3.1 EARTH RESOURCES

The earth resources addressed in this analysis include bedrock geology, topography, and soils. The regional and local geologic setting is described and includes identification of significant topographic features and landforms, soil types, and mineral resources. Geologic hazards that could affect construction and operation of the proposed project include: seismic activity, fault rupture, volcanic activity, ground motion/shaking, soil liquefaction, landslides, tsunamis and seiches. The intent of the analysis is to determine whether the proposed project would affect valuable earth resources or be at risk from geologic hazards.

STUDY AREA AND METHODOLOGY

The study area for earth resources includes the proposed project and wetland mitigation sites, where earth moving activities during construction would remove soils and change slopes. The Anacortes Subdivision also is included in the study area to assess earth resources impacts related to operations along the rail corridor. Regional geology is described to provide a general context for earth resources at the proposed project and wetland mitigation sites. Geologic hazards potentially affecting the proposed project are described based on the area of influence. For example, the study area for seismic hazards includes fault zones several miles from the proposed project site that may be active and have an impact on project facilities; volcanic activity more than 30 miles away could result in debris flows and ash falls that reach the Anacortes Subdivision. Because the potentially affected earth resources are within the footprint of the proposed project and wetland mitigation sites and immediate areas, the cumulative impacts study area for earth resources includes these areas and the land in their immediate vicinity.

To address concerns expressed during the EIS scoping process about landslides on rail corridors, the study area was extended to include the area along the BNSF Railway main line south of the proposed project site where landslides have affected rail transportation in the past (Figure 3.1-4). While landslide hazards exist on other portions of the rail corridor (e.g., along the Columbia River Gorge and near Mount St. Helens), it is beyond the scope of this EIS to address all potential hazards along the existing operational rail corridor.

Potential impacts to earth resources have been assessed by reviewing published reports on geology and geotechnical and soils studies from previous projects in and around the study area, from government resources agencies and from Shell. The following data sources were used in the impacts analyses:

- Washington State Department of Natural Resources (DNR) Geology and Earth Resources references (DNR 2016).
- U.S. Geological Survey (USGS) geological and fault zone maps (USGS 2016).

- U.S. Department of Agricultural-National Resource Conservation Service (USDA-NRCS) soil survey of Skagit County and Soil Survey Geographic (SSURGO) database (USDA-NRCS 2016).

Select laws, regulations, and guidance applicable to earth resources associated with the proposed project are summarized in Table 3.1-1.

Table 3.1-1 Laws, Regulations, and Guidance for Project-Related Earth Resources

Laws, Regulations, and Guidance	Description
Federal	
The Federal Coastal Zone Management Act	Through the Federal Coastal Zone Management Act, coastal states with approved Coastal Zone Management Programs (CZMP) require projects operating under a federal permit or license to demonstrate consistency with the CZMPs. Federal Consistency allows states to review those projects that are likely to affect state coastal resources or uses.
National Earthquake Hazard Reduction Program (NEHRP)	Develops, disseminates, and promotes knowledge, tools, and practices for earthquake risk reduction through coordinated, multidisciplinary, interagency partnerships among the partner agencies and their stakeholders.
State	
State Environmental Policy Act (SEPA) (RCW 43.21c; WAC 197-11)	Helps state and local agencies in Washington identify possible environmental impacts that could result from a proposed action, alternatives to the proposed action, and potential impact minimization and mitigation measures. Information learned through the review process can be used to change a proposal to reduce likely impacts and inform permitting decisions at the state and local levels.
Washington State Coastal Zone Management Program	Under Washington's Coastal Zone Management Program (WCZMP), projects that are likely to affect state coastal resources or uses must be consistent with the WCZMP's enforceable policies found in the Shoreline Management Act, the Ocean Resource Management Act, the Water Pollution Control Act, and the Clean Air Act and all state regulations that implement those Acts.
Washington Hazardous Waste Management Act (RCW 70.105; WAC 173–303)	Establishes and implements a comprehensive statewide framework for the planning, regulation, control, and management of hazardous waste that will prevent land, air, and water pollution and conserve the natural, economic, and energy resources of the state.

