3.2 Geology and Soils

What are the geologic and soils characteristics in the study area?

The study area for geology and soils includes the land within the boundaries of the Grays Harbor build alternative sites and the existing CTC casting basin facility in Tacoma (Exhibit 2-1 in Chapter 2). Information about geology and soil characteristics is important because it helps to determine the type and size of foundation on which the proposed casting basin would be built.

The geologic conditions at a site can be divided into *surficial* soil immediately at the ground surface, and *subsurface* soil, existing above bedrock. Generally, *subsurface* soil comprises those sediments below the zone where animals, roots, and biological activity exist. The characteristics underlying the study area determine to a large extent the design and construction methods that WSDOT would use to build the casting basin facility. Geology and soils also affect long-term project operational issues.

What is the Geology and Soils Technical Memorandum?

This section was derived from the Geology and Soils Technical Memorandum, which details the following information:

- Existing geologic and soils conditions
- Geology and soils analysis data sources
- Boring and well locations at the Grays Harbor build alternative sites
- Project potential effects
- Typical engineering solutions to minimize long-term settlement
- Potential avoidance, minimization, and mitigation measures

For more detailed information on these topics, please refer to this document in Appendix D.

CTC Facility

Before the Port of Tacoma was developed, the geology and soils at the present-day CTC site were largely the result of natural deposition processes from the Puyallup River flowing into Commencement Bay. The natural topography at the CTC site has since been altered; the CTC facility is mapped as being underlain by fill (Logan 1987), which would have been imported to the site.

The site is flat except for a small casting basin and launch channel that is located below grade. The surficial soils at the CTC site are mapped as “made land,” which is classified as soils that have been modified through dredging, grading, or industrialization. The subsurface soils at the CTC site are fill underlain by a loose to medium dense sand to silty sand (Hart-Crowser and Associates and Port of Tacoma, date unknown). WSDOT’s analysis found no groundwater information for the CTC site itself, but groundwater near the site typically is shallow, normally within the upper 12 feet (Port of Tacoma 2008), and its elevation is expected to fluctuate with the tide.

What is liquefaction?

Liquefaction is a phenomenon in which the strength and stiffness of a soil is temporarily reduced and the soil takes on the character of liquid. This can occur during an earthquake. Liquefaction occurs in saturated soils— soils in which the space between individual particles is completely filled with water.

The CTC site is prone to seismic hazards similar to those at the Grays Harbor build alternative sites (described below under *Seismic Hazards*), including ground-shaking, liquefaction, fault hazards, and inundation. This site is underlain by soil susceptible to liquefaction (Hart-Crowser and Associates and Port of Tacoma, date unknown). The CTC facility’s foundation consists of 14-inch-diameter piles that are bearing on a dense soil unit. The facility was not designed to withstand seismic hazards and would likely be damaged during a large earthquake. The site is also susceptible to inundation from mudflows or debris flows that could be caused by a volcanic eruption of Mount Rainier. Using this site would not alter the study area's geologic hazards, nor would soft soils and settlement be a geologic hazard at the CTC facility site.

Grays Harbor Build Alternatives

Present Condition of Geology and Soils

Similar to the CTC site, the geology and soils in the Grays Harbor area have been built up by natural deposition processes from the rivers flowing into Grays Harbor, although the area has since been altered with the area's development since the late nineteenth century. Soil for fill was imported and exported to and from the area, and soils were dredged from along the shoreline to keep the navigation channel clear and enable ships to dock at existing marine terminals, further altering the area's native geology and soils. Imported soil for construction purposes typically improves the ability of the soils to support new structures, roads, and other features needed in developing areas.

Underlying Geology and Soils

The study area is covered with fill, with varying amounts of wood waste in the upper 15 feet and underlain by alluvium (Logan 1987). According to available geotechnical reports (Landau Associates 2009a, b, c, d, e), fill was placed on both Grays Harbor build alternative sites, and it overlies the alluvium. The loose and soft alluvium soil deposits are underlain by denser material consisting of outwash from receding glaciers (recessional outwash). Exhibit 3.2-1 shows the geologic units underlying both Grays Harbor build alternative sites in a general cross-section profile for each site; individual soil units are listed for each site in the *Underlying Geology and Soils* subsection below. For the purposes of describing environmental effect in this Draft EIS, WSDOT analysts numbered the soil units so that they have similar characteristics between the two sites. Exhibit 3.2-2 summarizes typical engineering properties and hazard susceptibilities of the geologic units potentially within the site boundaries. The National Resources Conservation Service (NRCS) mapped surficial soils for the Grays Harbor build alternative sites as alluviums (NRCS 2008).

What is alluvium?

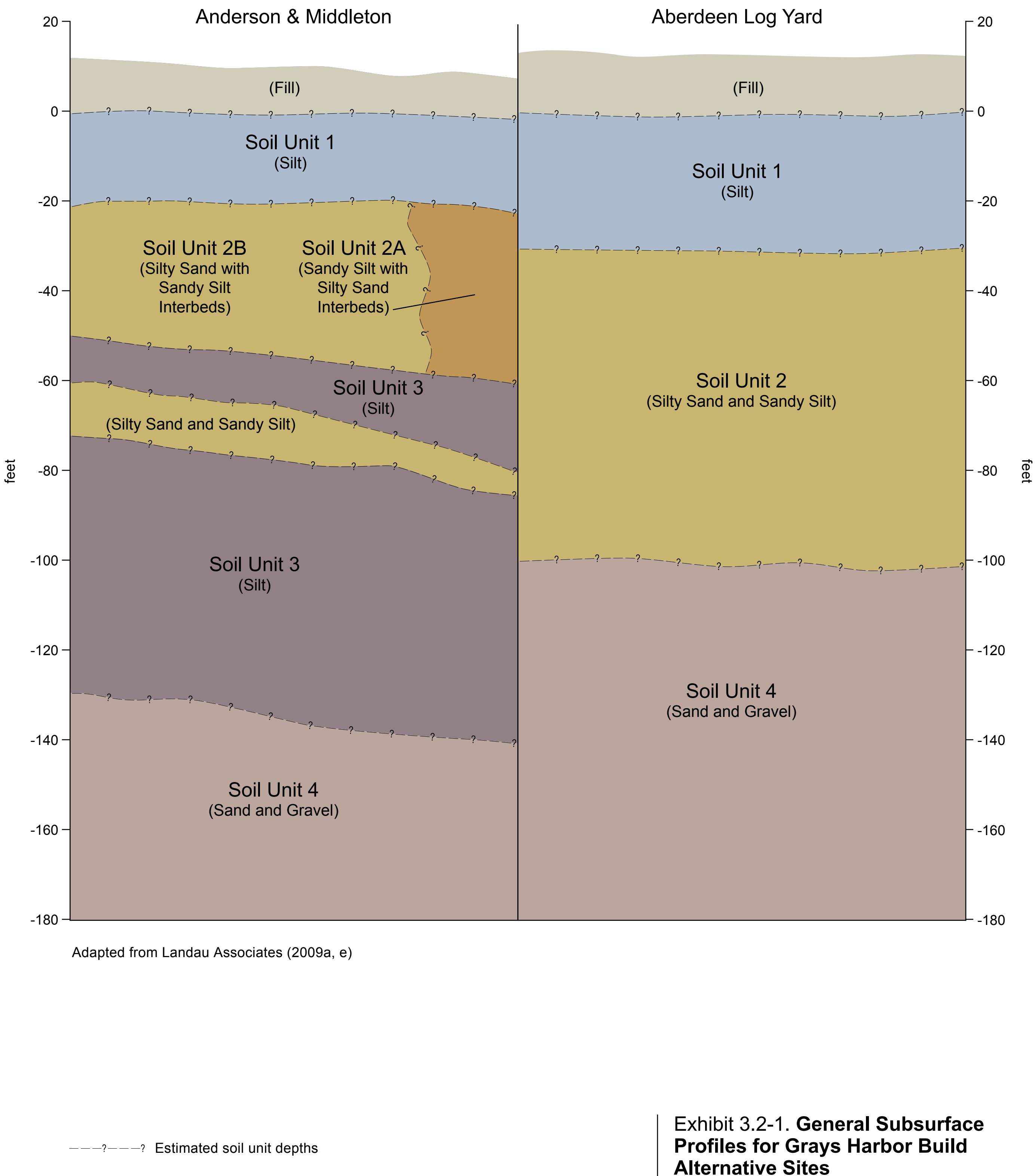
Alluvium refers to sediments or soils deposited by a river or stream; it can contain silt, clay, sand, and/or gravel.

