

FINAL ENVIRONMENTAL IMPACT STATEMENT
AND FINAL SECTION 4(F) AND 6(f) EVALUATIONS
SR 520 BRIDGE REPLACEMENT AND HOV PROGRAM

MAY 2010

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

Geology and Soils Discipline Report Addendum and Errata

**SR 520, I-5 to Medina:
Bridge Replacement and HOV Project
Final Environmental Impact Statement
and Final Section 4(f) and 6(f) Evaluations**

**Geology and Soils
Discipline Report
Addendum and Errata**



Prepared for
Washington State Department of Transportation
Federal Highway Administration

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Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
BMP	best management practice
EIS	environmental impact statement
FHWA	Federal Highway Administration
HOV	high-occupancy vehicle
I-5	Interstate 5
IBC	International Building Code
MTCA	Model Toxics Control Act
SDEIS	Supplemental Draft Environmental Impact Statement
SR	State Route
WSDOT	Washington State Department of Transportation



Introduction

What is the purpose of this addendum?

This addendum to the State Route (SR) 520, Interstate 5 (I-5) to Medina: Bridge Replacement and High-Occupancy Vehicle (HOV) Project Supplemental Draft Environmental Impact Statement (SDEIS) Geology and Soils Discipline Report (Washington State Department of Transportation [WSDOT] 2009a) presents the environmental consequences of the Preferred Alternative for the SR 520, I-5 to Medina: Bridge Replacement and HOV Project; compares its effects on the design options A, K, and L discussed in the SDEIS for the project (WSDOT 2010a); and reflects additional analyses that resulted from the public and agency comments received on the SDEIS. These analyses are shown in the context of the Preferred Alternative.

The information contained in the 2009 Geology and Soils Discipline Report on affected environment and project effects is still pertinent to the Preferred Alternative and its effects, except where this addendum specifically revises it. The discussion below supplements the Geology and Soils Discipline Report and provides comparisons using new text and new or updated exhibits, where appropriate. Text updated to reflect the Preferred Alternative has been cross-referenced using the page numbers within the 2009 Geology and Soils Discipline Report. Where an addendum exhibit updates or adds new data and/or potential effects of the Preferred Alternative to an exhibit contained in the 2009 discipline report, the exhibit name is followed by “(Update to Exhibit X of the 2009 Discipline Report).”

Sources of new information about the affected environment include the draft geotechnical report (WSDOT 2010a), the geotechnical data report (WSDOT 2010b), and the site-specific probabilistic seismic hazard analysis (WSDOT 2009b). New information used to analyze the potential effects of the Preferred Alternative on geology and soils was drawn from the Description of Alternatives Discipline Report Addendum (WSDOT 2011a), the Construction Techniques and Activities Discipline Report Addendum and Errata (WSDOT 2011b), and the geotechnical report (WSDOT 2010a). New information used to determine mitigation measures is included in the geotechnical report and the results of the test pile program (WSDOT 2010c; WSDOT 2010d).

An errata sheet is attached to this addendum (Attachment 1) to show revisions and clarifications to the 2009 Geology and Soils Discipline Report that do not constitute new findings or analysis.

What key issues were identified in the public and agency comments on the SDEIS and addressed in this addendum?

A key issue identified in public comments and addressed in this addendum is more information on construction effects of the bridge maintenance facility.



What are the key points of this addendum?

The primary effects on geology and soils related to the Preferred Alternative are summarized in the bullets below. In general, many of the effects would be similar to those the SDEIS options, except for the differences shown in bold below. The effects of the Preferred Alternative are discussed in the sections that follow.

Effects during Construction

- The Preferred Alternative would use up to approximately **185,000 cubic yards of soil and rock materials** (compared to amounts ranging from 52,000 under Option L to up to 320,000 under Option K), which would contribute to aggregate (that is, crushed stone) depletion from aggregate quarries in the Puget Sound region and western Washington.
- An abundance of compressible and low-strength soils in a region with high seismicity greatly increases the cost of a project. The greatest effect of the soils and geology on the SR 520, I-5 to Medina: Bridge Replacement and HOV Project would be that deep foundations would be required to support many of the proposed structures that are underlain by deep, weak, and compressible soils. The cost and time required to construct the structures is further increased by the high seismicity of the region and the difficulties of constructing over water.
- Artesian groundwater pressures have been measured in new explorations near the east approach and are anticipated in many locations on the Seattle side. Constructing drilled shafts through artesian groundwater conditions is more expensive and slower than in normal hydrostatic conditions and involves a slightly increased risk of drilling slurry release to the environment.
- The landslide hazards, soft soils of Portage Bay and Lake Washington, and active seismicity of the region could add substantially to the cost and complexity of constructing the Preferred Alternative. Increased complexity often translates to increased construction duration and more or larger construction machinery. While the geologic conditions could be challenging, modern engineering and construction techniques have been developed to deal with these challenges. For example, landslide failure during construction is a noted risk, and there are engineering practices to mitigate that risk. The risk of triggering landslides or inducing unwanted settlement during construction and over the design life of the facility would be relatively small.
- The bridge maintenance facility would be located on a slope mapped as having slide-prone soils, which would require relatively more expensive excavation support than for glacially overconsolidated granular soils to maintain the specified factor of safety. Construction dewatering would be required for the building foundation's excavation, as well as for two adjacent walls and the nearby spread footing foundation for Pier 3 of the east approach structure. Some metals contamination was found in unfiltered groundwater samples from the area, so testing and possibly treatment could be required prior to groundwater discharge. Filtered samples of the groundwater had either very low or nondetectable metals levels, so



treatment would most likely be limited to sediment removal, which is a standard discharge requirement even without contamination. Special disposal would be required for contaminated sediments.

Effects during Operation

- The Preferred Alternative would be designed to withstand an earthquake with a 1,000-year recurrence interval (that is, a 7 percent probability of exceedance over the 75-year design life of the structure), according to American Association of State Highway and Transportation Officials (American Association of State Highway and Transportation Officials [AASHTO] 2010) standards. With the No Build Alternative, the existing Portage Bay Bridge and west approach structures and ramps for the Evergreen Point Bridge could fail during a seismic event with a 210-year recurrence interval (WSDOT 2002). The already limited remaining design life of these existing bridges could be shortened by smaller events.
- With the bottom of slab elevation of 22 feet, as analyzed in the Draft Geotechnical Report (WSDOT 2010a), the bridge maintenance facility would have required a permanent underdrain system to limit uplift and lateral loads from groundwater. The underdrain system could have had a long-term discharge of approximately 80 to 100 gallons per minute and could have lowered the groundwater head by 10 feet at locations 100 feet from the facility. This could potentially change the groundwater flow regime, changing the upwelling characteristics of a small portion of the reported near shore sockeye spawning habitat in Lake Washington. Design revisions are underway to raise the floor elevation by several feet, which would substantially reduce the long-term discharge. As long as the underdrain materials are properly designed and constructed to meet filter criteria, the long-term underdrain discharge is unlikely to be contaminated.

What is the SR 520, I-5 to Medina: Bridge Replacement and HOV Project?

The SR 520, I-5 to Medina: Bridge Replacement and HOV Project would widen the SR 520 corridor to six lanes from I-5 in Seattle to Evergreen Point Road in Medina, and would restripe and reconfigure the lanes in the corridor from Evergreen Point Road to 92nd Avenue NE in Yarrow Point. It would replace the vulnerable Evergreen Point Bridge (including the west and east approach structures) and Portage Bay Bridge, as well as the existing local street bridges across SR 520. The project would complete the regional HOV lane system across SR 520, as called for in regional and local transportation plans.

What is the Preferred Alternative?

The new SR 520 corridor would be six lanes wide (two 11-foot-wide outer general-purpose lanes and one 12-foot-wide inside HOV lane in each direction), with 4-foot-wide inside shoulders and 10-foot-wide outside shoulders across the floating bridge. The typical roadway cross-section across the



floating bridge would be approximately 116 feet wide, compared to the existing width of 60 feet. In response to community interests expressed during public review of the January 2010 SDEIS, the SR 520 corridor between I-5 and the Montlake interchange would operate as a boulevard or parkway with a posted speed limit of 45 miles per hour and median planting across the Portage Bay Bridge. To support the boulevard concept, the width of the inside shoulders in this section of SR 520 would be narrowed from 4 feet to 2 feet, and the width of the outside shoulders would be reduced from 10 feet to 8 feet. Exhibit 1 highlights the major components of the Preferred Alternative.

