormwater volume and would in some instances be in slightly different locations. These BMPs are described in detail in the preceding section and are shown in Exhibit 22.

Exhibit 30. Proposed Best Management Practices in the Seattle Project Area

Location	Proposed BMP	Minimum Level of Treatment Required per HRM	Level of Treatment Proposed
Lake Union	Emerging technology BMP (these BMPs are selected from a list of options presented in the HRM)	Basic	Basic
Portage Bay	Water quality wet vault	Basic	Basic
	Treatment wetland - Montlake eastbound off-ramp	Basic	Enhanced
Union Bay[a]	Combination of high efficiency sweeping, modified catch basins, treatment wetlands, and bridge column wetlands	Basic	Enhanced

[a] Includes the west portion of Lake Washington.

Lake Washington

No Build Alternative

Under the Continued Operation Scenario, stormwater discharged to Lake Washington from the floating portion of the Evergreen Point Bridge would continue to be untreated. Future increases in traffic levels at the existing bridge mid-span between 2002 and 2030 could also increase pollutant loading of copper and zinc, which is not represented in the FHWA model results. Surface water effects from stormwater runoff would be the same as existing conditions. Water resources would be affected by untreated stormwater, and pollutant loading could increase due to higher traffic volumes.

Under the Catastrophic Failure Scenario, loss of the Evergreen Point Bridge would eliminate traffic crossing Lake Washington. Pollutant loading would decrease because vehicles would no longer be able to use the bridges. Pollutant loading would presumably shift to other parts of the highway system—I-90, I-5, SR 522, and I-405.

4-Lane and 6-Lane Alternatives

Under the 4-Lane Alternative, pollutant loading to stormwater would either remain the same as the 2002 levels or would decrease slightly at the minimum removal efficiency for the proposed BMPs. Under the 6-Lane Alternative, pollutant loading to stormwater would remain the same as the 2002 levels, with the same assumed removal efficiency.

Water quality criteria would be met for both the 4-Lane and 6-Lane Alternatives.[2]

Exhibit 31 identifies proposed BMPs for the Evergreen Point Bridge and compares them with treatment requirements in the HRM. Flow control is not required for discharges to Lake Washington according to HRM guidelines.

Exhibit 31. Proposed Best Management Practices for the Evergreen Point Bridge

Location	Proposed BMPs	Minimum Level of Treatment Required per HRM	Level of Treatment Proposed
Lake Washington (Evergreen Point Bridge)	Combination of high efficiency sweeping, modified catch basins, and spill containment lagoons	Basic	Enhanced

This system would remove many pollutants deposited on the bridge surface (from automobile brake dust and tire rubber particles) before they are transported in the stormwater to Lake Washington.

The water resources discipline team estimated the level of pollutant loading to the existing bridge as of 2002 and how much pollutant loading would occur if either the 4-Lane or 6-Lane Alternative were built. We calculated the mean event and annual pollutant loading of TSS, oil/grease, cadmium, copper, lead, and zinc without BMP application for equivalent bridge sections (420 feet long) by their different widths using the same FHWA method as discussed above for the Seattle project area (CH2M HILL et al. 2002) (Exhibit 32).

We then calculated pollutant loading to Lake Washington for existing conditions and each build alternative by (1) determining the removal efficiencies achieved for specific BMPs proposed for the 4-Lane and 6-Lane Alternatives, and (2) multiplying roadway-specific removal efficiencies and the estimated pollutant loading to each bridge configuration (CH2M HILL et al. 2002) (Exhibit 32).

[2] For the 6-Lane Alternative, chronic water quality criteria would be met at the same boundary as required for the acute (10-foot) mixing zone.

Exhibit 32. Comparison of Estimated Pollutant Loading Rates[a] for the Floating Portion of the Evergreen Point Bridge (Equivalent Bridge Section Lengths)

	TSS	Oil/Grease	Cadmium	Copper	Lead	Zinc
Annual Mass Loading Without BMP Applied (pounds/year)						
Existing and No Build	172.8	17.3	0.01	0.04	0.04	0.24
4-Lane Alternative	252.5	25.3	0.01	0.06	0.06	0.35
6-Lane Alternative	398.7	40.0	0.02	0.09	0.09	0.55
Removal Efficiencies Applied (Average in Efficiency Range) (percent)						
Existing and No Build[b]	44.5	37.5	40.0	26.5	40.0	26.5
4-Lane Alternative [c]	82.0	57.5	77.5	65.5	77.5	63.0
6-Lane Alternative [c]	82.0	57.5	77.5	65.5	77.5	63.0
Annual Mass Loading With Removal Efficiencies Applied (pounds/year)						
Existing Conditions	95.9	10.8	0.010	0.03	0.02	0.17
4-Lane Alternative	45.5	10.8	0.003	0.02	0.01	0.13
6-Lane Alternative	71.8	17.0	0.005	0.03	0.02	0.20

Source: CH2M HILL et al. (2002).
Note: Blue shading indicates pollutant loads are same or less than No Build Alternative.

[a] Calculations are based on the dimensions of the existing and proposed bridges (420 feet of bridge length by the width of the proposed alternative).
[b] BMP maintenance on the existing Evergreen Point Bridge is conventional sweeping that is done on a bimonthly basis.
[c] Efficiencies applied to proposed alternatives are average composite efficiencies from high-efficiency sweeping plus Modified Catch Basin/Cleaning.

From these calculations, the water resources discipline team determined that the proposed BMPs for the 4-Lane Alternative would not increase the amount of pollutants discharged to Lake Washington compared to existing 2002 conditions. This would represent an improvement over 2030 discharges under the Continued Operation Scenario (CH2M HILL et al. 2002). The same improvement would occur for the 6-Lane Alternative, except that oil/grease pollutant loading rate would increase by 57 percent compared to 2002 conditions and zinc would increase by 18 percent). The spill control feature of the spill containment lagoons would be an effective BMP that would prevent oil and grease from being discharged to Lake Washington. Proposed periodic maintenance would remove any material, such as oil and trash, trapped in the spill control lagoons by vactoring.

Vactoring is vacuuming stormwater and associated solids into a tank located on a truck for transport and disposal.

The AKART dilution modeling (CH2M HILL et al. 2002) predicted the amount of dilution that would be achieved at 10 feet from the lagoon interface with the lake and at the 100-foot mixing zone boundary for each alternative (Exhibit 33). This analysis modeled the dilutions for three rainfall/runoff scenarios—a low volume storm (10 percent of the design storm volume), a mean annual storm (50 percent of the design storm volume), and the 6-month, 24-hour design storm (CH2M HILL et al. 2002) (Exhibit 33). Overall, the smaller the storm volume generated, the greater the dilution achieved at the 10-foot and 100-foot distances from the lagoon/lake interface. The 4-Lane Alternative achieved greater levels of dilution than the 6-Lane Alternative for the different storms at the same distances (Exhibit 33).

These dilutions were then applied to the estimated mean event pollutant loads produced by the range of BMP removal efficiencies to calculate the concentrations of total metals (the sum of the dissolved and sediment bound forms of each metal present in stormwater). Using the dilution levels achieved for the 6-Lane

Exhibit 33. Summary of Stormwater Discharge Dilution Modeling Results for the Floating Portion of the Evergreen Point Bridge

	Rainfall/Runoff Scenario					
	Low Volume Storm[a]		Mean Annual Storm[b]		Design Storm	
Alternatives	**4-Lane**	**6-Lane**	**4-Lane**	**6-Lane**	**4-Lane**	**6-Lane**
Dilution at the Lagoon Interface with Lake Washington (10 feet)	474:1	292:1	95:1	58:1	47:1	29:1
Dilution at the Mixing Zone Boundary (100 feet)	1,895:1	1,166:1	379:1	233:1	189:1	117:1

Source: CH2M HILL et al. (2002).

[a] 10 percent of design storm volume.
[b] 50 percent of design storm volume.

Alternative (Exhibit 34), total metal concentrations in micrograms per liter (µg/L) for three removal efficiency scenarios (minimum, average, and maximum) were conservatively estimated in:

- The spill containment lagoon
- At 10 feet from the lagoon/lake interface
- At 100 feet from the lagoon/lake interface

These concentrations were compared to acute and chronic Washington state water quality criteria for dissolved cadmium, copper, lead, and zinc (WAC 173-201-320), and EPA’s 2001 proposed criterion for dissolved cadmium. Comparing total metal concentrations to dissolved criteria is conservatively protective of the environment because it overestimates the amount of dissolved metals present. Nonetheless, none of the estimated total metal concentrations exceeded either the relevant acute or chronic criteria at the 10-foot mixing zone boundary (Exhibit 34). No total metal concentrations exceeded the acute or chronic criteria in the spill control lagoon, assuming maximum removal efficiencies, and only cadmium and lead exceeded their chronic criteria in the spill control lagoon, assuming minimum removal efficiencies (Exhibit 34). The total metals concentrations discharged from the 4-Lane Alternative floating bridge at each of the selected locations would be even lower than the 6-Lane Alternative due to the greater level of dilution achieved in the 4-Lane Alternative spill control lagoon.

Acute Water Quality Standard
Pollutant concentrations that protect aquatic organisms from severe and rapid effects, such as mortality.