Groundwater Characteristics

Within the Chehalis River basin—in which both build alternative sites are located—there are two distinct aquifers within the alluvium: the upper aquifer extends to a depth of approximately 100 feet, and the lower aquifer is present below the 100-foot depth.

What is an aquifer?

An aquifer is an underground water-bearing layer of soil, gravel, or rock that can store and yield groundwater to wells or springs.



Adapted from Landau Associates (2009a, e)

Exhibit 3.2-1. **General Subsurface Profiles for Grays Harbor Build Alternative Sites**

Pontoon Construction Project

Washington State Department of Transportation

EXHIBIT 3.2-2
Typical Engineering Properties and Hazard Susceptibility of Geologic Units Underlying the Grays Harbor Build Alternative Sites

Geologic Unit	Strength	Permeability	Liquefaction Potential[a]
Fill (Soil Unit 1)	Potentially low	Variable	Potentially high
Alluvium (Soil Units 2 and 3)	Potentially low	Variable	Potentially high
Recessional outwash (Soil Unit 4)	High[b]	High	Low

[a] Liquefaction depends in part on material density and the groundwater table elevation; these ratings assume a shallow groundwater condition.

[b] High strength unless cut vertically below the water table, then potentially low to medium strength.

Note: The terms low, medium, and high were determined based on professional opinion of those with experience with the soil types. Hazard susceptibility was determined based on criteria in City of Hoquiam Municipal Codes 10.09.080 and professional opinion.

Geologic Hazards

Geologic hazards can be a risk to the safety of construction workers while a project is being built and for onsite personnel when a facility is operating. These hazards consist of *seismic* hazards and/or *soft ground settlement* hazards. For example, ground-shaking is a seismic hazard that, during an earthquake, can cause soil liquefaction, which can damage the structural integrity of facilities built on soils prone to liquefaction. Geologic hazards unique to each build alternative site are described below separately for each alternative.

Seismic Hazards

Seismic hazard areas pose risks to structures and property damaged by earthquake-induced ground-shaking, slope failure, settlement, soil liquefaction, or surface faulting. The primary seismic hazards in western Washington involve ground-shaking hazards, liquefaction hazards, faulting hazards, and tsunami inundation or seiche hazard. The potential for future earthquake-related ground-shaking is relatively high throughout western Washington (see Exhibit 3.2-3).

What is a seiche?

A seiche is a wave that swings back and forth in an enclosed body of water such as a lake or bay. A seiche can last from a few minutes to a few hours and is often caused by earthquakes.

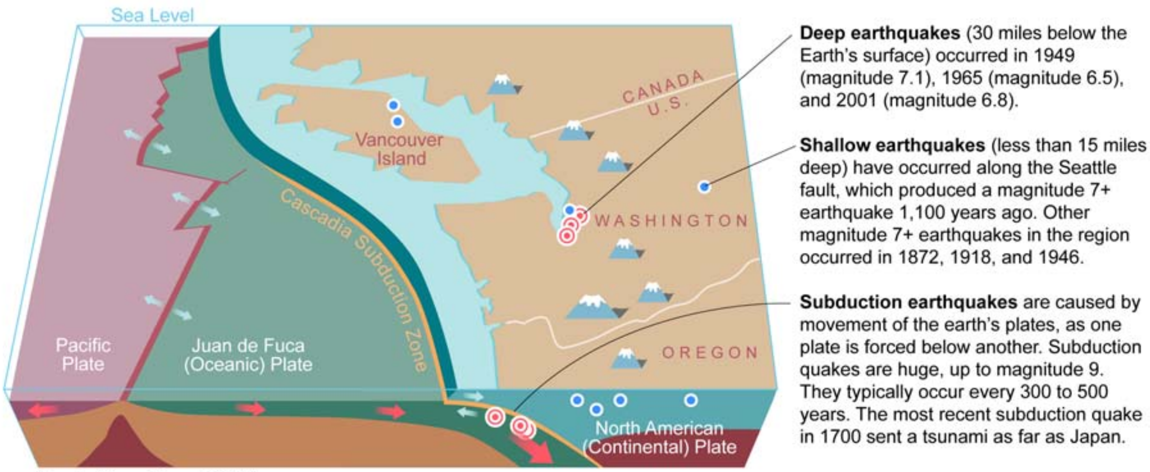
Direct effects on geology and soils from ground-shaking during earthquakes (not from vibration caused by machinery or equipment used for the project) include liquefaction, faulting, and tsunami inundation. Structural damage often occurs during an earthquake as the motion of the ground-shaking interacts with the structure.