The Preferred Alternative would include the following elements:

- An enhanced bicycle/pedestrian crossing adjacent to the East Roanoke Street bridge over I-5
- Reversible transit/HOV ramp to the I-5 express lanes, southbound in the morning and northbound in the evening
- New overcrossings and an integrated lid at 10th Avenue East and Delmar Drive East
- A six-lane Portage Bay Bridge with a 14-foot-wide westbound managed shoulder that would be used as an auxiliary lane during peak commute hours
- An improved urban interchange at Montlake Boulevard integrated with a 1,400-foot-long lid configured for transit, pedestrian, and community connectivity
- A new bascule bridge across the Montlake Cut that provides additional capacity for transit/HOV, bicycles, and pedestrians
- Improved bridge clearance over Foster Island and the Arboretum Waterfront Trail
- A new west approach bridge configured to be compatible with future high-capacity transit (including light rail)
- A new floating bridge with two general-purpose lanes, and one HOV lane in each direction
- A new 14-foot-wide bicycle/pedestrian path with scenic pull-outs along the north side of the new Evergreen Point Bridge (west approach, floating span, and east approach), connecting regional trails on both sides of Lake Washington
- A new bridge maintenance facility and dock located underneath the east approach of the Evergreen Point Bridge
- Re-striped and reconfigured roadway between the east approach and 92nd Avenue NE, tying in to improvements made by the SR 520, Medina to SR 202: Eastside Transit and HOV Project
- Design features that would also provide noise reduction including reduced speed limit on Portage Bay Bridge, 4-foot concrete traffic barriers, and noise absorptive materials applied to the inside of the 4-foot traffic barriers and lid portals. Quieter concrete pavement would also be used for the new SR 520 main line, and noise walls where recommended by the noise analysis and approved by affected property owners would be included in the design
- Basic and enhanced stormwater treatment facilities



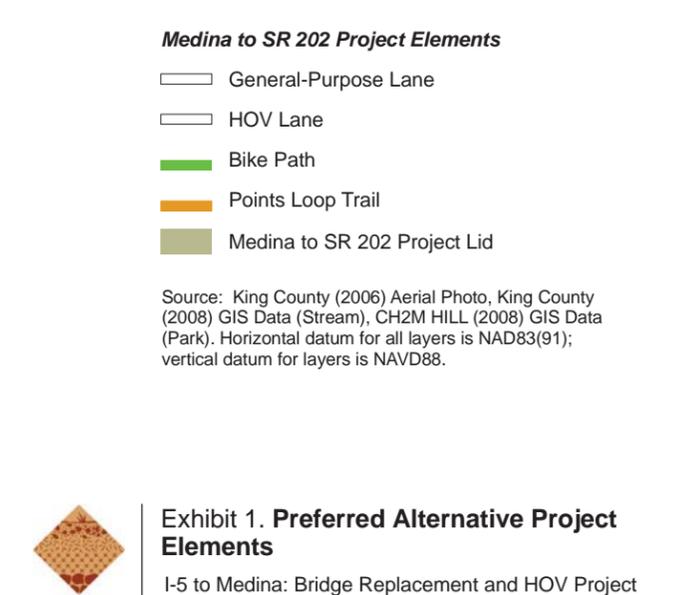
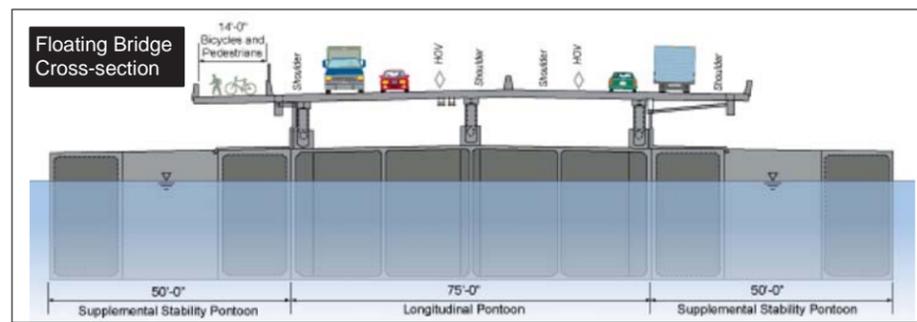
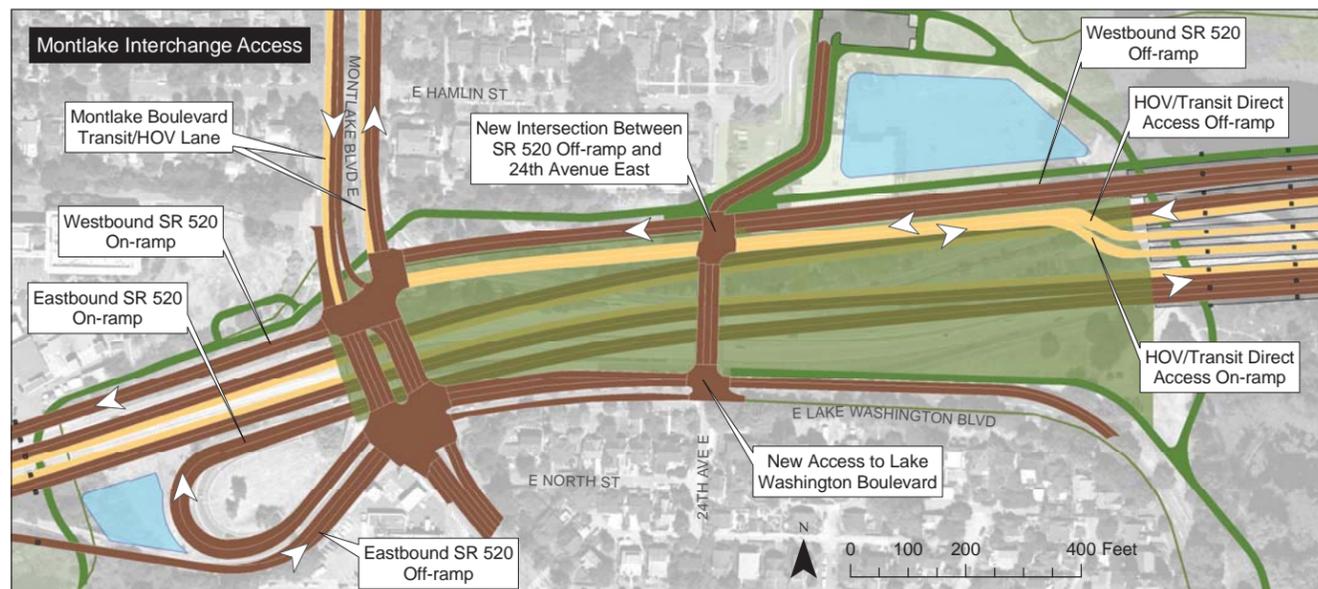
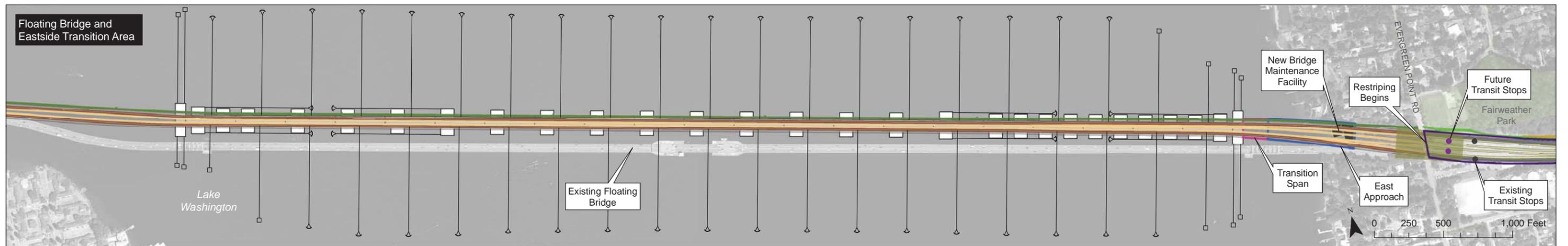
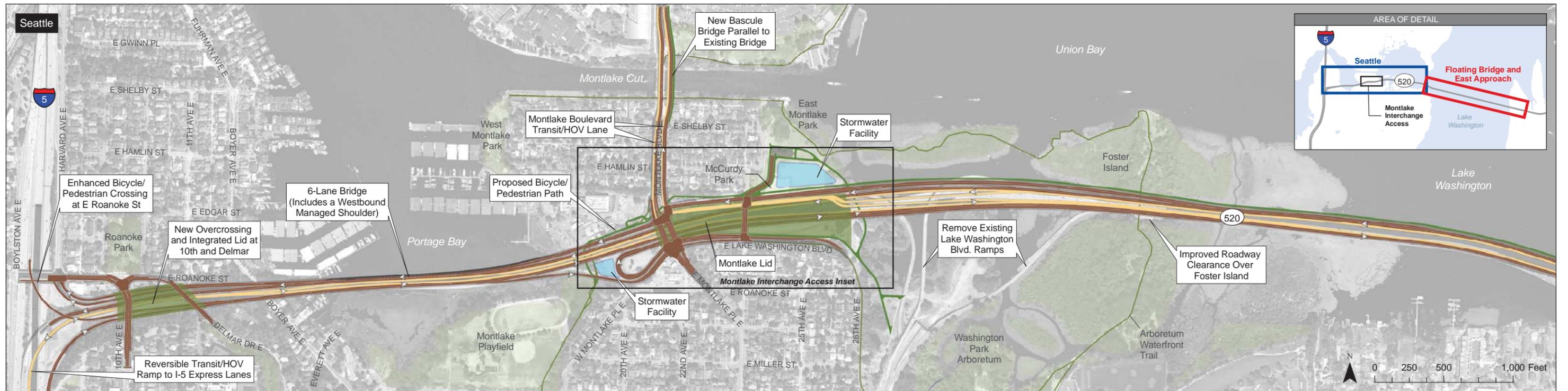


Exhibit 2 summarizes the Preferred Alternative design compared to the existing corridor elements, and compares the Preferred Alternative to design options A, K, and L as described in the SDEIS. For a more detailed description of the Preferred Alternative, see the Description of Alternatives Discipline Report Addendum (WSDOT 2011a).