Chronic Water Quality Standard
Concentrations that protect aquatic organisms from chronic effects that occur over a long period of time, such as mortality, reduced growth, reproduction impairment, harmful changes in behavior, and other nonlethal effects.

Eastside

No Build Alternative

Under the Continued Operation Scenario, stormwater collected from SR 520 within the Eastside project area would continue to be discharged to streams with no treatment or flow control. Compared to existing levels, the higher traffic volumes would occur between 108th Avenue Northeast and I-405 between now and 2030, which could increase pollutant loading (e.g., copper and zinc from automobile tires and brakes) to project corridor pavement.

Under the Catastrophic Failure Scenario, loss of the Evergreen Point Bridge would eliminate much of the automobile traffic and associated pollutant loading onto pavement because only local traffic would use the Eastside roadway between Lake Washington and I-405.

4-Lane Alternative

The 4-Lane Alternative would increase impervious surfaces in the Fairweather Creek, Cozy Cove Creek, Yarrow Bay wetland, and Yarrow Creek Basins from between 0.4 and 2.1 percent (Exhibit 35). No roadway improvements are proposed for the 4-Lane Alternative in the Kelsey Creek Basin, so changes to the stormwater system in that basin are not proposed under this alternative.

Stormwater discharges to Eastside basins under the 4-Lane Alternative would comply with water quality regulations, according to WSDOT's HRM (WSDOT 2004a). Overall, the proposed stormwater treatment system for the 4-Lane Alternative would reduce pollutant loading to Eastside streams compared to the No Build Alternative (Exhibit 36). In

Exhibit 34. **Effluent Pollutant Concentrations for Total Metals at Selected Locations under the 6-Lane Alternative**[a]

	Direction of Dilution			
	At Discharge Pipe to Spill Control Lagoon	**In Spill Control Lagoon**	**At 10-foot Mixing Zone Boundary**[b]	**At 100-foot Mixing Zone Boundary**[a]
Total Metal Concentration (µg/L) (Minimum Removal Efficiency Applied)				
Cadmium (Washington State Criterion)	2.3	0.2	0.1	0.02
Cadmium (2001 EPA Proposed Criterion)	2.3	0.2	0.1	0
Copper	11.8	1	0.4	0.1
Lead	7.9	0.7	0.3	0.1
Zinc	71.4	5.9	2.5	0.6
Total Metal Concentration (µg/L) (Average Removal Efficiency Applied)				
Cadmium (Washington State Criterion)	1.8	0.2	0.1	0
Cadmium (2001 EPA Proposed Criterion)	1.8	0.2	0.1	0
Copper	9.3	0.8	0.3	0.1
Lead	5.6	0.5	0.2	0
Zinc	55.2	4.6	1.9	0.5
Total Metal Concentration (µg/L) (Maximum Removal Efficiency Applied)				
Cadmium (Washington State Criterion)	1.4	0.1	0	0
Cadmium (2001 EPA Proposed Criterion)	1.4	0.1	0	0
Copper	6.7	0.6	0.2	0.1
Lead	3.3	0.3	0.1	0
Zinc	38.9	3.2	1.3	0.3

Water Quality Criteria for Dissolved Metals (at Critical Receiving Water Condition)					
		Dissolved Metal Concentration (µg/L)			
		Cadmium	**Copper**	**Lead**	**Zinc**
Washington Water Quality Standards (Present Criteria)	Acute	1.58	6.10	16.40	49.90
	Chronic	1.14	4.46	0.64	41.60
EPA Revised Standards (Future Criteria); applies only to cadmium	Acute	0.83	–	–	–
	Chronic	0.13	–	–	–

[a] Reproduced from CH2M HILL et al. (2002).
[b] Dilution assumes 6-Lane Alternative bridge conditions during water quality treatment storm event, where all stormwater is conveyed to the spill lagoons. The dilution factor is 12 in the spill control lagoon, 29 at the acute zone boundary, and 117 at the mixing zone boundary.

Coding

X.X (dark blue)	Total metal concentration exceeds acute and chronic dissolved water quality criteria
X.X (light blue)	Total metal concentration below acute dissolved water quality criteria, but exceeds chronic criteria
X.X	Total metal concentration below acute and chronic dissolved water quality criteria

Exhibit 35. Proposed Changes in Impervious Surface in the Eastside Basins Associated with the 4-Lane Alternative

Basin	Total Basin (acre)	Current Basin Impervious Surface (acre)	Impervious Surface Added by 4-Lane Alternative (acre)	Future Basin Impervious Surface (acre)	Current Impervious Surface (percent)	Future Impervious Surface (percent)	Increase in Basin Impervious Surface (percent)
Fairweather Creek	538.9	162.8	2.3	165.1	30.2%	30.6%	0.4%
Cozy Cove Creek	176.4	52.5	3.7	56.2	29.8%	31.9%	2.1%
Yarrow Bay Wetland	134.5	35.9	1.2	37.1	26.7%	27.6%	0.9%
Yarrow Creek	1666.2	446.0	2.3	448.3	26.8%	26.9%	0.1%

Exhibit 36. Pollutant Loading to Surface Water Bodies in the Eastside Project Area

Basins	Mean Pollutant Mass Loading per Rain Event (pounds/event)			Annual Mass Loading (pounds/year)		
	Copper	Zinc	TSS	Copper	Zinc	TSS
No Build Alternative – Continued Operation Scenario (No Stormwater Treatment)						
Fairweather Bay West	0.009	0.052	37.8	0.763	4.508	3273.8
Fairweather Bay East	0.009	0.054	39.3	0.795	4.696	3410.3
Cozy Cove	0.011	0.066	48.0	0.970	5.730	4160.5
Yarrow Bay Wetland	0.004	0.025	18.1	0.366	2.160	1568.7
Yarrow Creek	0.008	0.047	33.8	0.683	4.039	2932.8
West Tributary of Kelsey Creek	0.003	0.015	11.0	0.223	1.315	954.9
4-Lane Alternative (BMP Removal Efficiencies Applied)						
Fairweather Bay West	0.010	0.056	20.5	0.827	4.884	1773.3
Fairweather Bay East	0.007	0.009	8.0	0.592	0.823	697.1
Cozy Cove	0.009	0.013	10.8	0.794	1.105	935.8
Yarrow Creek – Wetland	0.003	0.005	3.9	0.284	0.394	334.2
Yarrow Creek	0.005	0.029	10.4	0.420	2.480	900.3
6-Lane Alternative (BMP Removal Efficiencies Applied)						
Fairweather Bay West	0.015	0.087	31.5	1.272	7.514	2728.2
Fairweather Bay East	0.007	0.009	7.7	0.567	0.789	668.4
Cozy Cove	0.009	0.013	11.0	0.811	1.127	954.9
Yarrow Creek – Wetland	0.004	0.006	4.8	0.357	0.496	420.1
Yarrow Creek	0.013	0.077	28.0	1.132	6.688	2428.1
West Tributary of Kelsey Creek	0.002	0.014	5.0	0.203	1.202	436.5

Note: Blue shading indicates pollutant leads are same or less than No Build Alternative.

contrast to this general pattern of reduction for the 4-Lane Alternative, pollutant loading to Fairweather Bay west would increase 8 percent (Exhibit 36).

6-Lane Alternative

Stormwater discharges to Eastside basins under the 6-Lane Alternative are presumed to comply with water quality regulations in accordance with HRM requirements (WSDOT 2004a). The 6-Lane Alternative would also have more impervious surface than the 4-Lane Alternative (Exhibit 37). As a result, pollutant loads under the 6-Lane Alternative are expected to be higher than those generated by the 4-Lane Alternative (Exhibit 36); however, stormwater discharges from the 6-Lane Alternative would meet water quality regulations. The proposed stormwater treatment system under the 6-Lane Alternative would reduce pollutant loading to Fairweather Bay east, Cozy Cove, Yarrow Bay wetland, and the West Tributary of Kelsey Creek, compared to the No Build Alternative (Exhibit 36). The 6-Lane Alternative would increase pollutant loading to Fairweather Bay west and Yarrow Creek compared to the No Build Alternative (Exhibit 36).

Exhibit 37. Proposed Changes in Impervious Surface in the Eastside Basins Associated with the 6-Lane Alternative

Basin	Total Basin (acre)	Current Basin Impervious Surface (acre)	Impervious Surface Added by 6-Lane Alternative (acre)	Future Basin Impervious Surface (acre)	Current Impervious Surface (percent)	Future Impervious Surface (percent)	Increase in Basin Impervious Surface (percent)
Fairweather Creek	538.9	162.8	1.4	164.2	30.2%	30.5%	0.3%
Cozy Cove Creek	176.4	52.5	3.3	55.8	29.8%	31.7%	1.9%
Yarrow Bay Wetland	134.5	35.9	1.9	37.8	26.7%	28.1%	1.4%
Yarrow Creek	1,666.2	446.0	7.9	453.9	26.8%	27.2%	0.5%
West Tributary of Kelsey Creek	1,001.9	416.7	0.2	416.9	41.59%	41.61%	0.02%

4-Lane and 6-Lane Alternatives Best Management Practices and Flow Control Approaches

Enhanced water quality treatment and flow control are required by the HRM for the streams located on the Eastside. Only discharges to Fairweather Bay (a part of Lake Washington) and Yarrow Bay wetland are exempt from flow control. The BMPs selected for the Eastside project area are shown in Exhibit 22 and described below in Exhibit 38.