During an earthquake, soil liquefaction and the accompanying settlement, lateral spreading, and floatation of buried pipes can occur where areas are underlain by low-density, cohesionless soils (for example, fine-grained sand, silt, or sandy silt), with a shallow groundwater table. The fills and alluvium that underlie each Grays Harbor build alternative site are loose and saturated and, therefore,

What is lateral spreading?

Lateral spreading consists of lateral movement of level or near-level ground associated with liquefaction of soil during an earthquake.

EXHIBIT 3.2-3
Potential Seismic Source Zones in the Pacific Northwest



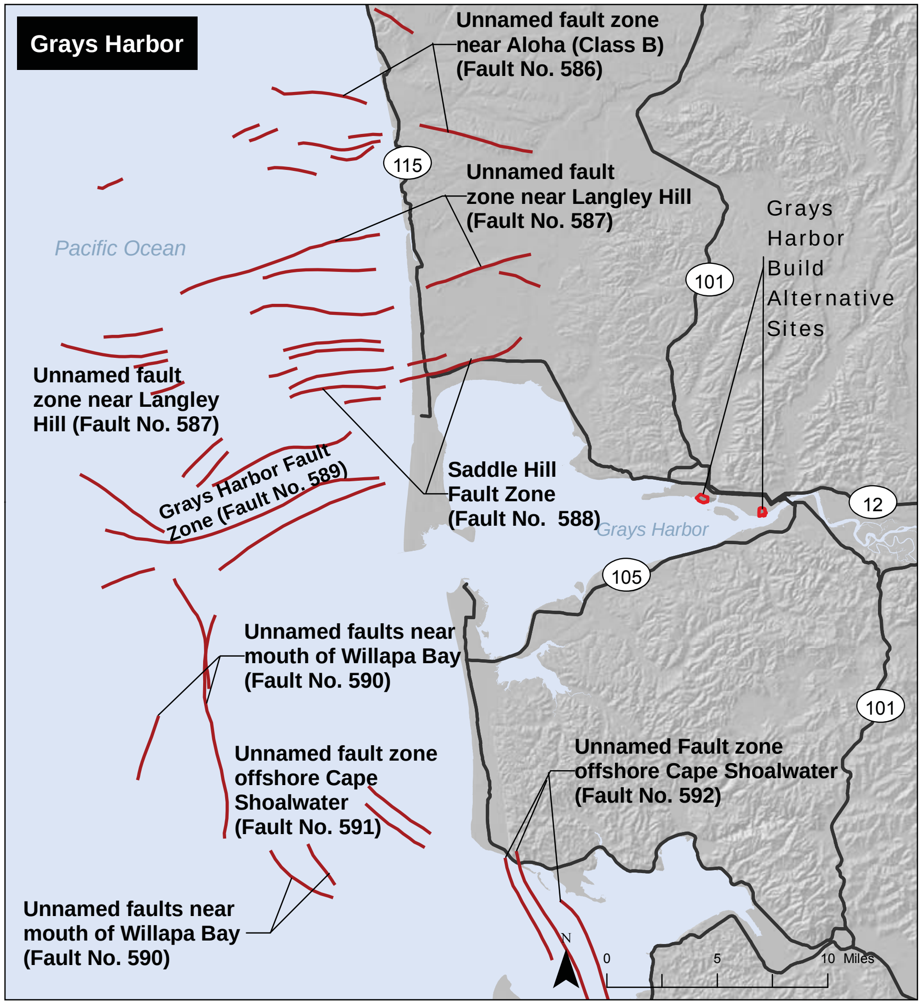
Adapted from Troost (2003)

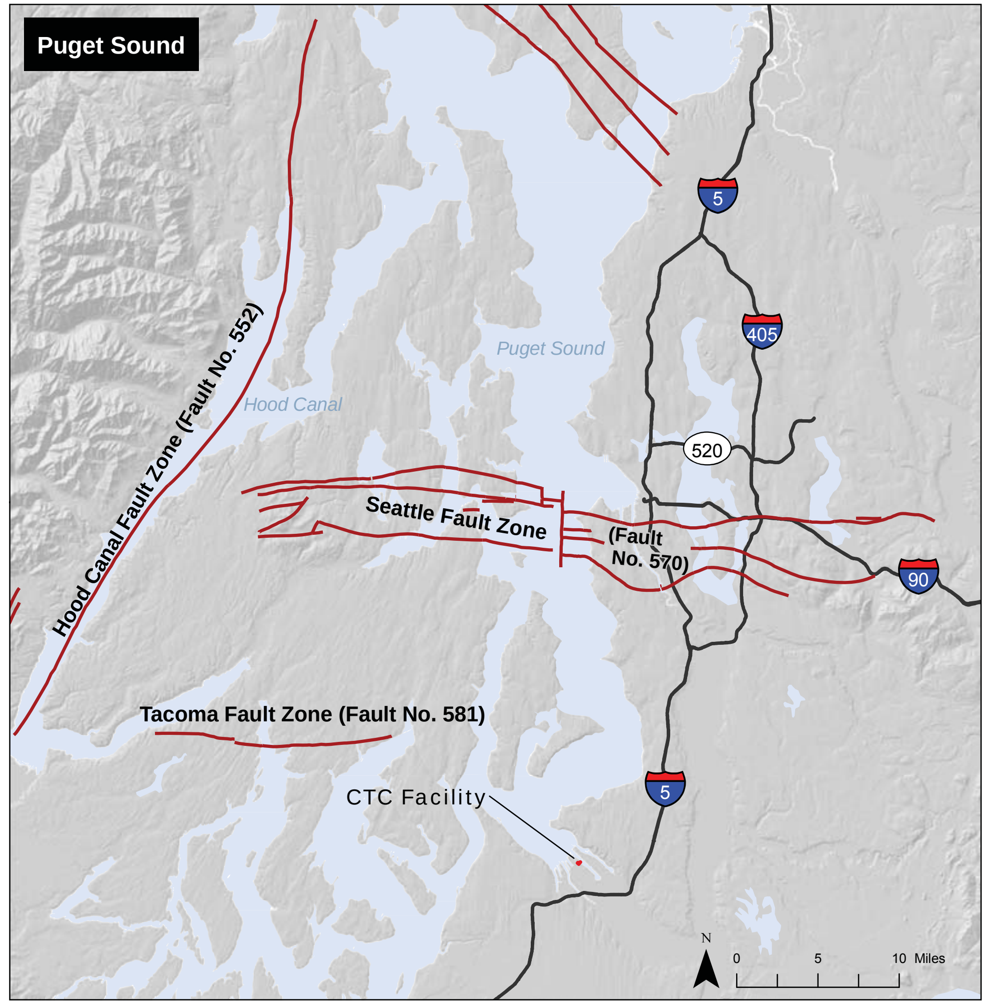
potentially susceptible to liquefaction during earthquake-shaking. There are six earthquake fault zones within 20 miles of the Grays Harbor build alternative sites; the closest is about 10 miles from the sites (Exhibit 3.2-4). Although these faults are considered active by the U. S. Geological Survey (USGS), the potential for a ground surface rupture from fault movement during an earthquake is low because of the distance (more than 10 miles) of the study area from the mapped faults. There might be, however, unmapped faults in the area that could potentially pose a risk to the alternative sites.