Exhibit 2. Preferred Alternative and Comparison to SDEIS Options

Geographic Area	Preferred Alternative	Comparison to SDEIS Options A, K, and L
I-5/Roanoke Area	The SR 520 and I-5 interchange ramps would be reconstructed with generally the same ramp configuration as the ramps for the existing interchange. A new reversible transit/HOV ramp would connect with the I-5 express lanes.	Similar to all options presented in the SDEIS. Instead of a lid over I-5 at Roanoke Street, the Preferred Alternative would include an enhanced bicycle/pedestrian path adjacent to the existing Roanoke Street Bridge.
Portage Bay Area	The Portage Bay Bridge would be replaced with a wider and, in some locations, higher structure with six travel lanes and a 14-foot-wide westbound managed shoulder.	Similar in width to Options K and L, similar in operation to Option A. Shoulders are narrower than described in SDEIS (2-foot-wide inside shoulders, 8-foot-wide outside shoulder on eastbound lanes), posted speed would be reduced to 45 mph, and median plantings would be provided to create a boulevard-like design.
Montlake Area	The Montlake interchange would remain in a similar location as today. A new bascule bridge would be constructed over the Montlake Cut. A 1,400-foot-long lid would be constructed between Montlake Boulevard and the Lake Washington shoreline. The bridge would include direct-access ramps to and from the Eastside. Access would be provided to Lake Washington Boulevard via a new intersection at 24th Avenue East.	Interchange location similar to Option A. Lid would be approximately 75 feet longer than previously described for Option A, and would be a complete lid over top of the SR 520 main line, which would require ventilation and other fire, life, and safety systems. Transit connections would be provided on the lid to facilitate access between neighborhoods and the Eastside. Montlake Boulevard would be restriped for two general-purpose lanes and one HOV lane in each direction between SR 520 and the Montlake Cut.
West Approach Area	The west approach bridge would be replaced with wider and higher structures, maintaining a constant profile rising from the shoreline at Montlake out to the west transition span. Bridge structures would be compatible with potential future light rail through the corridor.	Bridge profile most similar to Option L, and slightly steeper; structure types similar to Options A and L. The gap between the eastbound and westbound structures would be wider than previously described to accommodate light rail in the future.
Floating Bridge Area	A new floating span would be located approximately 190 feet north of the existing bridge at the west end and 160 feet north of the existing bridge at the east end. The floating bridge would be approximately 20 feet above the water surface at the midspan (about 10 to 12 feet higher than the existing bridge deck).	Similar to design described in the SDEIS. The bridge would be approximately 10 feet lower than described in the SDEIS, and most of the roadway deck support would be constructed of steel trusses instead of concrete columns.
Eastside Transition Area	A new east approach to the floating bridge, and a new SR 520 roadway would be constructed between the floating bridge and Evergreen Point Road.	Same as described in the SDEIS.



When will the project be built?

Construction for the SR 520, I-5 to Medina project is planned to begin in 2012, after project permits and approvals are received. To maintain traffic flow in the corridor, the project would be built in stages. Major construction in the corridor is expected to be complete in 2018. The most vulnerable structures (the Evergreen Point Bridge including the west and east approaches, and Portage Bay Bridge) would be built in the first stages of construction, followed by the less vulnerable components (Montlake and I-5 interchanges). Exhibit 3 provides an overview of the anticipated construction stages and durations identified for the SR 520, I-5 to Medina project.

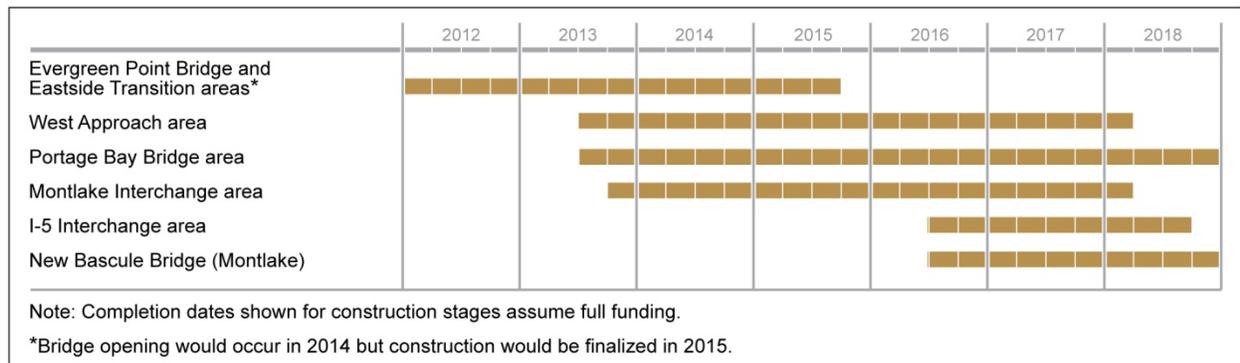


Exhibit 3. Preferred Alternative Construction Stages and Durations

A Phased Implementation scenario was discussed in the SDEIS as a possible delivery strategy to complete the SR 520, I-5 to Medina project in phases over an extended period. FHWA and WSDOT continue to evaluate the possibility of phased construction of the corridor should full project funding not be available by 2012. Current committed funding is sufficient to construct the floating portion of the Evergreen Point Bridge, as well as the new east approach and a connection to the existing west approach. The Final EIS discusses the potential for the floating bridge and these east and west “landings” to be built as the first phase of the SR 520, I-5 to Medina project. This differs from the SDEIS Phased Implementation scenario, which included the west approach and the Portage Bay Bridge in the first construction phase. Chapters 5.15 and 6.16 of the Final EIS summarize the effects for this construction phase. Therefore, this discipline report addendum addresses only the effects anticipated as a result of the updated construction schedule.

Are pontoons being constructed as part of this project?

WSDOT has completed planning and permitting for a new facility that will build and store the 33 pontoons needed to replace the existing capacity of the floating portion of the Evergreen Point Bridge in the event of a catastrophic failure. If the bridge does not fail before its planned replacement, WSDOT would use the 33 pontoons constructed and stored as part of the SR 520 Pontoon Construction Project in the SR 520, I-5 to Medina project. An additional 44 pontoons would



be needed to complete the new 6-lane floating bridge planned for the SR 520, I-5 to Medina project. The additional pontoons would be constructed at Concrete Technology Corporation in the Port of Tacoma, and if available, at the new pontoon construction facility located on the shores of Grays Harbor in Aberdeen, Washington. Final pontoon construction locations will be identified at the discretion of the contractor. For additional information about project construction schedules and pontoon construction, launch, and transport, please see the Construction Techniques and Activities Discipline Report Addendum and Errata (WSDOT 2011b).

Affected Environment

What were the updates to the affected environment?

Updates to the affected environment information for geology and soils since preparation of the SDEIS analysis include the following:

- New test borings, some with groundwater observation wells, have been drilled. Additionally, new subsurface profiles have been prepared, particularly for the vicinity of the bridge maintenance facility and east approach structure and stormwater treatment facilities, as well as the western interim connection bridge and adjacent stormwater treatment facility (WSDOT 2010b). In addition to refining the location and properties of various soil layers, the groundwater observation wells indicate artesian groundwater conditions at the east approach and bridge maintenance facility.
- Preliminary design geotechnical recommendations have been developed for the facilities listed above (WSDOT 2010a).
- A probabilistic seismic hazard analysis (WSDOT 2009b), which includes basin and directivity effects, was performed.
- A test pile program was completed to assess the efficacy of acoustical mitigation measures (WSDOT 2010d) as well as the potential effects on water turbidity (WSDOT 2010e).

These new studies generally confirmed the descriptions of soil types and geologic hazards in the 2009 Geology and Soils Discipline Report and added detail to support design development, particularly with regard to groundwater levels in the area around the bridge maintenance facility and east approach. Additional geotechnical work will continue to occur as WSDOT refines the engineering design for the Preferred Alternative.

The extent of construction did not change substantially; the Preferred Alternative would affect the same soil types as described for Option A. Pages 15 to 39 of the Geology and Soils Discipline Report describe the affected environment. However, as more design detail and subsurface information has been developed, the complexities of the project are more apparent.