Exhibit 38. Highway Runoff Manual Requirements and Proposed Best Management Practices in the Eastside Project Area

Location	Proposed BMP	Minimum Level of Treatment Required per HRM	Flow Control
Fairweather Bay West	Water quality wet vault	Basic	None required
Fairweather Bay East	Water quality wet vault, with enhanced treatment and flow control	Enhanced	Provided
Cozy Cove	Wet vault with flow control	Enhanced	Provided
Yarrow Bay Wetland	Stormwater treatment wetland without flow control	Enhanced	None
Yarrow Creek West	Water quality wet vault with enhanced treatment and flow control	Enhanced	Provided

The flow control (detention) requirement for the Eastside project area is identified in the HRM as the Western Washington standard. This standard specifies that the durations of post-development flow will be maintained at the predevelopment durations for flows between 50 percent of the 2-year flow and the 50-year flow.

Detailed detention facility designs are expected to be created with software based on the HSPF model that uses location-specific, long-term rainfall records. Consistent with the HRM, estimates of detention volume required in the design and siting of flow control facilities assumed that runoff from new pavement in the project corridor would be detained using existing conditions for predevelopment conditions along the SR 520 corridor—specifically, second-growth forest and grass.

How would project construction temporarily affect surface water bodies?

We evaluated temporary construction effects on surface water bodies by determining construction actions that may disturb soil and in-water sediments and by evaluating the potential for accidental spills of hazardous materials.

What construction activities could affect water resources in Portage Bay, Union Bay, and Lake Washington?

Construction of the Portage Bay Bridge would require building temporary 30-foot-wide work bridges to the north and south of the existing bridge for both the 4-Lane and 6-Lane Alternatives. Construction of the Evergreen Point Bridge would require building a 60-foot-wide temporary detour bridge south of the existing west approach to the Evergreen Point Bridge.

Rows of steel or untreated wood piles (18- to 24-inch diameter) spaced at 30-foot intervals would support the temporary bridge. Up to 450 temporary steel piles would be placed in Portage Bay. Between 1,110 to 1,600 temporary piles would be placed in the area of the west approach to the Evergreen Point Bridge. All piles would be removed along with the temporary bridges upon completion of project construction.

Concrete bridge support columns for the new permanent bridges would be constructed by the drilled shaft method. Steel cylinders would be inserted and sediment excavated from within the cylinder to provide a space for the cast-in-place concrete support column. The steel cylinder would prevent the release of excavated sediment during construction. Water pumped from inside the cylinder would be treated prior to discharge to Lake Washington or Portage Bay, preventing degradation of water quality that could affect fish.

Construction of the bridges would involve transporting large girders, pontoons, and other materials by barge through the Ship Canal and into Lake Washington. Work vessels would also move through the same area. These vessels would operate for prolonged periods in the shallow water along the bridge alignment in Portage Bay and possibly also in Union Bay. Work vessels would also operate for prolonged periods along the floating portion of the Evergreen Point Bridge to place anchors and pontoons.

Seattle

Potential effects on surface water bodies from constructing the 4-Lane and 6-Lane Alternatives in the Seattle project area would be related to:

- The installation, use, and removal of the work bridges for construction of the Portage Bay Bridge, as well as the demolition of the existing Portage Bay Bridge

- Installation, use, and removal of the temporary detour bridge to allow construction of the new Evergreen Point Bridge's west approach from the existing bridge, as well as demolition of the existing bridge

- Demolition of the existing Lake Washington and R.H. Thompson Expressway Ramps and construction of new Lake Washington Boulevard ramps

These effects would be avoided, minimized, and mitigated through the development and implementation of temporary erosion and sediment control (TESC) and spill prevention control and countermeasures (SPCC) plans (WSDOT 2004a). A TESC plan would detail the risk of erosion in different parts of the project area and would specify BMPs to be installed prior to construction activities. The SPCC plan would be prepared by the contractor(s) selected to complete the final design of the project, as required by WSDOT Standard Specification 1-07.15(1) (WSDOT 2004a). Each of these plans would include performance standards based on state regulations, such as turbidity and TSS levels in stormwater discharged from construction staging and work areas. Construction of either the 4-Lane or 6-Lane Alternative would require compliance with approved TESC and SPCC plans that would be based on these performance standards.

Lake Washington

For the 4-Lane and 6-Lane Alternatives, the potential construction effects in Lake Washington would involve installing the pontoons for the floating portion of the Evergreen Point Bridge. The bridge pontoons would be held in place by attaching anchor cables to either large concrete blocks or 35- to 40-foot fluke anchors. All anchors and blocks would be located at a depth of 35 feet or deeper in the lake. Installation of these anchors would likely displace sediment suspended in the water column. Potential effects from displacing sediment would be:

- Increased mortality of benthic invertebrate organisms living in the excavated sediment as they are displaced during anchor placement or covered when disturbed sediments redeposit

- Decreased light levels resulting from increased turbidity, leading to reduced phytoplankton productivity

- Chronic or acute effects on fish and water column invertebrates from increased TSS

In the short term, some benthic organisms living in the sediments where the anchors would be placed could die from:

- The impact of high-pressure jets of water that would be used to excavate the sediment
- Suffocation, which could occur when the sediments are displaced; some sediment-dwelling organisms could die if they were covered by redeposited sediments
- Predation, which could occur when the organisms are displaced from the sediment and become susceptible to predators

Over the long term, placement of the anchors likely would not have a detectable effect on the lake bottom benthic community. The small area that would be excavated relative to the entire lake bottom and the rapid rates of recruitment by these organisms from the water column would help ensure that the excavated areas are recolonized quickly.

Benthic organisms living in the sediments next to where the anchors would be placed could experience increased mortality from being covered by redeposited sediments. As with the displaced invertebrates, this is not likely to have a detectable effect on the lake bottom benthic community over the long term. The overall small area that would be covered by redeposited sediment and the rapid rates of recruitment by these organisms from the water column would help ensure that these covered areas are quickly recolonized.

Increased turbidity and TSS could affect water quality by (1) absorbing and scattering light and (2) interfering with oxygen exchange of fish and invertebrates by clogging and damaging their gills. Because of the limited currents in the depths where the anchors would be placed (from 35 to 190 feet below the lake surface), very little sediment would actually be transported away from the site; instead, it would quickly settle back to the lake bottom. Deposition of these suspended sediments would probably occur over a period of hours because (1) there are no strong currents to keep them suspended and (2) the sediment itself is likely of sufficient density to precipitate quickly. [3]

[3] Small-grained particles, such as clays, are more easily suspended and stay in suspension longer than larger-grained particles. Since these displaced particles come from the lake bottom (meaning they have already precipitated into lake sediments), they are more likely to have larger grains and higher densities that would redeposit quickly.

It is unlikely that turbidity would increase in the photic zone (the area of the lake or water body where there is enough light for photosynthesis to take place), and therefore turbidity from project construction would not adversely affect plant photosynthesis or lake productivity. Similarly, water column concentrations in these same upper layers of the lake would be unlikely to reach concentrations that would adversely affect fish (1,000 mg/L for 24 hour [Parametrix 1997]) in this same zone.

Eastside

Under the 4-Lane and 6-Lane Alternatives, the east approach to the Evergreen Point Bridge would likely be installed from falsework and from barges. Specific provisions for the installation and removal of the falsework and removal of the columns supporting the existing SR 520 structures would be designed around the same performance standards discussed for the TESC and SPCC plans. Activities conducted on the working barges during construction of the 4-Lane and 6-Lane Alternatives would be addressed through the TESC and SPCC plans. Similarly, compliance with the provisions of these approved plans would comply with state and federal regulations.

4-Lane Alternative

Construction of culvert extensions and replacements, retaining walls, and stormwater facility discharges would introduce fine sediments into Eastside streams, primarily through erosion and runoff processes. Fine sediments can negatively alter water quality. The potential for erosion and sedimentation would be highest where construction activities would take place in or directly adjacent to streams. Within the Eastside project area, these include areas where streams cross or flow adjacent to SR 520, areas where construction work would take place in-water (below the ordinary high water mark), or areas adjacent to or above waterbodies.

The potential sedimentation effects would be minimized by:

- **Avoidance—**The 4-Lane Alternative would use retaining walls to minimize effects on streams, wetlands, and other critical areas. Except where absolutely necessary, construction equipment would not enter below the ordinary high water mark of Eastside streams. Staging and stockpiling areas would be located well away from streams and lakes.

- **Construction Methods**—Streams would be dewatered before culvert replacement or lengthening work. All conditions of the Washington Department of Fish and Wildlife Hydraulic Project Approval (HPA) permits, including timing restrictions, would be strictly adhered to.
- **Prevention—**Appropriate BMPs (as outlined in Appendix E, *Ecosystems Discipline Report, Fish Resources Mitigation*) would reduce the risk of erosion and reduce or minimize the chance of sediments entering project waters. Erosion and sediment control measures could include mulching, matting, and netting; filter fabric fencing; quarry rock entrance mats; sediment traps and ponds; surface water interceptor swales and ditches; and the placement of construction material stockpiles away from streams. In addition, a TESC plan would be prepared and implemented. Erosion and sediment control BMPs would be properly implemented, monitored, and maintained during construction, so no long-term water quality effects would occur. Even with BMPs, some temporary short-term water quality effects from sediment (such as increases in stream turbidity) are possible, particularly during large storms. However, the magnitude of these effects would be small and not likely to cause harm to individual fish that may be in the project area.