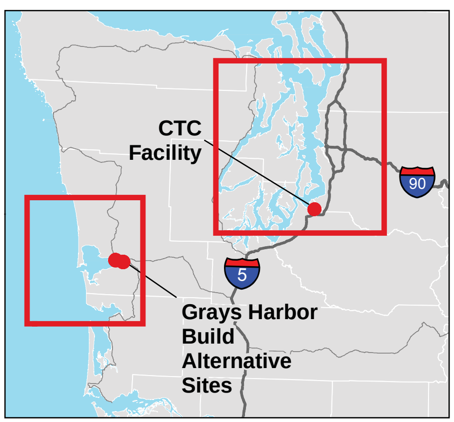
The Grays Harbor build alternative sites are in a tsunami inundation zone (Exhibit 3.2-5). Tsunamis present a severe threat to the coastal areas of Washington; however, geologists think the risk of tsunami inundation hazard is low, given the low annual frequency of large earthquakes. There would also likely be enough warning to evacuate if a large tsunami from a distant source is forecast. Nevertheless, a potential for these hazards does exist.

Settlement or Soft Ground Hazards

The ground in areas underlain by soft or loose compressible sediments can settle during and after construction. Structures and buried utilities might settle unevenly (differential settlement) and become damaged unless they are supported on piles or the ground is improved with special construction procedures. Generally, areas mapped as liquefaction areas (as are both build alternative sites) also coincide with areas of settlement hazard. At both build alternative sites, buried logs and old piles could protrude through the fill when settlement occurs.







Fault

Build Alternative Site

Source: USGS (1999) GIS Data (DEM) and (2004) GIS Data (Faults), WSDOT (2004) GIS Data (State Route). Horizontal datum for all layers is State Plane Washington South NAD 83; vertical datum for layers is NAVD88.

Exhibit 3.2-4. **Study Area Fault Zones**

SR 520 Pontoon Construction Project

Washington State Department of Transportation

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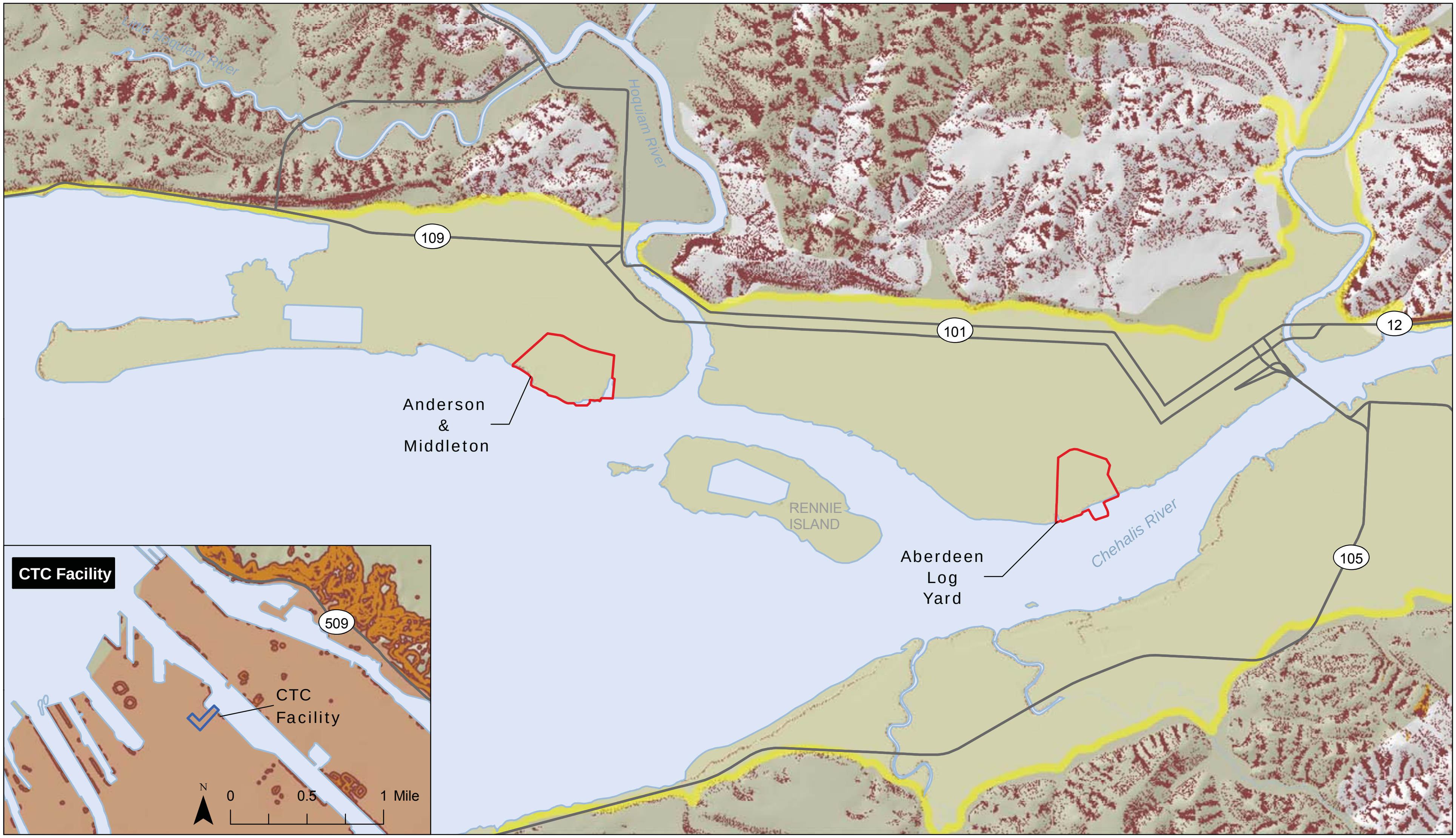

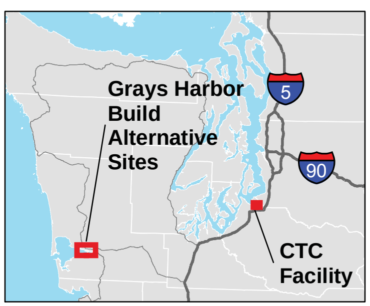

- Tsunami inundation limit
- Volcanic inundation limit
- Slope instability
- Landslide hazard
- Liquefaction hazard
- Build Alternative Site
- Existing CTC facility

Source: USGS (1999) GIS Data (10-meter DEM), WDNR (2000) GIS Data (Slope Instability), (2004) GIS Data (Liquefaction and Landslide Hazard), City of Tacoma (2006) GIS Data (Steep Slope), Pierce County (2004) GIS Data (Liquefaction), and Grays Harbor County (2006) GIS Data (Waterbody). Horizontal datum for all layers is State Plane Washington South NAD 83; vertical datum for layers is NAVD88.