Potential Effects

The 2009 Geology and Soils Discipline Report provides a detailed discussion of effects of the No Build Alternative and the SDEIS options (see pages 41 through 63). The discussion below supplements the Geology and Soils Discipline Report and discloses the effects of the Preferred Alternative, comparing it with the No Build Alternative and SDEIS options using new text and new or updated exhibits where appropriate.

How would construction of the Preferred Alternative affect geology and soils?

Construction effects of the Preferred Alternative would be similar to those described for Option A in the Geology and Soils Discipline Report (see pages 43 through 55).

Construction of the Preferred Alternative would encounter a number of potential geologic hazards along the corridor, including areas susceptible to erosion, steep-slope and landslide hazard areas, artesian groundwater conditions, soft soil conditions, and seismic risk. Corridor topography would also be affected by construction of the Preferred Alternative. Following are brief discussions of potential construction effects on geology and soils that could generally apply to the entire study area; these effects are the same as for Option A, except where noted. See pages 43 through 47 of the Geology and Soils Discipline Report for a more detailed discussion. Where unique effects would occur for a specific area, they are described under “Area-Specific Construction Effects.”

Earthwork Quantities

Construction of the SR 520 roadway would involve topographic grade changes that require cuts and fills and/or installation of bridge and retaining wall structures. After construction is complete, topographic changes to the corridor would be modest because the widened roadway would follow the same corridor as the existing roadway. In addition, the construction footprint would be minimized by using walls to contain and support areas requiring new fills and cuts. Earthwork quantities (cut and fill volumes) provide a relative measure of the amount of topographic change. Earthwork is an imperfect measure because relatively large excavations would be used to create lidded space in which the finish ground surface above the roadway may more closely match pre-freeway topography than the existing condition. However, the earthwork quantities also provide a relative measure of construction disturbance. The amount of excavation required for the Preferred Alternative would be slightly more than Option A and substantially less than Option K. Exhibit 4 identifies the total estimated excavation volumes and new material for construction elements along the corridor for each option. Most of the native materials that would be excavated along the project alignment would contain too much silt and clay to be reusable. It is assumed that most material used for construction would be imported sand and gravel.



Exhibit 4. Comparative Soils and Geology Project Effects (Update to Exhibit 18 of the 2009 Discipline Report)

Project Effect	Seattle Area				Lake Washington and Eastside Transition Area	Project Totals (from I-5 to 92nd Ave NE in Yarrow Point)			
	Preferred Alternative	Option A	Option K	Option L		Preferred Alternative	Option A	Option K	Option L
Total estimated excavation (volume of excavation, cy) ^a	129,700	290,000	1,250,000	400,000	48,000	177,700	340,000	1,300,000	450,000
Import fill (total volume of embankment, cy) ^a	185,000	66,000	300,000	32,000	20,000	205,000	86,000	320,000	52,000
Lane miles of new roadway not on structure	2.8	3.4	3.1	3.5	0.9	3.7	4.0	4.0	4.4
Area of new bridges and structures (square feet) ^b	1,660,000	1,600,000	2,200,000	2,000,000	1,300,000	2,960,000	2,900,000	3,500,000	3,300,000
Area of walls (square feet, includes all wall types and noise barriers) ^c	96,000	82,000	86,000	78,000	31,000	127,000	110,000	120,000	110,000
Length of new concrete barrier (linear feet) ^d	25,000	13,000	9,000	16,000	8,900	33,900	22,000	18,000	25,000
Number of new columns and shafts supporting structures over water	325	309	2,900	310	6	335	315	2,900	320
Number of temporary piles	3,526	3,000	4,000	3,000	205	3,731	3,205	4,205	3,205

^a Total excavation is the sum of estimated roadway excavation quantities and structure excavation quantities.

^b Area is square footage of the new structures (ramps, bridges, lids, etc.) and does NOT include any temporary structures or demolition.

^c Area is for all types of walls including structural earth wall, reinforced concrete retaining, soil nail, soldier pile, soldier pile/cylinder pile, and all noise barrier walls.

^d Linear feet of concrete barrier only. Does NOT include guardrail.

Note: Values have been rounded to two significant digits.



Erosion and Sedimentation

Construction of the Preferred Alternative would include the risk of erosion from exposed soils, landslides during slope excavation, and ground settlement in liquefaction zones. Clearing vegetation, fill placement, grading, and spoils removal or stockpiling during construction would allow rainfall and runoff to erode soil particles. Temporary erosion and sediment control measures will be employed to prevent erosion from affecting nearby water bodies. Contaminated soils encountered would require special handling, transport, and disposal at offsite locations.

Construction Dewatering

Many excavations for bridge and retaining wall footings would require dewatering. Dewatering of excavations located below the groundwater table can produce quantities of sediment-laden water. Water in contact with curing concrete adds to the risk of water quality contamination.

Dewatering could potentially result in the settlement of nearby structures if proper considerations are not given to the effects of potential changes in the water table, which is near the surface in many areas, including the Arboretum. Roadway design and construction methods would take the water table into account to avoid the potential for such effects. Any contaminated groundwater collected during dewatering would be treated prior to disposal.

Drilled Shaft Construction in Artesian Groundwater

In many locations, the anticipated groundwater head within the proposed drilled shaft excavations is higher than the near-surface groundwater table; sometimes the pressure is high enough that a well screened in the zone of excavation would be free flowing at the ground surface, or artesian. Drilled shaft foundation construction in artesian groundwater conditions requires more expensive techniques and increases the risk of inadvertent drilling slurry releases to the environment than when the groundwater head is below the ground surface. Construction techniques that are typically used to construct drilled shafts in artesian groundwater conditions include:

- Maintaining drilling fluid within a temporary casing a few feet above the groundwater elevation, so that groundwater cannot flow into the excavation
- Pumping from temporary wells to lower the groundwater pressure head a few feet below the ground surface so that control of groundwater within the excavation can be handled by conventional means. Once concrete is poured and set in the shaft excavation, the temporary wells would be decommissioned if no longer required for construction of other facilities.

Area-Specific Construction Effects

Area-specific construction effects of the Preferred Alternative would be similar to the area-specific effects for Option A (see pages 48 through 55 of the Geology and Soils Discipline Report). Exhibit 5 provides a qualitative rating of potential construction effects for specific areas and options within the study area. This qualitative review does not replace the detailed geotechnical work that would be required during the design phases.



Exhibit 5. Construction Effect Potential by Area (Update to Exhibit 19 of the 2009 Discipline Report)

Alignment	Geologic Hazard				Engineering Design and Construction			
	Erosion	Steep Slope/ Landslide	Soft Ground or Settlement	Ground- water ^a	Low Soil- bearing or Lateral Support	Construction Vibrations	Risk to Utility and Buried Structures	Risk to Overall Constructability
Seattle								
Preferred Alternative	L	M	L	M	L	M	M	L-M
Option A	L	M	L	M	L	M	M	L-M
Option K	L	M	M	H	M	M	M	M-H
Option L	L	M	M	M	L-M	M	M	M
Lake Washington	M	M	H	M	L	M	L	L-M
Eastside Transition Area ^b	M	M	L	H	L	M	M	M-H
No Build	L	L	L	L	L	L	L	N/A

^a Within 0 to 10 feet of the ground surface.

^b Risk in the Eastside transition area has been revised for Options A, K, and L based on additional information available since preparation of the Geology and Soils Discipline Report. The same risk levels apply to the Preferred Alternative in this area.

Rating Legend:

H = High potential of occurring or has major effect. Could cause major effects and might affect construction costs. Would require detailed studies.

M = Moderate potential of occurring or occurs in multiple locations. Could have some effects. Would require special consideration. Can be addressed using normal design and construction methods.

L = Low potential of occurring or localized occurrence. Does not appear to be a design or construction issue. Only a few locations would require consideration during design.

N/A = not applicable



A qualitative rating of the frequency or seriousness of the potential effects related to geology and soils was assigned as follows:

- A low rating (L) was given to an effect that would have a low potential of occurring or if the effect would only occur in a localized area.
- A moderate rating (M) was given to an effect that would have a moderate potential to occur or if the effect would occur at multiple locations.
- A high rating (H) was given to an effect that would have a high potential to occur or if it could cause major effects; this rating triggers the need for more detailed studies.

Based on the information available when performing this evaluation, none of the effects was determined to be a fatal flaw (an undue risk) that would prevent construction of the project.

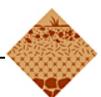
In all cases, the evaluation determined that the severity or frequency of the hazard or effect could be avoided or minimized using conventional design and construction methods. Where effects are listed as being moderate to high, more effort is necessary during design to evaluate the severity of the effect and to identify an adequate mitigation method.

The following subsections describe potential area-specific construction effects.