Other potential short-term construction effects could include spilling hazardous materials (for example, oil and gasoline), chemical contaminants, nutrients, or other material into project area waters. Control of hazardous materials is a standard provision in construction contracts and permits, and would be addressed with BMPs. Servicing and refueling of vehicles would not occur within 100 feet of streams and wetlands to reduce potential spills of petroleum and hydraulic fluids in sensitive areas. The contractor would be required to submit an SPCC plan before beginning work.

6-Lane Alternative

The construction effects of the 6-Lane Alternative on Eastside streams crossed by SR 520 would be the same as the 4-Lane Alternative. The difference between these alternatives would be the magnitude and locations of the potential effects.

The 6-Lane Alternative would affect more lineal feet of stream and require a higher number of culvert replacements than the 4-Lane Alternative (see Appendix E, *Ecosystems Discipline Report*). Therefore, there could be more effects from downstream sedimentation. This would be minimized by application of the BMPs and conservation measures discussed under the 4-Lane Alternative.

How do the alternatives differ in their effects on surface water bodies?

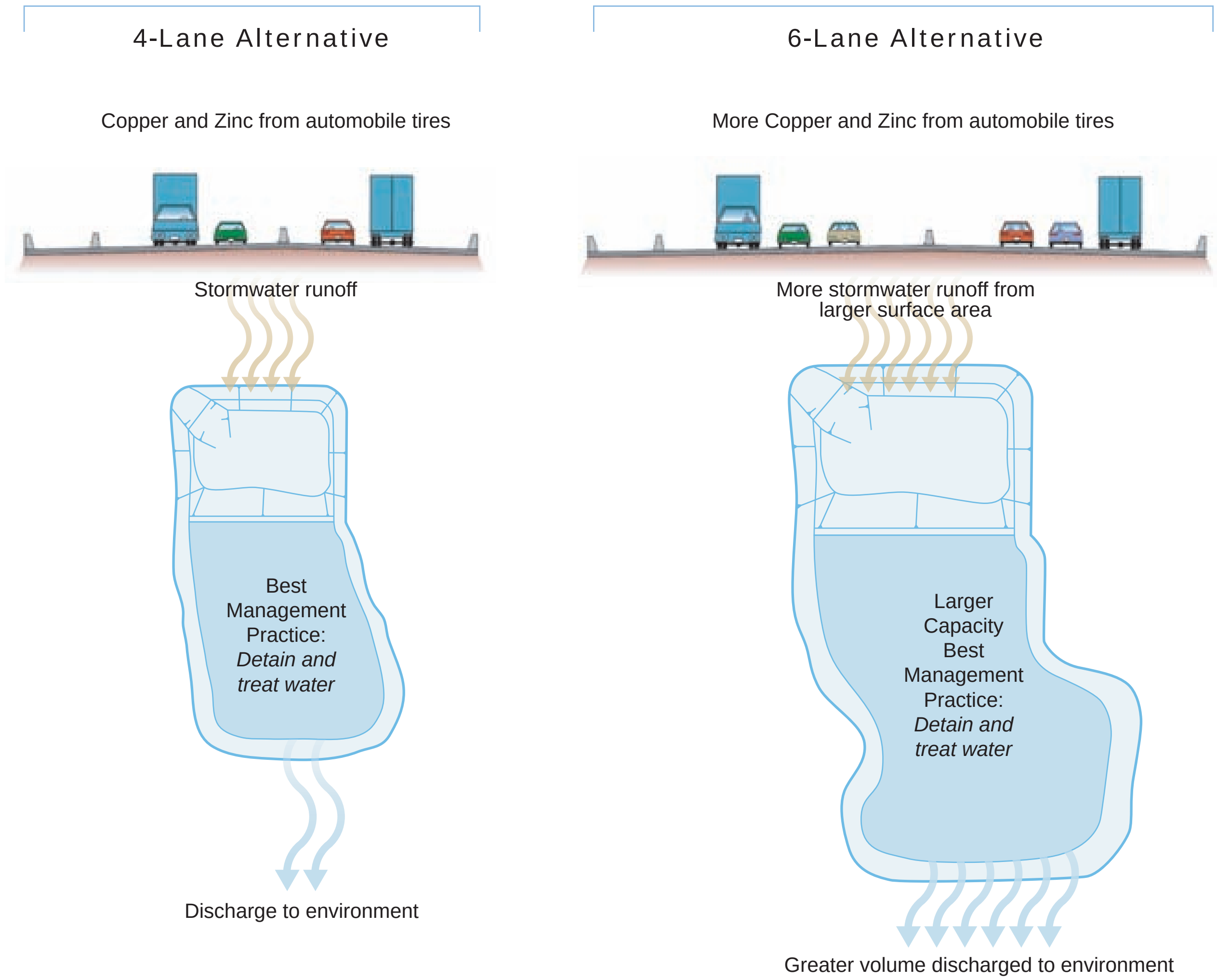
The Continued Operation Scenario of the No Build Alternative would either maintain existing conditions or further degrade surface water bodies. Water quality in the SR 520 corridor would likely improve under the Catastrophic Failure Scenario.

The 4-Lane and 6-Lane Alternatives would increase the area of PGIS in the surface water basins surrounding the project area. However, both alternatives would maintain or generally reduce existing pollutant loading levels in project area surface bodies because stormwater would be treated and flows controlled before they are discharged. Both alternatives would meet state and federal water quality regulations. Also, both alternatives provide more treatment than the HRM requires for stormwater discharging from the Evergreen Point Bridge.

The effects of the 4-Lane and 6-Lane Alternatives would be essentially the same, even though the 6-Lane Alternative traffic would load more pollutants overall (Exhibit 39). The reasons for this are as follows:

- Water quality treatment facilities would be sized to treat the stormwater generated. This means that stormwater treatment and flow control facilities for the 6-Lane Alternative would be larger than the 4-Lane Alternative's facilities. The pollutant removal efficiencies would be the same for both alternatives.
- Both alternatives would meet state and federal water quality regulations.

Construction effects would be similar between the 4-Lane and 6-Lane Alternatives. Both alternatives would require in-water construction for the bridges, anchors, and temporary bridges, so effects would be similar. The primary difference between the two alternatives is that the 6-Lane Alternative would require construction of roadway and a stormwater treatment facility in the West Kelsey Creek Basin and the 4-Lane Alternative would not. The potential effects associated with the construction in the West Kelsey Creek area would be avoided and minimized through the implementation of TESC and SPCC plans.



Both discharges presumed to comply with state and federal regulations as per *Highway Runoff Manual* Presumptive Approach

Exhibit 39. **Schematic Representation of Water Quality Flow Control and Treatment Outcomes for the 4-Lane and 6-Lane Alternatives**

SR 520 Bridge Replacement and HOV Project

Surface Water Mitigation

What has been done to avoid or minimize negative effects to surface water bodies?

Permanent negative effects of the build alternatives would be avoided through the inclusion of the stormwater treatment facilities described in *Treating the Project's Stormwater*. Overall, these facilities would either maintain or reduce current pollutant loading levels to water bodies in the project area.

Negative effects on surface water bodies during construction would be avoided or minimized by implementing water quality pollution control measures outlined in the required TESC and SPCC plans and by following permit conditions.

Potential sedimentation effects on Eastside streams during construction would be minimized by:

- **Avoidance** – Use of retaining walls to minimize effects to streams, wetlands, and other critical areas. Except where absolutely necessary, construction equipment would not enter below the ordinary high water mark of Eastside streams. Staging areas and stockpiling areas would be located well away from streams and lakes.
- **Prevention** – Use of appropriate BMPs to reduce the risk of erosion and reduce or minimize the chance of sediments entering project water bodies. Erosion and sediment control measures could include mulching, matting, and netting; filter fabric fencing; quarry rock entrance mats; sediment traps and ponds; surface water interceptor swales and ditches; and the placement of construction material stockpiles away from streams. In addition, a TESC plan would be prepared and implemented to minimize and control pollution and erosion from stormwater. Erosion and sediment control BMPs would be properly implemented, monitored, and maintained during construction. No long-term water quality effects would be expected, although even with BMPs, some temporary short-term water quality effects for sediment (such as increases in stream turbidity) are possible, particularly during large storm events. However, the magnitude of these effects would be small, and not likely to adversely effect stream water quality.

How could the project compensate for unavoidable negative effects to surface water?

No compensation would be required because negative effects have been avoided or minimized through provision of stormwater treatment facilities as part of the project design. Discharges from the 4-Lane and 6-Lane Alternatives would meet or exceed HRM requirements and water quality regulations.

This Page Intentionally Left Blank

Groundwater

The Clean Water Act establishes the basic structure for regulating pollutant discharges to groundwater. As previously described, EPA has delegated enforcement and implementation of the Clean Water Act to Ecology. Ecology has developed regulations, water quality standards, programs, and guidelines to protect groundwater and allow its use for drinking, irrigation, and manufacturing and commercial uses, as shown in Exhibit 40. Groundwater resources are studied as part of this EIS to determine if drinking water resources would be affected by the project and if the project or construction activities would affect the quantity of groundwater located in the project area.