N 0 1,500 3,000 6,000 Feet

Exhibit 3.2-5. **Study Area Geologic Hazards and Inundation Limits**

SR 520 Pontoon Construction Project

Washington State Department of Transportation

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Anderson & Middleton Alternative

Topography

The Anderson & Middleton site is relatively flat, and average surface elevations range from about +10 feet MLLW to +16 feet MLLW, with the western and southern portions of the site sloping down toward the shore.

Underlying Geology and Soils

The soils underlying the Anderson & Middleton site consist of five layers of soil: an upper unit of fill underlain by three units of alluvium, which are in turn underlain by a unit of glacial soils consisting of recessional outwash (Landau Associates 2009a). These soil units are generalized by the following soil types (and are shown on Exhibit 3.2-1):

- Fill: Loose and variable mixture of silt, sand, gravel, and wood debris with occasional cobbles and boulders
- Soil Unit 1: Soft silt (alluvium)
- Soil Unit 2: Soft or loose sand and silt (alluvium) which is further separated into the following:
  - Soil Unit 2A: Sandy silt
  - Soil Unit 2B: Silty sand
- Soil Unit 3: Soft to stiff silt (alluvium)
- Soil Unit 4: Dense to very dense sand and gravel (glacial recessional outwash and older, glacially consolidated outwash)

Groundwater

Groundwater at the Anderson & Middleton Alternative site is usually between 5 and 7 feet below ground and likely influenced by the tide. The casting basin would be up to 40 feet deep at this site. Due to the variation in the sandy soil at the site, which is highly permeable and easy for water to flow through, dewatering at the Anderson & Middleton site would change groundwater elevation across the site and potentially outside the project boundaries and would involve a large volume of water. These effects were described earlier in the *Settlement or Soft Ground Hazards* subsection**.**

What is soil permeability?

Soil permeability is a measure of the ease with which water flows through the soil. For example, water flows more quickly through high-permeable soil than low-permeable soil.

Geologic Hazards

The geologic hazards at the Anderson & Middleton site, including seismic hazards and settlement and soft ground hazards, are similar to those described previously for both Grays Harbor build alternative sites. The soils are susceptible to liquefaction and lateral spreading.

Aberdeen Log Yard Alternative

Topography

Surface elevations at the Aberdeen Log Yard site range from +4 feet MLLW near the shoreline to approximately +15 feet MLLW, with stockpiles as high as +30 feet MLLW.

Underlying Geology and Soils

Four soil layers underlie the Aberdeen Log Yard site: an upper zone of fill underlain by two units of alluvium, which are in turn underlain by a unit of glacial soils consisting of recessional outwash (see Exhibit 3.2-1). The glacial soils are underlain by siltstone (Landau Associates 2009e). Following are the typical composition of these soil units:

- Fill: Loose and variable mixture of silt, sand, gravel, and wood debris with occasional cobbles and boulders
- Soil Unit 1: Soft silt (alluvium)
- Soil Unit 2: Soft or loose sand and silt (alluvium)
- Soil Unit 4: Dense to very dense (sand and gravel (glacial recessional outwash and older, glacially consolidated outwash)

Groundwater

Groundwater at the Aberdeen Log Yard Alternative site is typically between 5 and 10 feet below ground and is likely influenced by the tide. Due to the sandy soils at the site, dewatering would change the groundwater elevation across the project site and, potentially, outside the site boundary, and could yield large quantities of water.

Geologic Hazards

The geologic hazards at the Aberdeen Log Yard site, including seismic hazards and settlement and soft ground hazards, are similar to those described previously for both Grays Harbor build alternative sites. The potential for liquefaction and lateral spreading also exist at this site. Placing fill when preparing the site for construction would cause the softer soils at this site to compress and settle. Based on historical site use, the Aberdeen Log Yard could have more piles and logs under the ground that would protrude if settlement occurred.

How did WSDOT evaluate the direct effects on geology and soils?

WSDOT analyzed potential direct project effects related to geology and soils using information in available geotechnical reports. Analysts examined existing borings, test pits, and Ecology boring logs to understand the specific geology and soil conditions and to identify potential effects on geology and soils.

How would construction of the casting basin directly affect geology and soils?

The following sections describe the effects of project construction on the local geology common to both Grays Harbor build alternative sites, and those effects that would be different at each Grays Harbor site. Construction effects at the CTC site are not discussed since the CTC facility is already constructed and operational.

Grays Harbor Build Alternatives

WSDOT would design the casting basin structure to withstand the effects of liquefaction and lateral spreading or mitigate for liquefaction sufficient to protect workers on the site, although such an earthquake might render the facility unusable.

To construct the casting basin facility at either Grays Harbor build alternative site, WSDOT would dewater the site, excavate the basin, and construct temporary side slopes, which would involve substantial earth-moving.

Moving soil from one location to another involves operating heavy machinery, such as bulldozers, excavators, and dredge machines. Moving soil during construction would have a low to moderate chance of producing substantial dust or erosion at either site because WSDOT would implement erosion and sedimentation control and extensive protective measures.

The existing fill in the upper soil layer at both build alternative sites is not suitable for structural fill. Constructing access roads, parking areas, laydown areas, and other facilities would require importing structural fill to replace or cover up to 48 inches of existing surface material.

What is structural fill?

Structural fill is an engineered fill that is typically constructed in layers of uniform thickness and compacted to a desired unit weight (density) in order to provide a strong, even surface on a construction site.