I-5/Roanoke, Portage Bay, Montlake, and West Approach Areas

Construction effects in the Seattle portion of the project would be similar to those described for Option A. See pages 50 through 52 of the Geology and Soils Discipline Report for further discussion of these potential effects. Following are brief descriptions of possible short-term effects in the Seattle portion of the project:

- Design and construction of temporary excavations would be complicated by the proximity of adjacent structures and foundations, which could require alternate excavation or wall systems.
- The existing infrastructure might affect design or construction methods of structures such as retaining walls, bridges, lids, or overcrossings.
- The eastern end of the bridge over Portage Bay and the western end of the Lake Washington west approach structure cross potentially liquefiable areas, which would require soil stabilization or ground improvement.
- The Preferred Alternative profile in the vicinity of the Montlake lid is slightly lower than in Option A but higher than in Option K. In some locations and at some times of the year, the profile may be below the groundwater surface, potentially requiring construction dewatering and the construction of additional wall heel width, uplift-resisting piles, or uplift-resisting anchors to provide an adequate factor of safety against floating. Wherever possible, the design profile will be adjusted so that the roadway grade is above the groundwater table. Compressible soils might exist beneath the embankments near the abutments on the east side



of the Portage Bay Bridge and the west side of the Evergreen Point Bridge; such soils would require mitigation to prevent damaging settlement.

- Soft soils extend to depths of up to 100 feet in Portage Bay, and groundwater is encountered at or within a few feet of the ground surface within and adjacent to Portage Bay, Union Bay, and Lake Washington. These conditions would require deep foundations and construction of work trestles for construction access.
- Construction dewatering could cause ground settlement, which could affect nearby structures or utilities in the zone of influence. Dewatering systems can be designed to limit the potential for damage due to ground settlement. WSDOT would monitor ground movement so that dewatering could be stopped or revised prior to causing damage to adjacent facilities.
- Construction dewatering could affect water quality if dewatering systems were not located and designed properly.
- Contaminated material, if present, could affect excavation of soils (see the Hazardous Materials Discipline Report [WSDOT 2009c] and the Hazardous Materials Discipline Report Addendum and Errata [WSDOT 2011c]).
- Spread footings are typically founded within 5 to 10 feet of the finished grade elevation. Construction of spread footings would require excavation, temporary dewatering if the excavation is below the water table, and placement of compacted backfill over and around the footing.
- A landslide hazard would exist if temporary slopes or excavations were made without sufficient stabilization or bracing.
- Demolition of bridges would require cutting of piles at or just below the mud line, which would cause some soil disturbance on the waterbody floor. Some existing piles could also be pulled, causing similar disturbance.
- Artesian groundwater conditions are suspected at the depths of drilled shaft foundations within and adjacent to Portage Bay and Union Bay. If artesian conditions are verified during design-level geotechnical explorations, they would affect the complexity of drilled shaft construction. Sand and gravel deposits (such as Vashon recessional outwash deposits) tend to be of moderate to high permeability, and excavation in these materials could require dewatering by rigorous methods if groundwater is penetrated. Temporary construction dewatering can be used to lower the groundwater table in the excavation and surrounding soils.

Lake Washington

Construction effects in the Lake Washington section would be similar to those described for Option A. See pages 54 through 55 of the Geology and Soils Discipline Report for further



discussion of these potential effects. Following are brief descriptions of possible short-term effects on geology and soils from construction:

- Disturbance of sediment on the lake bottom from temporary and permanent anchor installation.
- A low risk for construction of bridge foundations and temporary or permanent anchor installation to initiate submarine slope movement, which could damage underwater structures already in place.
- A low risk for a seiche or submarine slope movement occurring as a result of an earthquake during construction; these triggering events also have a low risk.
- Potential for construction dewatering or depressurization to affect water quality if dewatering systems were not properly located, designed, and maintained.

Bridge Maintenance Facility and Eastside Transition Area

- Effects at the bridge maintenance facility and in the Eastside transition area would be similar to Option A; however, more specific information was developed after publication of the SDEIS. Construction of the maintenance facility would cut through landslide-prone soils, into an existing slope. Evidence of slope creep and minor surficial slope movement was observed on the steep slope between Lake Washington and the existing east bridge abutment; however, deep-seated slope instability was not observed. Construction of the maintenance facility with cuts in these types of soils would be relatively more expensive than construction of cuts in other soils (such as the Vashon till or Vashon recessional or advance outwash deposits).

The supplemental explorations reported in 2010 indicate that there are elevated groundwater heads at the bottom of proposed excavations near the eastern approach. Exhibit 6 lists the estimated temporary construction dewatering flows for approximately the first two weeks of pumping and, thereafter, for each facility. Dewatering for all facilities need not be concurrent. The values in Exhibit 6 are likely to represent the highest dewatering rates due to the following reasons:

- The flows are based on seasonal high groundwater levels.
- Alternative designs with higher floor elevations are being pursued for the bridge maintenance facility.
- Use of compensating slurry weight within the drilled shaft temporary casing is likely to be used instead of deep aquifer depressurization for Piers 1 and 2.

Groundwater sampling and testing in the maintenance building/east highrise area has detected some metals levels in three wells that exceed the Model Toxics Control Act (MTCA) Method A cleanup levels. Groundwater pumped from this and any other areas of suspected groundwater



contamination will have to be tested and possibly treated prior to disposal. Potential treatment methods are likely to involve settlement and filtration to remove turbidity.

Exhibit 6. Approximate High Construction Dewatering Flows

Facility	Initial Pumping Rates (gpm)	Pumping Rates after Approximately First Two Weeks (gpm)
Piers 1, 2 (each)	30-60	30-60
Pier 3 Spread footing	1500	200-300
Wall 2	200-400	50-150
Wall 3	150-300	50-150
Soldier Pile Wall at Bridge Maintenance Facility	50-100	30-80
Bridge Maintenance Facility	100-150	50-100

How would operation of the Preferred Alternative affect geology and soils?

Following are brief discussions of potential operation effects of the Preferred Alternative on geology and soils that could generally apply to the entire study area. These effects are similar to Option A. See pages 56 through 63 of the Geology and Soils Discipline Report for a more detailed discussion. Where unique effects would occur for a specific area, they are described under “Area-specific Permanent Operational Effects.” The degree of these effects would depend on the specific site conditions, development plans, and final designs. However, with the exception of seismic hazards, the level of potential effects would be anticipated to be low. The risk of severe effects from seismic hazards under the Preferred Alternative would be significantly reduced by project design.

Topography

The finish topography of the project area would change somewhat through the construction of new embankments and the excavation of some areas. However, these changes would be relatively small because the widened roadway would follow the same corridor alignment as the existing roadway, which includes long bridge spans, and the footprint has been kept as small as possible by use of retaining walls.

Erosion Hazards

After construction and before re-established vegetation reaches protective levels, some accelerated erosion might occur. With proper mitigation, it is not anticipated that the erosion



rates would be high enough to change the character of lakebed materials or to affect lake water quality by observable amounts (see page 57 of the Geology and Soils Discipline Report).

Slope Instability and Landslides

The overall risk of slope instability and landslides would be low because the project would be designed to account for steep slopes and unstable soils, and long-term stability could be increased in some areas (see page 57 of the Geology and Soils Discipline Report).

Change in Groundwater Flow

Foundations, fills, or ground improvements included in the project design could alter groundwater flow paths beneath the ground surface; however, the potential direct effects are considered low (see page 58 of the Geology and Soils Discipline Report).

Long-Term Soil Settlement

Settlement of compressible soils beneath retaining structures, lids, or earth fills could occur and could require periodic maintenance of the new infrastructure. The potential long-term soil settlement would be accounted for in design, so its effect during operation should be low (see page 58 of the Geology and Soils Discipline Report). The main effect of compressible soils on long-term operation is to increase the risk that unforeseen subsurface variation, design error, or construction out of conformance with the plans and specifications could result in shortened pavement life or other damage to the facilities.

Seismic Hazards

The project corridor is located within a seismically active area. Seismic hazards and the related secondary effects would occur whether or not the project was built; however, the design of the facilities and earth-retaining structures would include seismic considerations so that collapse and irreparable damage do not occur, as required by current WSDOT standards (see pages 57 through 58 of the Geology and Soils Discipline Report). Structures would be designed to resist collapse from a seismic event with a 7 percent probability of occurrence over a 75-year design life (a recurrence interval of 1,000 years). A site-specific probabilistic hazard analysis was conducted and will be used in the project design (WSDOT 2009a).

Area-Specific Permanent Operational Effects

Effects would be similar to those for Option A (see pages 58 through 63 of the Geology and Soils Discipline Report). Exhibit 7 provides a qualitative rating of potential permanent effects for specific areas and options within the study area. This qualitative review does not replace the detailed geotechnical work that would be required during design development.