Laws, Regulations, and Guidance	Description
Farmland Preservation (RCW 89.10)	Establishes the Office of Farmland Preservation and the State's commitment to the retention of agricultural land and supports the viability of farming for future generations.
Local	
Skagit County Critical Areas Ordinance (SCC 14.24)	This ordinance was developed under the directives of the Growth Management Act to designate and protect critical areas and to assist in conserving the value of property, safeguarding the public welfare and providing protection for these areas. Critical areas are defined as wetlands, aquifer recharge areas, frequently flooded areas, geologically hazardous areas, and fish and wildlife habitat conservation areas.
Skagit County Comprehensive Plan	The Natural Resource Lands Element establishes the purpose and intent of policies to guide long-range planning, programs, and regulations to conserve agricultural, forest, and mineral natural resource lands.
Skagit County Grading Permit	A Fill and Grade Permit may be required for any grading work involving substantial ground-disturbing activity (either fill or excavation) or any additional activity that affects drainage in the area.

Consistent with the SEPA Handbook, the impacts analysis predicted direct construction and operational impacts of the proposed project on geologic and soil conditions, as well as indirect impacts on these resources (Ecology 2004). Potential impacts could include changes to the geologic structure, soil loss and erosion, or loss of economic mineral resources values. Included in the analysis is an assessment of geologic hazards that could affect the proposed project.

The proposed changes to earth resources have been evaluated and assessed for significance based on whether the resources are rare or unique, or in other ways important for their economic or cultural value. Potential impacts related to geologic hazards need to be taken into consideration because they could have implications for design, construction, and operation of the proposed project.

AFFECTED ENVIRONMENT

Regional Geologic Setting

The geology of the study area is dominated by glacial deposits (drift, glaciomarine, and till) that have accumulated over the last 15 million years.

The proposed project is located in the geologic region known as the Puget Lowland Physiographic Province. Area geology consists primarily of glacial deposits of the Pleistocene age deposited over older ocean sediments (Dragovich et al. 2000). These deposits are consistent with glacial marine drift and outwash, composed of clayey silt, silty clay, and clay, with localized lenses and layers of sandy, gravelly, and silty outwash (depicted in Figure 3.1-1 as $Qgdm_e$). Underneath these drift deposits are nonstratified glacial till deposits (depicted in Figure 3.1-1 as Qgt_v), which are dense to very dense glacially consolidated soils consisting of clay, silt, sand, and gravel in various proportions, with scattered cobbles and boulders, and rare lenses of sand or gravel. Holocene nearshore deposits also occur in the region (Q_n in Figure 3.1-1) and are comprised of fine sand, silt, and clay, with localized flood overbank and peat deposits.

The underlying bedrock in the study area consists of metamorphic formations (e.g., rock units that have been subject to heat and pressure such that their mineral composition has been altered). The depth to bedrock is generally far below the surface, up to 1,000 feet deep in the Puget Lowlands (DNR 2016). In the geotechnical investigations at the proposed project site, bedrock was not encountered in borings to a depth of greater than 100 feet (URS 2014a). No construction activities are planned for such depths. There are no mineral resources of economic value in the areas proposed for construction.

During the most recent glacial period, glaciers advanced into and occupied the Puget Sound region for approximately 10,000 years. The advance and retreat of the ice sheets resulted in the geologic deposits and topography commonly seen today.

Topography

The topography is relatively flat from the proposed project site east along the Anacortes Subdivision to Burlington. The proposed project site is on a gently sloping glaciomarine terrace at an elevation of 10 to 80 feet above mean sea level. At the southern and middle portions, slopes are gentle and relatively flat, generally under 3 percent. Slopes become steeper in the northern portion. Slope grades are greater on the west side of the rail spur alignment and decrease at a gentle grade on the east side of the alignment toward Padilla Bay (URS 2014a). The wetland mitigation site and the Anacortes Subdivision are nearly completely flat.