Certain construction activities (listed below) could cause the ground to settle to several inches at both build alternative sites:

- Increasing the effective weight of soils by dewatering
- Backfilling behind the perimeter walls of the casting basin with soils that are heavier than the existing soils
- Adding structural fill and all-weather surfacing layers across the site for laydown areas and site access roads.
- Storing excavated materials for the short or long term

Imported aggregate would be needed to backfill casting basin walls and drains, line the launch channel, grade the access road, and repair the rock berm at the Anderson & Middleton site. WSDOT would export material excavated from the casting basin and dredged from the launch channel to locations offsite. The launch channel at the Anderson &

Middleton site would be substantially shorter than the launch channel at the Aberdeen Log Yard site and, therefore, would require less dredging and offsite material transport.

WSDOT would specify that excavated soil or stockpiles of imported material be placed at a specified distance from the perimeter walls of the proposed casting basin and from the buried utilities to avoid inducing settlement that could damage the walls or utilities. Also, materials would be stockpiled a sufficient distance from the site boundaries to avoid affecting adjacent structures or the stability of the slopes along the water bodies.

Anderson & Middleton Alternative

The project would make permanent topographic changes at the Anderson & Middleton site, where WSDOT would increase the height of the shoreline berm and create access roads and laydown areas with imported fill. The surface topography would potentially be raised approximately 1 to 2 feet to create a flat surface to construct the casting basin facility. To safely excavate the casting basin at the Anderson & Middleton site, WSDOT would dewater the area around the casting basin. Construction dewatering could lower the groundwater elevation at the site and also could lower the groundwater table beyond the site boundaries due to the soils at this site.

Pumping from the dewatering system would begin approximately 1 to 4 months before excavation begins and would discharge large volumes of water. Lowering the groundwater table could potentially cause the soil to settle within and beyond the site boundaries and could threaten the structural integrity of nearby residential and commercial structures, utilities, and roadways. A settlement analysis performed at an adjacent site with similar soils estimated several inches of settlement due to site filling and dewatering (Landau 2009c). Dewatering could also alter groundwater contaminant migration pathways and draw contaminants from offsite properties into the study area, requiring that dewatering water be monitored and treated before discharge into Grays Harbor.

Exhibit 3.2-6 presents the maximum estimated quantities of soil and refuse encountered during casting basin and launch channel excavation that would be exported offsite as well as soils brought to the site for fill. Some excavated material could be stockpiled onsite, thereby reducing the exported quantities.

EXHIBIT 3.2-6
Maximum Estimated Export, Import, and Dredging Material Quantities for Grays Harbor Build Alternative Sites

Material	Anderson & Middleton Alternative (cubic yards)	Aberdeen Log Yard Alternative (cubic yards)
Exported materials[a]	840,000	999,000
Imported materials	450,000	550,000
Dredged materials	23,000	111,200

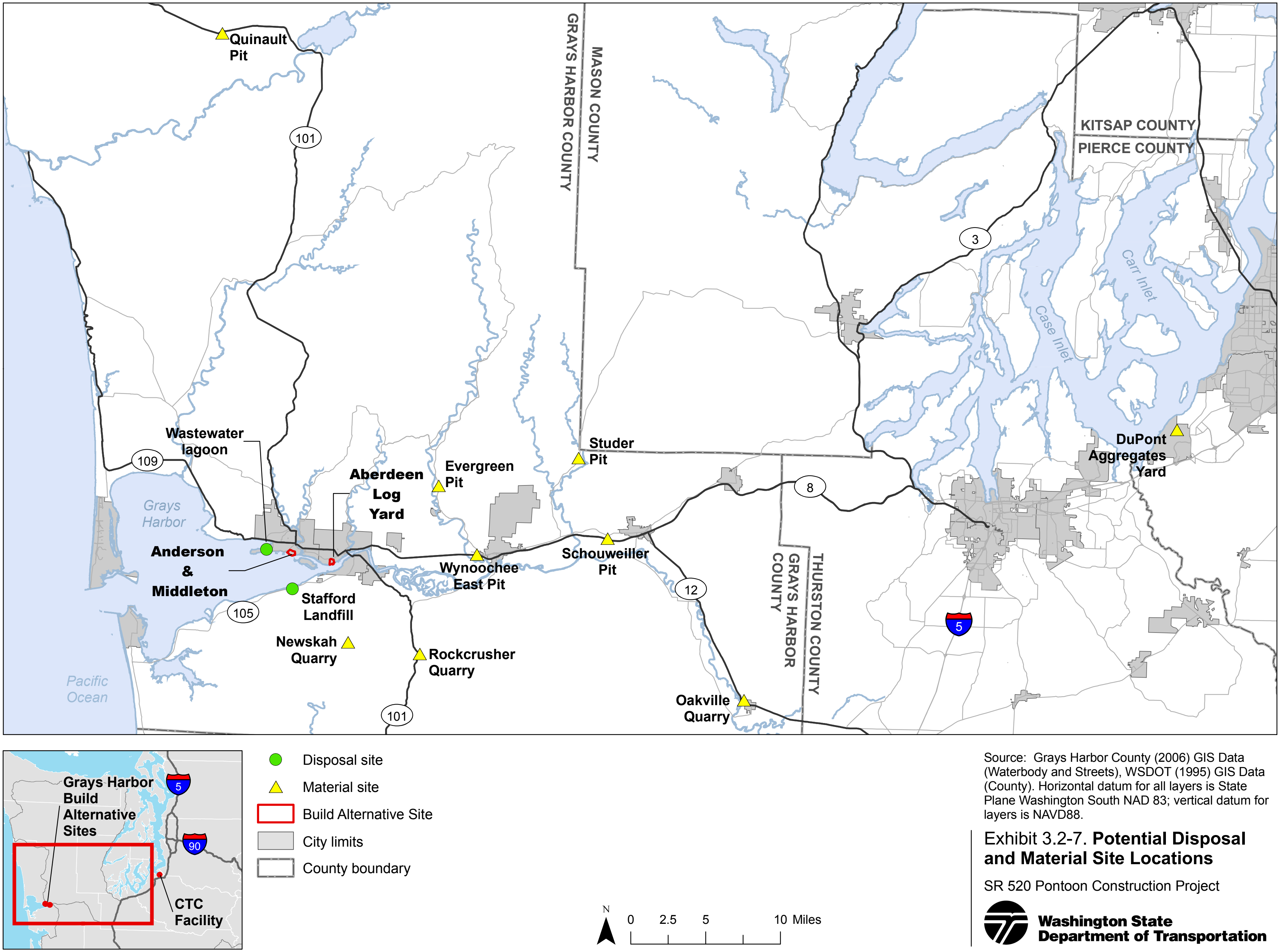
[a] Does not include exporting of dredged material.
Source: Appendix B, Description of Alternatives and Construction Techniques Discipline Report

Exhibit 3.2-7 shows locations of sites that could potentially be used for exporting or importing these materials. This Draft EIS assumes trucks would transport materials, although rail or barge could also transport materials. Exhibit 3.2-6 also includes material that would be dredged and transported offsite during construction of the in-water portion of the launch channel. The estimated quantities of dredge material could be up to 23,000 cubic yards at the Anderson & Middleton site. Because the launch channel at this site would not be as long as at the Aberdeen Log Yard site, the launch channel would require less dredging and offsite transport of material.