Exhibit 40. Ecology's Policies and Regulations for Groundwater Management in the Project Area

Agency/ Organization	Policies/Regulations	Role
Ecology	EPA water pollution control regulations (Section 431.02 of the Clean Water Act and corresponding State of Washington regulations)	Establishes the basic structure for regulating discharges of pollutants to groundwater.
	Water Quality Standards for Groundwaters of the State Of Washington (WAC 173-200)	Establishes maximum contaminant concentrations for the protection of a variety of beneficial uses of Washington's groundwater
	Washington Groundwater Management Areas (WAC 173-100)	Establishes procedures to designate groundwater management areas and procedures for developing groundwater management programs to protect groundwater quality.
	Washington Well Head Protection (WAC 246-290)	Establishes the boundaries for each well, well field, or spring with 6-month and 1-, 5-, and 10-year travel times, plans to identify potential contamination of groundwater, and contingency sources of drinking water for users of this water.
	Washington Underground Injection Control Program (WAC 173-218)	Protects groundwater quality by regulating the disposal of fluids into the subsurface.
	Washington water rights regulations (various)	A permitting process to allow applicants to apply water to a specific beneficial use.
Local Cities	Local Critical Aquifer Recharge Area (CARA) ordinances	Provides local governments with a mechanism to classify, designate, and regulate areas deemed necessary to provide adequate recharge and protection for aquifers used as sources of potable (drinking) water.

Affected Environment

What information was collected to identify groundwater resources?

The water resource discipline team obtained information on the following groundwater resources from Ecology, the Washington State Department of Health, the U.S. Geological Survey (USGS), and King County:

- Sole source aquifers
- Critical Aquifer Recharge Areas (CARA)
- Public water supply wells
- Domestic/residential water wells

What is a sole source aquifer?
A sole source aquifer is defined as an aquifer that supplies "at least 50 percent of the drinking water consumed in the area overlying the aquifer. These areas can have no alternative drinking water source(s), which can physically, legally, and economically supply all those who depend upon the aquifer for drinking water" (U.S. EPA 2004c).

What is a Critical Aquifer Recharge Area (CARA)?
A CARA is defined as a geographic area that has a critical recharging effect on aquifer(s) used for drinking water supply (RCW 36.70A.030(5)).

What groundwater resources are located in the project area?

There are several aquifers in the project area, but human use of groundwater from these aquifers is limited. Groundwater resources and their uses are discussed in detail in the following sections.

General Groundwater Information

It is important to first provide a regional perspective on groundwater because of its complex overlapping nature. Groundwater in the project area is contained within aquifers, which are geological units or groups of units that hold and convey water.

Every location within a drainage basin can be designated as either a groundwater recharge or discharge area. This designation depends on the direction that groundwater flows within the aquifer. Near the ground surface of a recharge area, flow is directed underground, while a discharge area will have an upward flow to the surface (Freeze and Cherry 1979). In the Puget Sound basin, most groundwater recharge occurs from precipitation in upland areas—especially where higher permeability soils are present at or near land surface. In general, a large proportion of annual rainfall recharges the Puget Sound regional aquifers (approximately 70 percent [Vaccaro et al. 1998]). However, the extensive conversion of forest cover to residential and commercial land uses that has occurred over the last 100 years in the Seattle area has likely reduced the recharge rates occurring in these developed environments.

When groundwater discharges to the land, it can be a source for springs, wetlands, and creeks. Many rural communities outside the project area may also use the water in aquifers to supply their drinking water.

Aquifers in the Puget Sound Basin located close to the surface are often shallow, making them more susceptible to contamination. Deeper aquifers in the Puget Sound Basin are better protected from contamination by aquitards. Attachment 1 contains a detailed description of the major project area aquifers and their relationships.

Project Area Groundwater Resources

As part of this analysis, we reviewed available information to determine which types of groundwater resources existed in the project area. Exhibit 41 summarizes and provides the sources of this information. This report does not provide any further discussion of resources that were not found in the project area.

Project Area Groundwater Use

The use of groundwater as a drinking water supply within the project area is limited. Seattle Public Utilities supplies most of the drinking water in the project area from three primary sources—Chester Morse Reservoir, South Fork Tolt Reservoir, and the Highline Well Field (located in the Renton area). There is one community public water supply well in Bellevue (Exhibit 42; Johnson pers. comm. 2002). This well, the Sorem Group B well, is more than 500 feet away from SR 520 in Clyde Hill. The well has been in use since at least 1970 and currently serves four connections. The well is 50 feet deep and has a pumping capacity of 5 gallons per minute (gpm) (Johnson pers. comm. 2004; DOH 2004).

Group A public water supply wells provide drinking water to 15 or more connections (such as households).

Group B public water supply wells provide drinking water to 14 or fewer connections.

There are 23 water wells of record listed in the area 1 mile north and south of SR 520. The current condition, uses, or continued existence of these wells are unknown. Because they are generally located in areas supplied by municipal water, if these wells still exist, they are most likely not used for drinking water supply.

Project Area Groundwater Aquifers

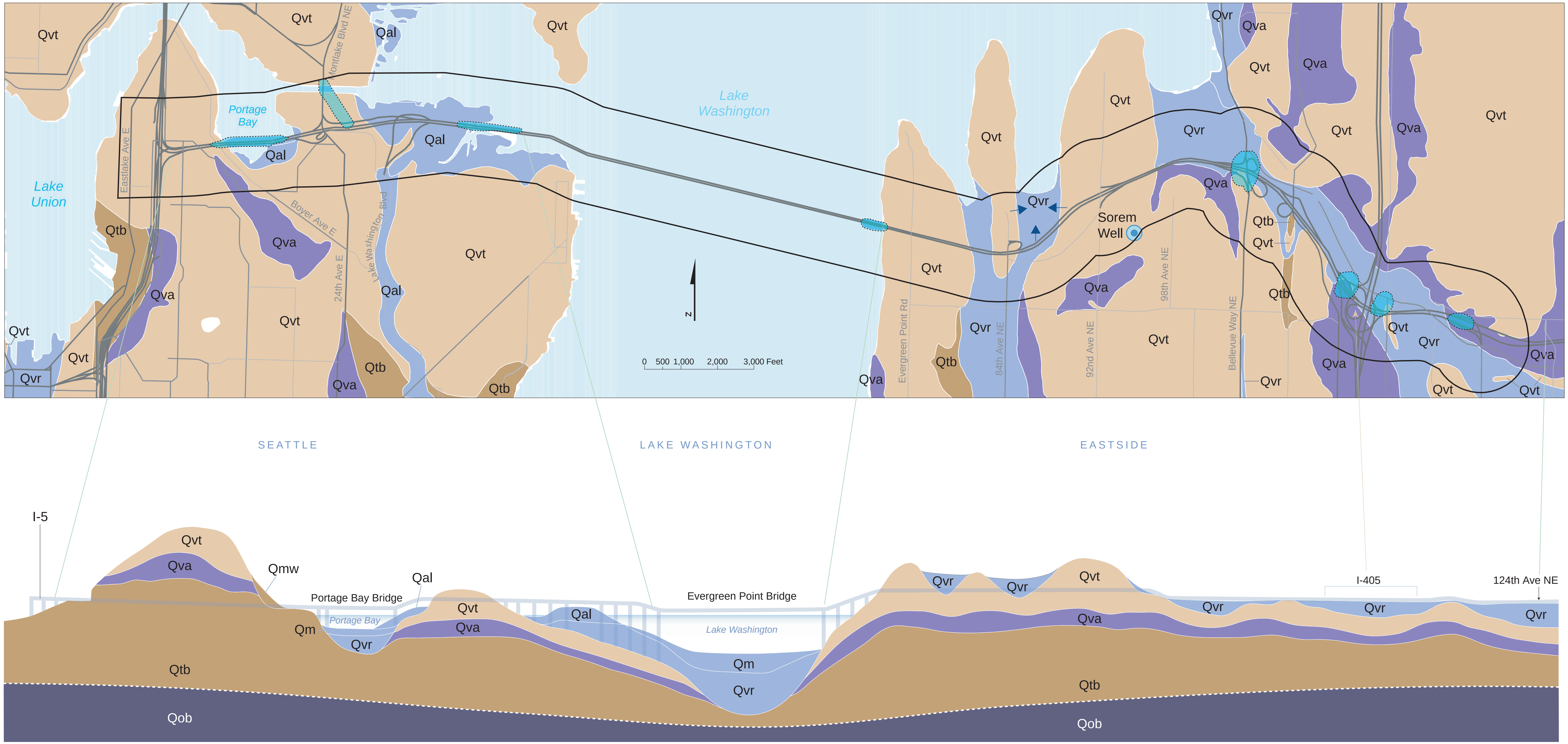
Seattle

Exhibit 42 describes and shows aquifers and aquitards located in the project area. In the Eastlake neighborhood of Seattle, the Vashon