Geologic Units (1:24,000 Scale)

- Glacial and nonglacial deposits (Qe)
- Ablasion or flow till (Qgt(e))
- Alluvium (Qal)
- Artificial Fill (af)
- Beach deposits (Qgom(ee))
- Fine glaciomarine sediment (Qgdm(ec))
- Glaciomarine outwash (Qgd/om(e))
- Glacial Till (Qgt(v))
- Interbedded fine-grain metasedimentary rocks (KJm*
- Lahar runout deposits (Qvl)
- Landslide deposits (Qls)
- Metasedimentary rocks (Jhs)
- Metavolcanic rocks (Jhg)
- Nearshore deposits (Qn)
- Peat (Qp)
- Possession stiff till (ot)
- Silt and Clay Deposits (Qga(v))
- Unsorted glacial deposits (Qgdm(ed))

DATA SOURCE: (Skagit County 2015, USGS 2015, WSDOT 2015)

- Proposed Project Site
- Proposed Wetland Mitigation Site
- Anacortes Subdivision
- Bellingham Subdivision
- BNSF Railway
- State Highway
- Interstate Highway

N

0 1 2 Mile

Figure 3.1-1

GEOLOGIC UNITS – PROPOSED PROJECT VICINITY

Geologic Hazards

Geologic hazards identified for this project include seismic activity (earthquakes/faults), volcanic activity, ground motion/shaking, soil liquefaction, erosion, landslides, and tsunamis and *seiches*.

A seiche is a temporary series of waves in an enclosed or partially enclosed body of water (e.g., harbors, lakes, bays, and rivers) as a result of earthquake shaking. Typically, seiches do not occur close to the epicenter of an earthquake, but from earthquakes that have occurred hundreds of miles away.

Seismic Activity

Two major tectonic plates—the North American and Juan de Fuca—converge off the coast of western Washington. The crust beneath the Pacific Ocean that comprises the Juan de Fuca plate is slowly sinking (known as subduction) beneath the North American continent at a rate of just over 1 inch per year. This geologic process is responsible for earthquakes throughout the Pacific Northwest and results in northwest-trending fault zones.

While there are no fault trenches or other expressions of seismic faults at the proposed project site, fault zones have been mapped in the surrounding region. The closest projected fault trace is approximately 8 miles south of the proposed project site. The Darrington-Devils Mountain Fault is the largest in the region and runs east to west approximately 10 miles to the south of the proposed project site. Other faults that could have consequences in the study area, if active, are the Southern Whidbey Island Fault and the Seattle Fault, which are approximately 22 and 64 miles south of the proposed project site, respectively. Several earthquakes on record have originated in the region, all less than magnitude 2.5 and at depths of greater than 6.8 miles below the surface (DNR 2016).

Ground Motion/Shaking

Ground motion during a seismic event can cause damage to buildings and other structures, and can be a human health risk. The National Earthquake Hazard Reduction Program (NEHRP) establishes site classes (B through F) representing the potential for enhanced ground shaking based on existing soil conditions. An area classified as site class B would have the lowest potential for increased ground shaking; site class F would have the highest potential. Within the project study area, the following site classes exist (Palmer et al. 2004):

- Proposed project site (site class C).
- Proposed wetland mitigation site (site class D-E).
- Anacortes Subdivision (site class D-E or site class E).

Site class C indicates that earthquake shaking would be slightly amplified, but would be unlikely to generate substantial ground-motion hazards. Site classes D-E and E indicate that there is the possibility of generating high ground-motion hazards during a large earthquake.