Aberdeen Log Yard Alternative

Dewatering at the Aberdeen Log Yard would be necessary during casting basin construction. If pumping were used to dewater the site, then WSDOT expects that offsite groundwater drawdown or alteration of contaminant migration pathways at this site would be similar to that at the Anderson & Middleton site.

Exhibit 3.2-6 lists the maximum estimated quantities of materials that would be exported from and imported to the Aberdeen Log Yard site. The estimated quantities of dredged material from the launch channel would be up to 111,200 cubic yards. As a point of reference, at the adjacent wastewater treatment plant, 5 feet of fill was placed, which caused an estimated 14 to 16 inches of settlement. Several more inches of settlement occurred in the 10 to 20 years (Shannon and Wilson 2001) after the fill was initially placed. Soils at the Aberdeen Log Yard site would settle as a result of site filling and dewatering.



Source: Grays Harbor County (2006) GIS Data (Waterbody and Streets), WSDOT (1995) GIS Data (County). Horizontal datum for all layers is State Plane Washington South NAD 83; vertical datum for layers is NAVD88.

Exhibit 3.2-7. **Potential Disposal and Material Site Locations**

SR 520 Pontoon Construction Project

Washington State Department of Transportation

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How would pontoon-building operations directly affect geology and soils?

CTC Facility

The CTC casting basin is already operating in place and, therefore, would not have any operational effects from project pontoon-building activities on geology and soils.

Grays Harbor Build Alternatives

Effects on geology and soils during pontoon-building activities would be similar at both build alternative sites. Throughout the project pontoon-building phase, maintenance activities would be necessary for the in-water portion of the launch channel at either Grays Harbor build alternative site because underwater currents and other natural processes would deposit soil in the dredged portion of the launch channel. These deposits would occasionally need to be removed by dredging. WSDOT would transport the dredged materials from the launch channel to an approved disposal site.

As part of site development, WSDOT would permanently replace up to 48 inches of existing fill at either build alternative site. Adding structural fill could potentially cause the ground to settle across either build alternative site. Although both build alternative sites are relatively flat, excavating the pontoon launch channel would create permanent armored slopes along the launch channel at both sites.

Several project features could cause long-term soil settlement of several inches to over 1 foot unless minimized by project design. Settlement of this magnitude is unacceptable below roadways and utilities and around structures. Nearby residential and commercial structures could potentially experience long-term settlement from site development as well. Settlement would cause additional down-drag loads on the casting basin pile foundations, but the applicable codes require that these down-drag loads be considered during design.

What is a down-drag load?

A down-drag load occurs when soil around a deep foundation settles, causing the soil to exert extra downward force on the foundation.

Anderson & Middleton Alternative

An operation (permanent) dewatering system would keep the groundwater at a manageable level for the foundation piles supporting the casting basin during pontoon construction. If this dewatering system were to fail, the potential of an uplift force on the piles and casting basin caused by a high groundwater table could cause substantial structural damage to the casting basin facility unless contingency plans were in place to flood the basin and counteract the uplift forces. An alternative basin support system to enable the piles and basin floor and

What are recurrence interval earthquakes?

The recurrence interval, or return period, is the average time span between large earthquakes at a particular site.

walls to withstand partial or full uplift would be very costly and involve more construction time and site disruption.

After the SR 520 Pontoon Construction Project has been completed, the proposed casting basin would need to be dewatered as long as it is maintained as a dry basin. At the Anderson & Middleton site, permanent armored slopes would also be created along the berm. These slopes—as well as the casting basin walls—could potentially become unstable if not designed correctly, but WSDOT would design and construct the slopes and walls to withstand potentially destabilizing forces. As a result, the potential for slope stability problems would be small.

Aberdeen Log Yard Alternative

The berm at the Aberdeen Log Yard site would also be reinforced but would not require improvements as extensive as those required for the Anderson & Middleton site because the Aberdeen Log Yard is more protected from wave action.

As with the Anderson & Middleton site, an operation dewatering system would likely be necessary to keep the groundwater at a manageable level for the foundation piles supporting the casting basin and on the casting basin slab. If this dewatering system were to fail, an uplift force on the piles and casting basin caused by a high groundwater table could cause substantial structural damage to the casting basin facility unless contingency plans were in place to flood the basin. An alternative basin support system to enable the piles and basin floor and walls to withstand partial or full uplift would be very costly and would require additional construction duration and disruption.

The potential for groundwater pressure to cause uplift on the foundation piles at the Aberdeen Log Yard site would be similar to that at the Anderson & Middleton site. Depressurizing this soil unit could prevent potential uplift. WSDOT would provide an operation (permanent) dewatering system to prevent the uplift.

Because this site has been more developed over the years than the Anderson & Middleton site, there is a higher potential for existing buried piles, slabs, tanks, and previously consolidated soil underlying the site that would cause more differential (uneven) settlement. Because of the higher volume of wood waste at this site—as well as high organic matter within underlying soil—settlement might occur over a longer period than at the Anderson & Middleton site.

What are consolidated and unconsolidated soils?

Consolidated soil is a soil that has been compressed by geologic processes. Unconsolidated soil is an uncompressed soft soil that is prone to settlement.

How would pontoon moorage directly affect geology and soils?

Shallow (2 to 3 feet), localized sediment scouring could occur beneath the moored pontoons but would likely fill after the pontoons are removed. WSDOT expects that these project-specific effects would be negligible.

How would the Grays Harbor build alternatives compare in their direct effects on geology and soils?

Exhibit 3.2-8 summarizes and compares the geology and soils effects of the Grays Harbor build alternatives.

EXHIBIT 3.2-8
Geology and Soils Summary of Direct Effects

Type of Effect	Anderson & Middleton Alternative	Aberdeen Log Yard Alternative
Casting basin construction	Casting basin excavation volume would be up to 740,000 cubic yards.	Casting basin excavation volume would be up to 887,000 cubic yards.
	Launch channel excavation volume would be up to 100,000 cubic yards (onshore) and up to 23,000 cubic yards (offshore).	Launch channel excavation volume would be up to 112,000 cubic yards (onshore) and up to 111,200 cubic yards (offshore).
	Imported material volume would be up to 450,000 cubic yards.	Imported material volume would be up to 550,000 cubic yards.
	There would be the potential for offsite soil settlement due to construction dewatering.	Effects would be the same.
Pontoon-building operation	There would be periodic launch channel dredging; volumes unknown at this time.	Effects would be the same.
Long-term	Soil settlement could occur as a result of dewatering activities and site filling on offsite facilities.	Effects would be the same.
	There would be a potential for long-term contaminant migration toward the permanent dewatering system requiring long-term water treatment.	
Pontoon moorage	Sediment scouring beneath moored pontoons could occur but should be negligible.	Effects would be the same.