Exhibit 41. Project Area Groundwater Resources

Type of Resource	Does this resource exist in the project area?	Source
Sole source aquifer	No	U.S. EPA (2004c)
Critical aquifer recharge area	No	King County iMap Tool; King County Groundwater Department (Johnson pers. comm. 2004)
Designated wellhead protection area	No	King County iMap Tool; King County Groundwater Department (Johnson pers. comm. 2004)
Group A public water supply well	No	Washington State Department of Health; King County Groundwater Department (Johnson pers. comm. 2004)
Group B public water supply well	Yes, the Group B Sorem well with four connections (see Exhibit 42 for location)	Washington State Department of Health; King County Groundwater Department (Johnson pers. comm. 2004)
Domestic/ residential water well	Yes, 23 water wells of record are listed in the area 1 mile north and south of SR 520. The current condition, uses, or existence of the wells are unknown, but because they are generally located in areas supplied by municipal water, if they exist they are most likely not used for drinking water supply.	Ecology (2004a)
Exposed aquifers crossed by the project corridor	Yes (see Exhibit 42), as follows: Seattle Project Area—SR 520 crosses 5,800 feet of exposed Alluvial Aquifer deposits and 1,700 feet of exposed Vashon Advance Outwash Aquifer deposit Eastside Project Area –SR 520 crosses 600 feet of exposed Alluvial Aquifer deposits and 10,700 feet of exposed Vashon Recessional Outwash Aquifer deposits	
Aquifer recharge areas where stormwater percolates to groundwater in the project corridor	Yes, all pervious surfaces are potential aquifer recharge areas.	Morgan and Jones (1999)

Advance Outwash Aquifer lies near the ground surface by East Boston Street. To the north, it becomes deeper and is overlain by the Vashon Till Aquitard. The Vashon Till Aquitard is located near the ground surface from the east shore of Portage Bay to the Arboretum. The Alluvial Aquifer flows toward Portage Bay, the Montlake Cut, and Union Bay from all sides. The Vashon Advance Outwash Aquifer



Regional Hydrogeologic Units	Regional Geologic Units	Geologic Description
Ground Surface		
Alluvial Aquifer	Qal	**Alluvium** (Qal) - fine-grained sand, silt, clay and organic matter.
Vashon Recessional Outwash Aquifer	Qvr	**Vashon recessional outwash** (Qvr) - loose to medium dense, silty sand with scattered gravel.
Vashon Till Aquitard	Qvt	**Vashon till** (Qvt) - usually a very dense mixture of glacial sand, silt and gravel.
Vashon Advance Outwash Aquifer	Qva	**Vashon advance outwash** (Qva) - stratified clean sand and gravel with silt beds.
Transition Beds Aquitard	Qtb	**Transition beds** (Qtb) - fine-grained laminated clayey silt with minor lenses of sand, gravel, peat and wood.
	Qob (fines)	
Sea-Level Aquifer	Qob (coarse)	**Olympia beds** (Qob) - stratified sand with minor silt and clay beds deposited by streams.
	Older Deposits	**Older** - undifferentiated sedimentary deposits and bedrock

Group B Well

Groundwater Flow in Upland Aquifer

Project Corridor Boundary

NOTES:

Cross-section schematic drawing not to scale.

Please see other exhibits for surficial geology and geologic hazard areas.

Sea-level aquifer is not exposed at ground surface.

SOURCE FOR SURFICIAL GEOLOGY:

King County (2003); Minard (1983)

Exhibit 42. **Surficial and Cross-Section View of Aquifer and Aquitard Units in the Project Area**

SR 520 Bridge Replacement and HOV Project

180171.ag.a5.02_WR_Ex42_Surficial xsection_25apr05

underlies all of this area, except where it has been eroded beneath Portage Bay.

Lake Washington

The Alluvial Aquifer is present on the shores of Lake Washington. The Vashon Advance Outwash Aquifer has been eroded beneath portions of the lake (Exhibit 42). Groundwater from the Alluvial and Vashon Advance Outwash Aquifers (and probably the Sea-Level Aquifer) locally discharge to the lake.

Eastside

The east shore of Lake Washington consists of Alluvial Aquifer deposits that are overlain by the Vashon Till Aquitard in the Medina highlands. Vashon Recessional Outwash Aquifer deposits are exposed in low areas where Vashon Till deposits have eroded at 80th Avenue Northeast and 86th Avenue Northeast. The Vashon Advance Outwash Aquifer becomes exposed at 96th Avenue Northeast, followed by Vashon Recessional Aquifer deposits at 98th Avenue Northeast. Groundwater flow between 95th Avenue Northeast and Bellevue Way/104th Avenue Northeast is generally northward toward Yarrow Bay.

What is the quality of groundwater in the project area?

In the state of Washington, all groundwater is considered to be a potential drinking water source and the state regulates the quality of this resource to protect it from degradation. In general, groundwater quality in the project area is good and suitable for most purposes (Vaccaro et al. 1998).

Groundwater contamination may occur locally due to industrial, commercial, or agricultural activities. Soil and groundwater contamination has been documented at a number of locations in Seattle and on the Eastside. Please see Appendix I, *Hazardous Materials Discipline Report*, for further details.

The most commonly found groundwater contaminant in the Puget Sound region is nitrate (Stewart et al. 1994, as cited by Staubitz et al. 1997). Nitrates come from many possible sources, including fertilizers used on farms and lawns, human sewage and animal waste, or naturally occurring nitrogen sources. The EPA maximum contaminant level goal for nitrate in drinking water is 10 mg/L (U.S. EPA 2004e). Elevated nitrate levels greater than 5 mg/L have been found in shallow wells located in highly permeable soils in urban and suburban areas (Stewart et al. 1994, as cited by Staubitz et al. 1997).

Potential Effects of the Project

What methods were used to evaluate effects on groundwater resources?

The water resources discipline team reviewed Ecology's policies and regulations to establish the criteria for determining the potential effects of this project. We then evaluated the potential permanent effects on groundwater quantity and quality, focusing on how each alternative could decrease existing well yields, decrease base flow discharge to local surface waters, or degrade the quality of groundwater pumped for water supply or local surface water flow. We also evaluated whether the project would reduce the size of the recharge areas, degrade the quantity of runoff entering the recharge area, or cause dangerous and hazardous chemical spills. The qualitative and quantitative measures we used to evaluate potential effects were:

- Length of highway crossing over critical aquifer recharge areas and wellhead protection areas
- The number of people using groundwater for their water supply who could potentially be affected
- Length of highway crossing over shallow unconfined aquifers unprotected by overlying till or another similar low-permeability layer

The water resources discipline team determined the effects on groundwater by asking the following questions:

1. Could stormwater infiltration transport contaminants into groundwater aquifers and degrade aquifer water quality?
2. Would groundwater recharge be affected enough to reduce the quantity of groundwater for drinking sources and base flows to surface water?

Based on the potential of the build alternatives to temporarily alter the flow of surface and groundwater, we identified the potential short-term construction effects on the quantity and quality of groundwater resources.

How would the project permanently affect groundwater?

Seattle

No Build Alternative

Under the Continued Operation Scenario, the amount of impervious surface and the quantity of stormwater infiltration would not change. Based on the current movement of stormwater from the existing SR 520 pavement and the location of stormwater outfalls (Exhibit 14), there is a low probability that stormwater infiltration would further degrade groundwater in the Seattle project area.

Under the Catastrophic Failure Scenario, which is expected to decrease traffic volumes in the project corridor, it is unlikely that groundwater quality would improve because the existing roadway has little effect on groundwater.

4-Lane and 6-Lane Alternatives

The 4-Lane and 6-Lane Alternatives would have either minimal or no effect on the quantity or quality of Seattle project area groundwater.

The increased impervious surface associated with the 4-Lane and 6-Lane Alternatives in the Seattle project area would have minimal or no effect on groundwater recharge because the increase in impervious surface of the overland portions of the roadway is only a fraction of the total recharge area of the groundwater system. The 4-Lane Alternative would increase impervious surfaces in the project area by 8.3 acres, and the 6-Lane Alternative would increase impervious surfaces by 12.9 acres. The size of the associated groundwater basins is unknown, but typically they can be much greater in size than surface water basins. Therefore, these minimal reductions in potential recharge areas based on surface water basin sizes are conservative.

Groundwater quality would not be affected because the 4-Lane and the 6-Lane Alternatives would both treat stormwater prior to discharging to Lake Union, Portage Bay, and Lake Washington. Considering the net movement of groundwater from adjacent aquifers into Lake Union, Portage Bay, and Lake Washington (and not back into these aquifers from these lakes), stormwater discharged to these water bodies would not be a source of groundwater contamination in these aquifers.

Lake Washington

Because stormwater runoff from the existing bridge does not affect the aquifers underlying Lake Washington, the proposed bridges would also not affect the aquifers.

Eastside

No Build Alternative

There would be no change in the quantity or quality of Eastside project area groundwater under either the Continued Operation or Catastrophic Failure scenarios.

As discussed above for the Seattle project area, the Continued Operation and Catastrophic Failure scenarios would not change the amount or quality of stormwater percolating to the groundwater. Consequently, the existing quantity and quality of groundwater in the Eastside project area would also not change.

4-Lane and 6-Lane Alternatives

The 4-Lane and 6-Lane Alternatives would have either minimal or no effect on the quantity or quality of Eastside project area groundwater.

As discussed above for the Seattle project area, the increased impervious surface associated with build alternatives would also have minimal or no effect on groundwater recharge because the roadway is only a fraction of the size of the total recharge area of the groundwater system. Exhibits 35 and 37 show the amount of increased impervious surface under the alternatives and how much the potential recharge areas would be reduced. These amounts vary from between 0.02 and 1.9 percent for the surface water drainage basins.