Exhibit 7. Operation Effect Potential by Area (Update to Exhibit 20 of the 2009 Discipline Report)

Area	Geologic Hazard				Long-Term Effects	
	Seismic Ground Shaking	Liquefaction	Seiche Risk	Erosion	Steep Slope/Landslide	Long-Term Settlement
Seattle						
Preferred Alternative	M-H	L	L	L	L	L
Option A	M-H	L	L	L	L	L
Option K	M-H	M	L	L	L	M
Option L	M-H	M	L	L	L	M
Lake Washington	M-H	L	L	M	M	L
Eastside Transition						
	M-H	L	L	M	L	L
No Build	H	M	L	L	M-H	M

Rating Legend:

H = High potential of occurring. Could cause major effects and might affect construction costs. Would require detailed studies.

M = Moderate potential of occurring or occurs in multiple locations. Could have some effects. Would require special consideration. Can be addressed using normal design and construction methods.

L = Low potential of occurring or localized occurrence. Does not appear to be a design or construction issue. Only a few locations would require consideration during design.

A qualitative rating of the frequency or seriousness of the potential effects related to geology and soils was assigned as follows:

- A low rating (L) was given to an effect that would have a low potential of occurring or if the effect would only occur in a localized area.
- A moderate rating (M) was given to an effect that would have a moderate potential to occur or if the effect would occur at multiple locations.
- A high rating (H) was given to an effect that would have a high potential to occur or if it could cause major effects; this rating triggers the need for more detailed studies.

Based on the preliminary engineering information that was available when performing this evaluation, none of the effects was determined to be a fatal flaw (an undue risk) that would prevent operation of the project.

The following subsections describe some potential area-specific operational effects. Geologic and soil issues would be addressed during final design. With the implementation of appropriate design, potential effects would be avoided.

I-5/Roanoke, Portage Bay, Montlake, and West Approach Areas

Potential operational effects of the Preferred Alternative in the Seattle portion of the project would be similar to those described for Option A. See pages 60 through 61 of the Geology and



Soils Discipline Report for further discussion of these potential effects. Following are brief descriptions of possible long-term effects specific to the Seattle portion of the project:

- Steep slopes are located along the existing project alignment, and the roadway passes through areas of historical landsliding and landslide-prone soils. The overall risk of landslide effects would be low because slope stability would be an engineering consideration for the proposed structures.
- The structures would be designed to avoid collapse during the design seismic event. Maximum design shaking could cause damage that would require temporary closures for repair.
- Overall (global) stability analyses would be performed during design, and retaining walls would be engineered to stabilize the slopes. In some cases, the factor of safety with a structure or cut slope in place would be improved over the existing factor of safety. Theoretically, steep slopes along alignments with the potential for sliding would be considered a low risk; construction of the project would actually improve the stability and decrease the risk of slope instability during operation. However, to account for potential unknowns in subsurface conditions, a low to medium risk has been assigned.
- The eastern end of the bridge over Portage Bay and the western end of the Lake Washington west approach structure would cross potentially liquefiable areas. Liquefaction could cause settlement, reduction in soil support around bridge foundations, and increases in vertical loads on bridge foundations from liquefied soil.
- The Preferred Alternative profile in the vicinity of the Montlake lid is slightly lower than in Option A but higher than in Option K. In some locations and at some times of the year, the profile may be below the groundwater surface, potentially requiring design of watertight structures, supplemental pumping to remove leakage, and design using widened structure heels, tie-down piles, or tie-down anchors to resist uplift. Wherever possible, the profile will be adjusted so that the roadway grade is above the groundwater table.
- Compressible soils beneath the embankments near the abutments on the east side of the Portage Bay Bridge and the west side of the Evergreen Point Bridge might settle over time. Design would include settlement mitigating measures, but there is always some risk that unforeseen subsurface conditions could cause settlement that occurs for longer periods or in excess of that anticipated.
- Preferred Alternative has effects similar to Option A for the crossing of the Montlake Cut.

Lake Washington

The City of Seattle (under Ordinance 122370) classifies the shoreline and upland areas along Lake Washington within the study area as having an “unknown risk from seiches.” Permanent effects



on geology and soils from operation of the Lake Washington elements might include the following:

- Seiche or tsunami risk to the bridge due to earthquake shaking. During the design life of the bridge, the likelihood of a seiche or tsunami that would be large enough to damage the Lake Washington elements is considered low.
- Unanticipated and undetected settlement of temporary or permanent anchors could damage the cables.
- A submarine landslide initiated by an earthquake might cause anchors to slide.
- A submarine landslide could induce a tsunami. During the design life of the bridge, the likelihood that a submarine landslide would be large enough to induce a tsunami of a magnitude that could damage the Lake Washington elements is considered low.

Eastside Transition Area

Permanent effects on geology and soils from operation of the Eastside transition area elements might include the following:

- The City of Seattle (under Ordinance 122370) classifies the shoreline and upland areas along Lake Washington within the study area as having an “unknown risk from seiches.” The maintenance facility dock would be located on Lake Washington. Lake Washington might also have a tsunami risk if the Seattle Fault Zone, located at the southern end of Lake Washington, were to rupture. Small seiches in Lake Union have damaged docks and pulled them from their moorings. The project’s maintenance facility dock would be designed with seismic considerations in mind. In addition, during the design life of the dock, the likelihood that the Seattle Fault Zone would rupture is considered low.
- The bridge maintenance facility would replace soil and an existing slope with a three-story-high building. This building would be designed to withstand the loads from landslide-prone soils, which would increase the stability of the existing slope, which is currently below WSDOT goals for global stability of critical structures. However, if unanticipated subsurface conditions exist, long-term, additional loading from increased groundwater levels or an earthquake could damage the structure.
- Groundwater would be captured by the underdrains for retaining walls 2 and 3, the abutment wall at Pier 3, and the wall and underdrain for the bridge maintenance facility. Estimated long-term discharge from these sources is listed in Exhibit 8.
- Near the bridge maintenance building, groundwater heads from both perched and deep confined aquifers have been measured at elevations above the lake level. Flow from these high-head groundwater zones may intercept the foundation for the maintenance building, resulting in uplift on the structure as well as high lateral loads on the upslope walls.



Alternatives to reduce the uplift forces will continue to be examined during design but could include the following:

- Design of an underdrain system that would gravity drain to the lake
- Revision of the site plan so the structure does not penetrate so deeply into the ground
- Design of a watertight structure supported by tension piles or tie-down anchors to resist uplift loads
- Design of a pumped underdrain system that would drain to the lake

Exhibit 8. Approximate Long-Term Wall Drain or Underdrain Discharge

Facility	Approximate Long-Term Wall Drain or Underdrain Discharge Rate (gpm)
Piers 1, 2 (each)	None ^a
Pier 3 Abutment Wall	30-40
Wall 2	<10
Wall 3	<10
Soldier Pile Wall at Bridge Maintenance Facility	25-35 ^b
Bridge Maintenance Facility	80-100 ^b

^a The completed bridge shafts can tolerate existing hydrostatic pressures once the concrete has set, so long-term dewatering is not required.

^b High estimated rate for floor at elevation 22 feet. Alternatives to raise the floor elevation are being pursued, which would decrease the flow rate.

A watertight structure with tension piles or anchors is not preferred because of the high cost and need for double wall system to keep leakage from the building interior. A facility using a pumped underdrain system is also not preferred because of high cost and reliability concerns. Currently, modifications are being explored to raise the floor of the maintenance building as much as possible to allow gravity drainage of an underdrain system.

Long-term flow from an underdrain system with a floor at elevation 22, as shown in Exhibit 8, could lower the groundwater head by 10 feet at locations 100 feet from the facility. Flow and drawdown from a higher floor elevation would be less. The downgradient effects of water capture and aquifer depressurization by this and the other long-term sources listed in Exhibit 8 are unknown, but at worst case, they could potentially alter the groundwater flow regime, changing the upwelling characteristics of a small portion of the reported near shore sockeye spawning habitat in Lake Washington.

Contaminated groundwater with arsenic concentrations above MTCA Method A cleanup levels have been found in unfiltered samples from three wells in the east highrise/maintenance building area. However, the contamination is at very low levels or nondetectable in filtered samples. This suggests that after initial stabilization there would be no metals contamination in long-term underdrain discharge as long as the underdrain system was carefully designed and constructed to meet geotechnical granular filter criteria.



Mitigation

What has been done to avoid or minimize negative effects on geology and soils?

This report discusses various procedures that could be implemented to avoid or minimize negative effects of the project related to geology and soils. The mitigation methods and procedures listed in this report are not a comprehensive listing of all mitigation methods and procedures, but they provide potential measures for expected project effects. Mitigation measures outlined here will be further developed during detailed engineering design and construction planning.

Use of Aggregate Resources

One approach to reduce the amount of imported aggregate would be to mix onsite materials that were slightly over optimum moisture content with additives (such as fly-ash or cement) to facilitate their reuse. This approach could be costly and require additional working space and time. Therefore, the trade-offs between reuse and hauling materials offsite would have to be carefully evaluated.

Another way to reduce the amount of imported aggregate could be to recycle existing pavements or structures. It is anticipated that some or all existing pavements and structures might be recycled for this project. Onsite aggregate recycling machinery would comply with applicable noise and air quality regulations. Scheduling and space requirements might limit which recycled materials could be efficiently reused on this project, but it is likely that the recycled materials could be used on other Puget Sound area projects.