What indirect effects would the project have on geology and soils?

CTC Facility

The CTC facility is a permitted facility that has previously been used to build pontoons. Continued operation of this facility would not have an indirect effect on soils and geology, nor would pontoon moorage and towing.

Grays Harbor Build Alternatives

During pontoon-building operations, water resources or ecosystems could be indirectly affected if sediment or high pH water were released as a result of measures to stabilize the soil at either Grays Harbor build alternative site. The project could indirectly affect geology and soils in the long term if soil settlement occurred onsite or at adjacent properties. Proposed project features—such as dewatering, adding structural fill, and all-weather surfacing layers for laydown work areas or truck access—could contribute to soil settling.

No indirect effects related to soils and geology would be anticipated to result from mooring the pontoons.

How would geology and soils be affected if the project were not built?

With the No Build Alternative, WSDOT would not develop either Grays Harbor build alternative site. These sites would not be affected by the project; however, because no improvements would be made at either build alternative sites, they would still be vulnerable to liquefaction during an earthquake. Since the sites are used primarily for log sorting and storage, liquefaction would not be a major concern.

The existing berm at the Anderson & Middleton site serves as an armored shoreline, and the berm at the Aberdeen Log Yard site is primarily used to control stormwater runoff. With the No Build Alternative, WSDOT would not increase the height of the berm at either site nor repair eroded sections. Without the proposed project improvements, the berms would continue to be susceptible to erosion and possible inundation during storms.

What mitigation measures does WSDOT propose to reduce direct effects on geology and soils?

Erosion and Sedimentation Control

If construction schedule constraints would allow, WSDOT could reduce erosion and sedimentation caused by project construction by limiting the period when soil would be exposed to erosion or disturbed. During casting basin facility construction, WSDOT would implement erosion and sedimentation control practices to achieve water quality standards and apply, at a minimum, best management practices following Ecology and WSDOT guidelines. Listed below are some possible best management practices for erosion and sedimentation control:

- Install quarry spalls (crushed rock)
- Require regular sweeping and washing of adjacent roadways
- Require silt fences downslope of all exposed soil
- Construct quarry, spall-lined temporary ditches, with periodic straw bales or other sediment catchment dams
- Require temporary covers over soil stockpiles and exposed soil
- Construct temporary sedimentation ponds to remove solids prone to settling before discharge
- Place limits on the area exposed to runoff at any given time

Water Quality

For water-handling during project construction and operation, water quality must meet the state's water quality standards. Furthermore, fueling areas might require covers and spill-containment features. Groundwater and stormwater runoff could be separated from process water. Turbidity and pH could be monitored and the system designed so that water could be temporarily stored and treated if needed.

Ground Settlement

WSDOT will refine settlement estimates as the project design continues. Potential settlements caused by project construction and operation could damage pipes, structures, or rail lines. Best management practices to minimize potential dewatering effects could include the following:

- Installing temporary or permanent cutoff walls
- Underpinning sensitive structures
- Reinjecting groundwater locally near susceptible facilities so that compressible soils are not dewatered

Slope Stability

WSDOT could mitigate the potential for destabilizing slopes and earth-retaining structures with proper design and construction. The design of slopes and earth-retaining structures (both temporary and permanent) would include standard factors of safety against movement during construction, long-term static conditions, and long-term seismic conditions. Berms and slopes that have no effect on structures or critical or costly utilities are not designed to resist seismic conditions unless a life safety concern exists. A layer of quarry rock riprap could be placed along the entire length of the Anderson & Middleton Alternative site's shoreline berm to protect against waves and would line also the launch channel of both sites. At the Aberdeen Log Yard site, the design might call for flatter side slopes along with localized dewatering to ensure stability.

Stabilization in Liquefaction Hazard Areas

Ground improvements could be used to mitigate the effects of liquefaction and lateral spreading. The improvement zone would extend vertically from the ground surface to the limits of liquefiable soil. WSDOT could make improvements for liquefaction mitigation only around structures and expensive or life-safety-critical utilities.

Mitigation

Effects such as soft soil settlement, slope instability, and erosion could be limited or eliminated by using suitable design and construction techniques as described above. If the project were to cause damage from ground settlement, WSDOT would work with property owners to find an acceptable solution to repair the damage.

How could WSDOT mitigate for indirect effects on geology and soils?

WSDOT could mitigate the potential release of sediments and high pH water during pontoon-building operations at either Grays Harbor build alternative site by properly implementing erosion and sediment control measures at the site.

Long-term settlement could be mitigated by using proper design and construction techniques. If the project were to cause damage to nearby pipes, structures, or rail lines, then WSDOT would work with property owners to find an acceptable solution to repair the damage.

What would the cumulative effect on geology and soils likely be?

CTC Facility

WSDOT did not identify any potential direct or indirect effects on geology and soils from operating the CTC facility. Therefore, there would be no contribution to cumulative effects on geology and soils associated with pontoon-building or towing activities at this site.

Grays Harbor Build Alternatives

Constructing the SR 520 Pontoon Construction Project, along with other projects in the vicinity (such as the Grays Harbor Deeper Draft Dredging project or the Paneltech Expansion project [see Exhibit 3-3], could contribute to cumulative effects on study area geology and soils. Many of these projects would require some soil importing, exporting, and/or dredging, thereby changing the volume and/or condition of soil at each site and possibly contributing to the depletion of aggregate or other soil resources offsite. The amount of soil exported and dredged for any of the proposed projects shown in Exhibit 3-3 would be very small relative to the existing soils in the study area. Although bringing in structural fill to the Grays Harbor area would be a cumulative effect, it would strengthen the geology and soils to better support structures and roads, and the amount of material imported would be very small in comparison with existing soil quantities in the study area.

The cumulative effect on the regional geology and soils resource would not harm the resource or create scarcity, and the SR 520 Pontoon Construction Project's contribution to the cumulative effect would be very small.

How could cumulative effects on geology and soils be mitigated?

Because the SR 520 Pontoon Construction Project would not likely contribute to negative cumulative effects, potential mitigation measures to address them are not discussed.