The size of the associated groundwater basins is unknown, but typically they are much larger than surface water basins. Therefore, these minimal reductions in potential recharge areas based on surface water basin sizes are conservative.

There is a Group B well located in the Eastside project area (Exhibit 42). Because this well is located over 500 feet upgradient of SR 520, there would be minimal or no effect from stormwater on the roadway infiltrating and affecting groundwater that supplies water to the well. Currently, stormwater from SR 520 is discharged to creeks flowing north of the roadway and ultimately to Lake Washington and south through the West Tributary of Kelsey Creek, which also discharges to Lake Washington. Similarly, groundwater quality would be unaffected because stormwater from each alternative would be treated and discharged directly to Fairweather Creek, Cozy Cove Creek, the unnamed tributary, Yarrow Creek, and the West Tributary of Kelsey Creek. While the connectivity of these streams with groundwater is uncertain, it is unlikely these water bodies would contribute contaminants to the groundwater and vice versa.

How would project construction temporarily affect groundwater?

Potential effects on groundwater during construction of the 4-Lane or 6-Lane Alternatives would be related to:

- The project's disturbed area footprint during construction
- Any dewatering required during construction

Construction of roadways and bridges may temporarily alter the flow of groundwater. For example, groundwater could be affected by the temporary piles being driven into the ground to provide a framework for bridge or wall construction. Piles or shafts act as obstacles that groundwater must flow around. Another construction activity that could temporarily alter groundwater flow is the use of dewatering wells to lower groundwater levels to allow subsurface construction in a dry environment. This could cause a temporary reversal of groundwater flow towards the construction area; however, these effects would be localized and temporary.

Possible areas of dewatering include the east side of the Portage Bay Bridge, the Bellevue Way interchange, and 124th Avenue Northeast (Dawson pers. comm. 2004). Other areas that could require dewatering include 112th Avenue Northeast, 116th Avenue Northeast, and 120th Avenue Northeast (CH2M HILL et al. 2002). Where retaining walls need to be installed, dewatering rates would be an estimated 5 gpm or less per linear foot of wall construction. The duration of a wall installation would be between 1 and 5 weeks (Dawson pers. comm. 2004).

Groundwater generated from dewatering activities during construction would be stored in either temporary treatment ponds at or near the location of the permanent stormwater treatment wetlands or in portable steel tanks. Water would be stored for a sufficient amount of time to allow particles to settle, or chemical flocculants could be used to reduce suspended particles, before the water is discharged to the stormwater system. For more details, see Appendix H, *Geology and Soils Discipline Report*.

The temporary effects on groundwater used for drinking in the project area are negligible. The temporary effects to groundwater-supported surface water systems are minimal because water that is removed during construction would be discharged to surface water systems.

Under both the 4-Lane and 6-Lane Alternatives, intermittent dewatering could temporarily alter groundwater flow direction. The groundwater flow direction would return to normal after construction is completed. The effect of the project on the Sorem Group B water supply well and the 23 potential wells located within 1 mile of the project area would most likely be negligible.

How do the alternatives differ in their effects on groundwater?

The 4-Lane and 6-Lane Alternatives would add different amounts of impervious surface, thereby reducing the size of the recharge area; this reduction in recharge area would be small compared to the entire groundwater basin (8.3 acres for the 4-Lane Alternative and 12.9 acres for the 6-Lane Alternative). The differences in recharge area between the alternatives would be within normal annual and climatic variability. Therefore, for all practical purposes, there would no difference between the alternatives in their effects on groundwater recharge.

The effects on groundwater quality from the 4-Lane and 6-Lane Alternatives would be minor. Under the No Build Alternative, stormwater runoff would continue to be directly discharged to surface water bodies, but the 4-Lane or the 6-Lane Alternatives would treat the stormwater runoff before discharge. Treating stormwater runoff removes particles and compounds before discharging to surface water bodies. The treated stormwater would infiltrate into the ground and provide some groundwater recharge within the project area.

Construction effects on groundwater would also be similar under either the 4-Lane or 6-Lane Alternative. Both alternatives would require the same kinds of construction activities, including installation of temporary piles or shafts and dewatering. These activities would have similar effects on the groundwater system.

Groundwater Mitigation

What has been done to avoid or minimize negative effects to groundwater?

See the discussion under *Surface Water Mitigation*. The project's stormwater treatment facilities would protect groundwater quality.

How could the project compensate for unavoidable negative effects to groundwater?

The 4-Lane and 6-Lane Alternatives would increase the amount of land covered by PGIS in the project area; however, this increase would not cause a detectable change to groundwater recharge. Pollutant loading to stormwater discharges would be maintained or reduced; therefore, potential groundwater contamination is not a concern. Since permanent effects on groundwater effects would be negligible, and human use of groundwater in the project area is limited, no additional compensation is required.

Potential effects on groundwater during construction would be negligible. These potential effects would be minimized through the implementation of the TESC and SPCC plans.

This Page Intentionally Left Blank

References

Anderson & Ray Landscape Architecture, The Watershed Company, Roth Hill Engineering Partners Inc., and Robert Foley Associates P.E. 2001. *Medina Creek Conceptual Restoration Plan.* 20 pp.

Booth, D.B. 1989. Runoff and Stream-Channel Changes Following Urbanization in King County, Washington. *Engineering Geology in Washington,* Vol. II, Washington Division of Geology and Earth Resources. Bull. 78.

Booth, D.B. and C.R. Jackson. 1997. Urbanization of Aquatic Systems: Degradation Thresholds, Stormwater Detection, and the Limits of Mitigation. *Journal of the American Water Resources Association* 32:1077-1090.

Booth, D.B., R.A. Haugerud, and J.B. Sacket. 2002. Geologic Map of King County, Washington.

Brake Pad Partnership. 2004. Brake pad partnership overview. http://www.suscon.org/brakepad/index.asp. Accessed July 8, 2004.

CH2M HILL. 1981. Geotechnical Assessment of Proposed Yarrow Village Project. Seattle, Washington. September 1981.

CH2M HILL. 1999. *Denny Way/Lake Union Combined Sewer Overflow, Biological Assessment.* Report to King County Department of Natural Resources, Wastewater Treatment Division, Seattle, Washington. 35 pp. and appendices.

CH2M HILL and Parametrix, Inc. 2004. *Preliminary Stormwater Management Report.* Prepared for the Washington State Department of Transportation Urban Corridors Office and Sound Transit, Seattle, Washington.

CH2M HILL, Parametrix, Inc., and Parsons Brinckerhoff. 2003. *SR 520 Bridge Replacement and HOV Project. West End Bridge Design and Stormwater Treatment and Discharge: Minimizing the Impact.* Prepared for the Washington State Department of Transportation Urban Corridors Office and Sound Transit. December 10, 2002.

CH2M HILL, Parametrix, Inc., Parsons Brinckerhoff, and EnviroIssues. 2002. Trans-Lake Washington Project. *AKART and Water Quality Studies for an SR 520 Replacement Floating Bridge.* Prepared for the Washington State Department of Transportation Office of Urban Mobility and Sound Transit. December 23, 2002.

Chrzastowski, M. 1983. Historical Changes to Lake Washington and Route of the Lake Washington Ship Canal, King County, Washington. USDI Geological Survey. To accompany Water Resources Investigation Open File Report 81-1182. 8 pp.

Corps of Engineers. 2004a. Lake Washington Ship Canal and Hiram M. Chittenden Locks. http://www.nws.usace.army.mil/Public Menu/Menu.cfm?sitename=lwsc&pagename=Water_management. Accessed March 31, 2004. U.S. Army Corps of Engineers, Seattle District.

Corps of Engineers. 2004b. Lake Washington Basin, Lake Washington Summary Hydrograph. http://www.nwd-wc.usace.army.mil/nws/hh/basins/lwscsh.htm. Accessed March 31, 2004. U.S. Army Corps of Engineers, Seattle District.

Cubbage, J. 1992. *Survey of contaminants in sediments in Lake Union and adjoining waters (Salmon Bay, Lake Washington Ship Canal, and Portage Bay).* Prepared for Deborah North, Urban Bay Action Team, Northwest Regional Office, Washington State Department of Ecology. August 1992.

Dawson, Karen. Geotechnical Engineer, CH2M HILL, Bellevue, WA. June 8, 2004. Telephone conversation.

Ecology. 2001. *Stormwater Management Manual for Western Washington.* Prepared by the Washington State Department of Ecology Water Quality Program. Publication Number 99-11 through 99-15. August 2001.

Ecology. 2004a. Washington State's Water Quality Assessment [303(d)], 2002/2004 303(d) List Information. http://www.ecy.wa.gov/programs/wq/303(d)/index.html. Accessed March 31, 2004. Washington State Department of Ecology, Olympia, Washington.

Ecology. 2004b. Appendix C – A Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans. Watershed and Limnological Background Information. http://www.ecy.wa.gov/programs/wq/plants/management/manual/appendixc.html. Accessed July 28, 2004.

Ecology. 2004c. *Guidance for Evaluating Emerging Stormwater Treatment Technologies, Technology Assessment Protocol - Ecology (TAPE).* Prepared by the Washington State Department of Ecology Water Quality Program, October 2002 (Revised June 2004). Publication Number 02-10-037

Edmondson, W.T. 1991. *The Uses of Ecology: Lake Washington and Beyond.* University of Washington Press, Seattle, Washington. 303 pp.