Seismic Hazard

Where movement of liquefiable soils could cause collapse or irreparable damage to structures or critical utilities, the liquefiable materials could be stabilized by one of several methods of ground improvement. The zone of improvement commonly extends vertically from the ground surface to the limits of liquefiable material. The horizontal limits of ground improvement could be determined from slope stability analyses. At the current state of design development, no ground improvement is needed or planned. Typically, if ground improvement is needed, it can be limited horizontally to the area several feet in front of and behind the bridge abutment fill walls. WSDOT policy does not require that liquefaction be prevented, only that soil deformations caused by liquefaction be limited to prevent collapse or irreparable damage to structures, walls, or critical utilities.



Typical methods of ground improvement include the following:

- Stone columns, which are typically 3-foot-diameter columns of compacted gravel, horizontally spaced at approximately 7 to 10 feet on center
- Ground densification using vibro-densification or vibro-replacement methods
- Grouted columns of cement and soil that range in diameter from 2 to 5 feet
- Excavation and replacement with nonliquefiable soil

Where liquefiable soils are present beneath or adjacent to bridge or elevated structure columns, the soil could be improved or the bridge could be designed to withstand the lateral loading of the liquefied soil. Lightweight embankment materials are sometimes used to reduce the driving loads that could induce movement of the liquefied soil.

Construction methods used to improve soils that are subject to liquefaction during a seismic event could generate earth spoils and water with a high sediment content and high pH where cement was used. Spoils and runoff from spoils could be contained by ditches, silt fences, berms, or possibly sheet pits, depending on the location and topography. Runoff from spoils containment and storage areas could be monitored and treated if necessary to meet specified discharge criteria.

A seismic event could initiate movement on known or unknown unstable submarine slopes in Lake Washington. The stability of slopes with a history of landsliding will be evaluated in detail during final design so that the integrity of structural anchorages is maintained during the design earthquake.

Long-Term Settlement

Much of the SR 520 I-5 to Medina corridor is through soils subject to long-term settlement. Deep foundations could support the bridges, with the foundations bearing in very dense, relatively incompressible material. However, in transitional areas, retaining structures and fill materials could be constructed over normally consolidated (that is, not overridden by glaciers) silt or clay or over existing fill, which could settle over time. These sections could be engineered to limit long-term settlement to levels that would not damage structures or substantially reduce the life of Portland cement concrete pavement.

Example solutions to minimize long-term settlement include the following:

- Preloading the soil so that most of the anticipated primary settlement occurs prior to final grading
- Lengthening the construction period to allow time for the soils to consolidate before final grading or paving



- Installing vertical drains, possibly in combination with preloading, so that the predicted settlements occur quickly, before final grading
- Strengthening the ground by installing soil cement columns or stone columns, or by jet grouting or cement deep-soil mixing so that the total settlement, over any time period, would be reduced
- Reducing the weight of the earth fill by constructing it of closed-cell polystyrene blocks (that is, expanded polystyrene or Geofoam), imported pumice, expanded shale (all three of which are petroleum-intensive), or lightweight cellular concrete so that minimal settlement would be induced
- Constructing the embankment as a pile-supported embankment where deep foundations are used to transfer earth loads to incompressible strata
- Relocating or protecting utilities in locations where ground settlement could not be mitigated
- Underpinning structures if it appeared that new fill materials would cause settlement below existing structures
- Installing recharge wells for de-watering if construction de-watering analyses indicated that de-watering would result in settlement below structures or other settlement-sensitive facilities
- Modifying construction techniques (such as the type of pile or installation equipment)

Pre-, during-, and post-construction surveys of potentially affected structures and a construction monitoring program could be established, where necessary. These could include surface survey points and subsurface instrumentation. The monitoring program could include the use of slope inclinometers to monitor horizontal movement, borehole extensometers or settlement plates to monitor settlement within different layers, and groundwater observation wells to monitor the dissipation of excess pore water pressures resulting from fill placement.

Groundwater flow conditions, foundation support of adjacent existing structures, and construction scheduling could be considered during design to implement the proper solution for minimizing settlement. Restrictions could be added to construction contracts that specify means to avoid the settlement of nearby facilities during construction. If settlement of facilities is unavoidable or economically infeasible, corrective measures could be required. These measures could include regrading and paving roadways, rerouting or temporarily pumping buried utility lines, and constructing new lines after settlement is mostly complete.

Landslide Hazards

Slopes and earth-retaining structures could be designed to provide either standard factors of safety or limited permanent movement during long-term static and seismic conditions.



Measures that could be used to reduce the risk of landslides include the following:

- Using designs appropriate for the soil properties
- Improving surface and subsurface drainage to increase soil strength
- Using retaining structures or ground anchors to stabilize slope movement
- Incorporating construction specifications and quality assurance programs that would maintain soil strength

Glacially overconsolidated clays (glaciolacustrine deposits [Qvgl] and transitional beds [Qtb]) are known to be landslide-prone in this area. The Lawton clay is a relatively well-publicized example of a slide-prone glacially overconsolidated clay in the Seattle area. Where the glacially overconsolidated clay is present, the major causes of slope instability and methods of mitigation are typically as follows:

- In retaining wall design, the soil is often allowed to deform so that the interparticle friction takes a large portion of the lateral load. This amount of deformation in the Lawton clay (or similar materials) could result in the material losing a substantial amount of strength. The local design practice developed over several years has been to design walls for this residual soil strength and to limit the height of temporary unsupported cuts and slopes so that movement is limited.
- The removal of upper soil layers can sometimes allow surface water infiltration to saturate existing vertical cracks in the top of the overconsolidated clay; the water reduces the strength of the overconsolidated clay. Most of the widening for the project could be accomplished by constructing walls rather than cutting, so there would be small risk of changing how water infiltrates. The addition of subsurface drainage in the form of seepage collection trenches and horizontal drains could be considered to lower the possibility of additional infiltration into the overconsolidated clay. Surface water runoff could be diverted around known clay slopes to minimize the risk of infiltration.
- The glacially overconsolidated clay is frequently interbedded with sandy zones, which tend to convey groundwater at a much higher rate and are frequently under much higher groundwater pressure heads than the adjacent clay and silt layers. Sometimes when these sandier layers are exposed, internal erosion (called piping) due to the groundwater pressure can cause sloughing and destabilization of the face. Drainage blankets, horizontal drains, and confinement of the face could be used to control this type of sloughing.
- Cyclic weathering deterioration can reduce the strength of the glacially overconsolidated clay. As noted previously, little is planned to change the topography outside of the roadway prism made by retaining walls. In some locations, however, surcharge weights might be considered over exposed glacially overconsolidated clay to limit this strength loss.



The global stability of a hillside is considered during design. The boundaries of this stability analysis are natural features that tend to halt the natural progression of movement downslope, as illustrated on Exhibit 9. Therefore, the design would consider both the right-of-way and the surrounding property.

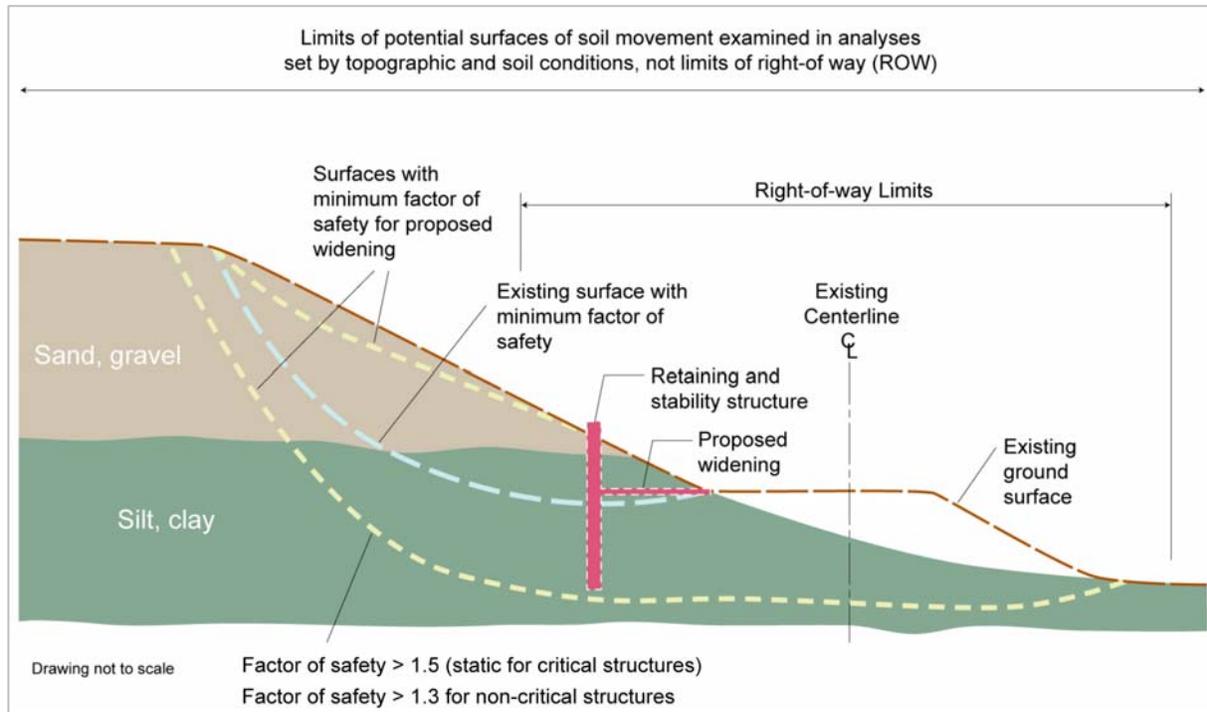


Exhibit 9. Limits of Slope Stability Analysis (Update to Exhibit 21 of the 2009 Discipline Report)

Where stability conditions appear to be uncertain, a monitoring program could be developed to monitor changes in pore water pressures in the soil and horizontal movement during construction.