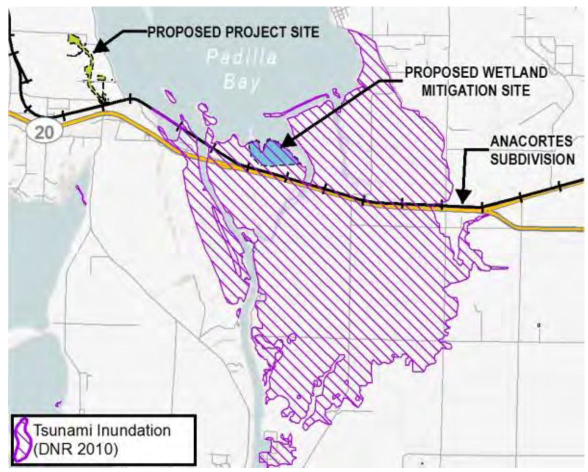
Soil Liquefaction

Liquefaction occurs when the shaking of a strong earthquake causes soil to rapidly lose its strength and behave like quicksand. This phenomenon typically occurs in artificial fills and in areas of loose, water-saturated soils. While the risk of liquefaction within the proposed project site is low, there is moderate to high risk of liquefaction at the wetland mitigation site and along the Anacortes Subdivision from the Swinomish Channel Delta east to Burlington (DNR 2016) (Figure 3.1-2).

Tsunamis and Seiches

There is no written historical record of tsunamis or seiches affecting Skagit County (Skagit County Department of Emergency Management 2008); however, there is still some risk of a tsunami or seiche occurring in the study area. Based on currently available data for common earthquake scenarios (Walsh et al. 2005), a tsunami could cause water to surge onto land and cover the low-lying areas east of the proposed project site from about 0.5 mile west of the Swinomish Channel to the approximate location where State Route (SR) 536 and the Anacortes Subdivision meet (Figure 3.1-3). In such an event, water over this area, also known as inundation, could be 0.5 to 2 feet deep. As March Point is surrounded by two partially enclosed bays (Padilla and Fidalgo), there is the risk that an earthquake event could generate a seiche, which could result in damage to shoreline areas that are outside of the tsunami inundation area (Skagit County Department of Emergency Management 2008).