Emery, R.M., C.E. Moon, and E.B. Welch. 1973. Delayed Recovery of a Mesotrophic Lake After Nutrient Diversion. *Jour. Water Poll. Control Fed.* 45(5):913-925.

EPA. 2004a. *Laws and Regulations, Clean Water Act History*. United States Environmental Protection Agency. http://www.epa.gov/region5/water/cwa.htm. Accessed on August 17, 2004.

EPA. 2004b. *Introduction to the Clean Water Act.* United States Environmental Protection Agency. http://www.epa.gov/watertrain/cwa/. Accessed on August 18, 2004.

EPA. 2004c. *Sole Source Aquifer Designations for Region 10 web page*. United States Environmental Protection Agency. http://www.epa.gov/safewater/swp/ssa/reg10.html. Accessed on June 18, 2004.

EPA. 2004d. *Region 8 - Polluted Runoff (Nonpoint Source).* United States Environmental Protection Agency. http://www.epa.govregion08/water/nps/oldnps/npsurb.html. Accessed on August 26, 2004.

EPA. 2004e. *Consumer Factsheet on: NITRATES/NITRITES.* United States Environmental Protection Agency. http://www.epa.gov/safewater/contaminants/dw_contamfs/nitrates.html. Accessed on October 18, 2004.

Freeze, R. and Cherry, J. 1979. *Groundwater.* Englewood Cliffs, NJ: Prentice Hall.

Hansen, L., T. Georgianna, D. Houck, and J. Frodge. 1994. Lake Union Data Compilation and Review. King County Department of Metropolitan Services, Seattle, Washington.

Johnson, Ken. 2002. Groundwater Program Lead. King County Department of Natural Resources, Seattle, Washington. September 23, 2002 – email.

Johnson, Ken. 2004. Groundwater Program Lead. King County Department of Natural Resources, Seattle, Washington. March 11, August 3 and August 4, 2004–Telephone.

Karr, J.R. and E.W. Chu. 1999. *Restoring life in running waters: better biological monitoring.* Island Press, Washington D.C., USA.

King County. 1994. *Water Quality of Small Lakes and Streams: Western King County 1990 to 1993.* King County Department of Metropolitan Services, Seattle, Washington.

King County. 2001. Department of Natural Resources and Parks, Water and Land Resource Division. King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay. Appendix C: Issue Papers. Available at http://dnr.metrokc.gov/wlr/waterres/wqa/C.pdf.

King County. 2003. *King County GIS Data CD #3: Standard Data/March 2003, and Data CD #4: Parcel Data/March 2003*. ArcGIS 8.3. http://www.metrokc.gov/gis/services/sales_main. htm. King County GIS Center, Seattle, Washington.

King County. 2004. Lake Washington Water Quality. Department of Natural Resources Web page. http://dnr.metrokc.gov/wlr/waterres/lakes/Wash.HTM. Accessed July 1, 2004.

Kleindl, W.J. 1995. A benthic index of biotic integrity for Puget Sound lowland streams, Washington, USA. Thesis, University of Washington.

Knudsen, E.E. and S.J. Dilley. 1987. Effects of Riprap Ban Reinforcement on Juvenile Salmonids in Four Western Washington Streams. *North American Journal of Fisheries Management*, 7; 351-356.

Metro. 1989. *Quality of Local Lakes and Streams: 1988-1989 Status Report.* Prepared by Water Resources Section, R. Brenner, S. Hennig, A. Hold, and V. Ridge-Cooney. Municipality of Seattle, Seattle, Washington.

Minard, J.P. 1983. *Geologic Map of the Kirkland Quadrangle, Washington*. U.S. Geological Survey Miscellaneous Field Studies Map MF-1543.

Morgan, David S. and Joseph L. Jones. 1999. Numerical model analysis of the effects of ground-water withdrawals on discharge to streams and springs in small basins typical of Puget Sound lowland, Washington. Prepared in cooperation with the Washington State Department of Ecology. U.S. Geological Survey Water-Supply paper 2492.

Parametrix, Inc. 1977. *Aquatic life and human health detailed risk assessment of sewage treatment plant discharges, sewer overflows, and stormwater discharges to the Georges River.* Prepared for Sydney Water Board, Sydney, Australia. 10 March, 1997

Staubitz, W., S. Bortleson, A. Semans, and R. Black. 1997. *Water-Quality Assessment of the Puget Sound Basin, Washington, Environmental Setting and Its Implications for Water Quality and Aquatic Biota.* U.S. Geological Survey Water-Resources Investigations Report 97-4013.

Stewart, S., Cogger, C., and C.F. Feise, 1994. *The state of our groundwater - a report on documented chemical contamination in Washington: Seattle, Wash.*, Washington Toxics Coalition and Washington State University Extension Service, EB1756, 42 p., 6 pls.

Vaccaro, J.J., A.J. Hansen Jr., and M.A. Jones. 1998. *Hydrogeologic Framework of the Puget Sound Aquifer System, Washington and British Columbia*. U.S. Geological Survey Professional Paper 1424.

Washington State Department of Health (DOH). 2004. *Water System Data*. http://www.doh.wa.gov/ehp/dw/our_main_pages/data.htm. Accessed August 2004.

Washington State Department of Transportation (WSDOT). 2004a *Highway Runoff Manual*, Publication M31-16. March 2004.

Washington State Department of Transportation (WSDOT). 2004b *Environmental Procedures Manual.* Revision 2004-1. Sections 431, 432, and 433. Publication Number M31-11, March 2004.

Winer, Rebecca. 2000. *National Pollutant Removal Performance Database for Stormwater Treatment Practices*. 2nd Edition. Prepared by Center for Watershed Protection, Ellicott City, Maryland. Prepared for U.S. EPA Office of Science and Technology in association with Tetra Tech, Inc., Fairfax, Virginia. June 2000.

Attachment 1
Description of Project Area Aquifers

Attachment 1

Description of Project Area Aquifers

In the Puget Sound Basin, groundwater is contained in two major aquifers—the Vashon Advance Outwash Aquifer and the Sea-Level Aquifer. These aquifers are also known as the Fraser Aquifer and the Puget Aquifer, respectively (Vaccaro et al. 1998). The Vashon Advance Outwash and Sea-Level Aquifers are present throughout most of the project area and are sufficiently thick and water-saturated to be considered an important source of groundwater (see Exhibit 42 in the main text).

Two minor aquifers also underlie parts of the project area, the Alluvial Aquifer and the Vashon Recessional Outwash Aquifer. These aquifers are either not present in the large majority of the project area or, where present, do not store large amounts of groundwater (Vaccaro et al. 1998). These aquifers can be found in a few places in the study area such as around Lake Washington and atop several hills (Exhibit 42).

Vashon Advance Outwash Aquifer

This aquifer consists of glacial advance outwash sand and gravel deposits. In areas where it is overlain by the Vashon Till Aquitard, it is semi-confined. Where the till has eroded, the Vashon Advance Outwash Aquifer is unconfined. The Vashon Advance Outwash Aquifer is located in the highlands on both sides of Lake Washington (Exhibit 42). The main source of recharge to the aquifer in the project area is precipitation or downward seepage through the Vashon Till. In areas where the Vashon Advance Outwash Aquifer is close to the ground surface, the aquifer is susceptible to contamination. Water from the aquifer is transported underground and discharged into creeks and lakes. This water can be an important contribution to these water bodies during the summer when precipitation and flows are low. Some of the water contained in the aquifer leaks through the aquitard and provides recharge to the Sea-Level Aquifer.

Sea-Level Aquifer

This deepest regional aquifer is confined. Although it is present throughout the Puget Sound Basin and has good water quality, the Sea-Level Aquifer is seldom used for water supply in the project area because of its greater depth beneath other aquifers (Exhibit 42).

Recharge to the Sea-Level Aquifer occurs from precipitation in the Puget Sound basin, as well as leakage from overlying aquifers, lakes, and rivers. Because of the great thickness of this aquifer, its large areal extent, and the quantity of precipitation in the Puget Sound basin, this aquifer has the capacity to store the greatest amount of groundwater. The Sea-Level Aquifer ultimately discharges to Puget Sound.

Alluvial Aquifer

This aquifer consists of sand and gravels deposited by water on the shores of lakes and in stream or river valleys (Exhibit 42). Groundwater in this aquifer is unconfined and is generally encountered just below the ground surface to 100 feet below ground throughout the project area. The gravel composing the Alluvial Aquifer is permeable. Water, and any contaminants it may contain, are easily transported into and through the aquifer. Within the project area this aquifer is located near the ground surface and is susceptible to contamination.

Vashon Recessional Outwash Aquifer

This aquifer consists of stratified sand and gravel and well-bedded silty sand and silty clay deposited during the retreat of the Vashon glaciers (Booth et al., 2002). Groundwater in this aquifer is unconfined or semi-confined. Groundwater in the aquifer is generally encountered from just below the ground surface to 100 feet below ground surface throughout the project area. The Vashon Recessional Outwash Aquifer is saturated beneath Portage Bay and Lake Washington, while east of Lake Washington (between the highlands) the aquifer may be unsaturated (Exhibit 42). In areas where the permeable geologic units that comprise the Vashon Recessional Outwash Aquifer are close to the ground surface, the aquifer is also susceptible to contamination.