Erosion and Sedimentation Control

A comprehensive temporary erosion and sediment control plan will be prepared before construction begins. The temporary erosion and sediment control plan would be implemented using best management practices (BMPs) for erosion control and the current WSDOT Highway Runoff Manual. Monitoring will be performed to ensure continued mitigation throughout construction.

Erosion and sedimentation could be reduced by limiting the major earthwork to drier months of the year where soil was disturbed or where soil was exposed in erosion and landslide hazard areas. WSDOT will implement erosion and sedimentation control practices to limit the amount of suspended solids in the runoff leaving the project site and will apply BMPs to protect water quality. WSDOT will monitor BMP performance and compliance with all federal, state, and local regulations.



BMPs might include the following:

- Maintaining vegetative growth and providing adequate surface water runoff systems
- Using modified construction driveways, and where practical, truck washes at construction vehicle exits from the site
- Regularly sweeping and washing adjacent roadways
- Constructing silt fences downslope of exposed soil where appropriate
- Using quarry-spall-lined temporary ditches with straw bales or other sediment catchment dams to control construction stormwater runoff
- Covering and stabilizing exposed soils to prevent and minimize erosion
- Constructing temporary sedimentation ponds for removal of settleable solids prior to discharge
- Limiting the area exposed to runoff at any given time

Permanent erosion control could be achieved by the following:

- Constructing stormwater detention facilities to limit flow velocities
- Revegetating disturbed slopes as permanent erosion control
- Collecting concentrated drainage in rock-lined ditches or pipes
- Providing energy dissipation upstream of discharge points where appropriate

These facilities and measures could be monitored to verify function and could be maintained, as necessary, over the life of the project.

Vibration

Permitted compliance conditions for demolition and construction would limit the magnitude of ground vibrations. The limitations would depend on the types of structures nearby and the consequences of any potential damage to these structures. To minimize the effect of ground vibrations during construction, equipment that minimizes the potential for vibration could be selected.

Methods to minimize vibration may include the following:

- Using drilled piles or shafts instead of pile-driving
- Switching to a different hammer or pre-boring pilot holes before pile-driving



- Driving piles that are within water bodies inside cofferdams to attenuate vibrations (which could allow pile-driving work to continue during in-water work fish windows) or scheduling as much pile-driving as possible to occur outside the fish window to reduce effects on fish
- A pile-vibration test program was conducted in October 2009 (WSDOT 2010c). This test program involved collecting underwater and in-air sound data during test pile-driving using three sound attenuation methods to evaluate the sound propagation characteristics in the study area and to provide information necessary for a contractor to design the work trestles. Turbidity levels associated with each attenuation method were also measured (WSDOT 2010c).

Groundwater

Where construction dewatering could result in settlement that might damage adjacent facilities, mitigation could include the following:

- Reinjecting the pumped groundwater between the dewatering wells and the affected facility
- Using construction methods that do not require dewatering, such as:
 - Slurry cutoff walls, secant pile walls, or sheet pile walls with a bottom tremie plug
 - Using existing low-permeability soil layers to reduce flow under the walls
- Using ground freezing as a groundwater cutoff
- Whenever reasonable, keeping the finish grade or floor of facilities above the groundwater table to avoid the need for long-term pumping

What would be done to mitigate negative effects that could not be avoided or minimized?

Negative effects on geology and soils could be avoided or minimized through the measures identified above. The only effects that could not be avoided are those related to seismic ground shaking and disturbance of cultural resources due to excavation.

Operation Mitigation

All roadway options would be designed to WSDOT and AASHTO design standards, which address seismic loading, retaining walls, and related components of the project. Facilities continuously occupied by people, such as the bridge maintenance facility, would be designed per the International Building Code (IBC).

Areas would be stabilized where soils are liquefiable and/or prone to settlement or landslide, including the eastern end of the Portage Bay Bridge and the Evergreen Point Bridge west approach structure. These measures could include supporting the roadway on columns, improving soils beneath bridge columns, designing bridge columns to withstand seismic motion,



and/or excavating areas of vulnerable soil and replacing them with stronger material. Slide-prone slopes at the east bridge approach and bridge maintenance facility would be supported by soldier pile or secant pile walls, which would increase the factor of safety of sliding above existing levels.

Due to the sensitive nature of Foster Island as a traditional cultural property, ground disturbance and excavation in this area would be limited as much as possible. Other mitigating methods are discussed in the Final Cultural Resources Assessment and Discipline Report (WSDOT 2011d).

The bridge maintenance building walls at the eastern approach could be designed to the higher of the AASHTO or IBC standards so that their damage during a seismic event would not affect the adjacent Pier 3 bridge abutment. Although the IBC design is for an earthquake with a recurrence interval of 2,500 years, higher than the 1,000-year AASHTO standard, various design factors do necessarily make the IBC more earthquake resistant than the AASHTO standard.

What negative effects would remain after mitigation?

An unavoidable adverse effect would be one that has a high likelihood of occurrence and would present a risk to public property or public safety, one that might require new locations for the project, or one that might require a different method of supporting a roadway or structure. An example of an unavoidable adverse effect for geology and soils would be a landslide risk on a new roadway in an area of steep slopes. In this example, it might be necessary to change the roadway alignment to reduce risk to an acceptable level.

The most substantial unavoidable adverse effect related to geology and soils is the potential effect of earthquake ground-shaking on the stability of soils supporting the project structural components. Appropriate mitigation methods are available to deal with the consequences of seismic loading, including mitigation for liquefaction potential and densification of the soil through use of ground improvement methods. In addition, designers must follow WSDOT and AASHTO design requirements for seismic loading in their designs of all bridges, retaining walls, and related components of the project.

Other unavoidable effects would include localized lowering of the groundwater table where pond bottoms or drainage layers for structures are located below the water table. For example, the bridge maintenance facility building with a finish floor at elevation 22 could result in localized water table lowering, or drawdown, of 10 feet at a distance of 100 feet from the facility. Design revisions are underway to increase the floor elevation and reduce this drawdown. However, unless the bridge maintenance facility, retaining walls 2 and 3, and the Pier 3 abutment wall are located above the water table, there will be some, though relatively minor unavoidable effects on the groundwater flow. With the current understanding of groundwater flow in the area, it is not possible to say if these drain captures would have measurable effects on the reported upwelling in the near-shore environment of Lake Washington.



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Attachment 1

Errata

Attachment 1

Geology and Soils Discipline Report

Errata

The following table corrects errors in and provides clarifications to the Geology and Soils Discipline Report (WSDOT 2009a). The discipline report and SDEIS will be further updated as errors are discovered or to clarify points of confusion. Additional updates and corrections will be made either with additional errata or in the Final EIS, anticipated to be released in spring 2011.

Page	Current Text	Corrected Text/Clarification
3	<ul style="list-style-type: none"> Usual and accustomed fishing areas of tribal nations that have historically used the area's aquatic resources and have treaty rights 	<ul style="list-style-type: none"> Usual and accustomed fishing areas <u>of the Muckleshoot Tribe, which has tribal nations that have</u> historically used the area's aquatic resources and <u>have</u> treaty rights <u>for their protection and use</u>
49	Exhibit 19, Seattle – Overall row	<i>Deleted</i>
59	Exhibit 20, Seattle – Overall row	<i>Deleted</i>
65	Mitigation measures could be identified and evaluated during detailed engineering design and construction planning and could be finalized during the Record of Decision process.	Mitigation measures could <u>would</u> be identified and evaluated during detailed engineering design and construction planning and could be finalized during the Record of Decision <u>permit acquisition</u> process.
69	A comprehensive temporary pollution control plan would be required before construction began. The temporary pollution control plan...	A comprehensive temporary pollution <u>erosion and sediment</u> control plan would be required before construction began. The temporary pollution <u>erosion and sediment</u> control plan...