Figure 3.1-3 Tsunami Inundation Zone



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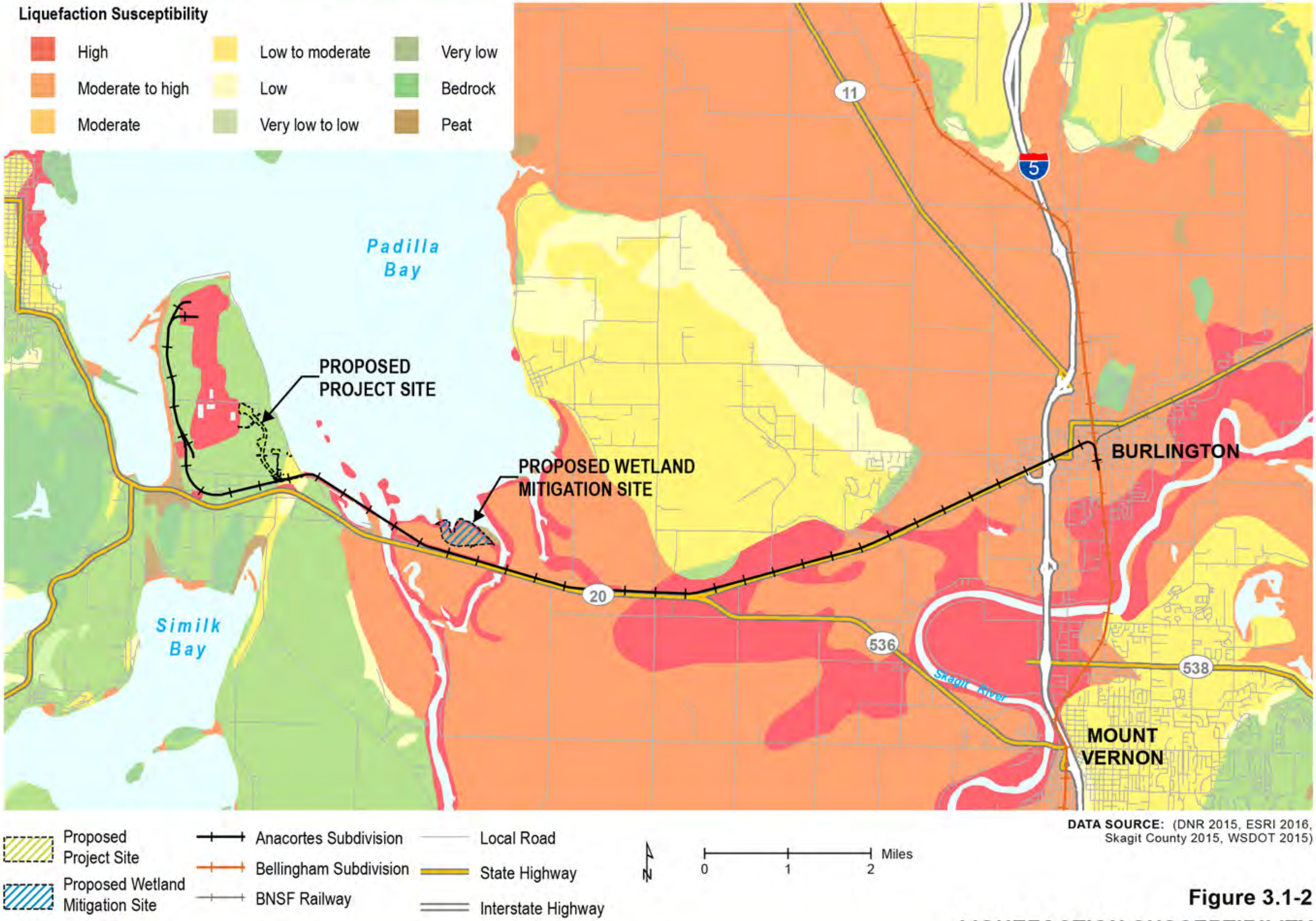


DATA SOURCE: (DNR 2015, ESRI 2016, Skagit County 2015, WSDOT 2015)

Figure 3.1-2

LIQUEFACTION SUSCEPTIBILITY

Volcanic Activity

Two volcanoes in the Cascade Range, east of the proposed project site and outside of Skagit County, present a potential hazard to the project site, wetland mitigation site, and Anacortes Subdivision. These volcanoes are Mount Baker (about 39 miles to the northeast), and Glacier Peak (about 70 miles to the southeast). Both volcanoes have been active in the past 4,000 years with eruptions that have resulted in pyroclastic flows, ash falls, lava flows, and *lahars* (Washington Military Department 2012).

> A lahar is a type of mudflow or debris flow composed of a slurry of volcanic material, rocky debris, and water. The material moves down from a volcano, typically along a river valley.

According to a USGS National Volcano Early Warning System assessment of the threat of eruption, both Mount Baker and Glacier Peak are ranked as having a very high threat of eruption (USGS 2016). The proposed wetland mitigation site and Anacortes Subdivision are in a volcanic hazard zone for both Mount Baker and Glacier Peak because a lahar from either volcano could inundate the Skagit River Valley (Gardner et al. 1995a; Waitt et al. 1995). Lahars extending from Glacier Peak to Puget Sound have occurred during at least two eruptive episodes in the past 15,000 years (Waitt et al. 1995). However, it is unknown whether lahars from Mount Baker have reached the Skagit River (Gardner et al. 1995b). There is a 1 in 100 annual probability that small lahars or debris flows would impact river valleys below Mount Baker, and less than a 1 in 1,000 annual probability that the large destructive lahars would flow down the slopes of Glacier Peak (Washington Military Department 2012).

> A volcanic threat is defined as the qualitative risk posed by a volcano to people and property. It combines volcanic hazards (the dangerous or destructive natural phenomena produced by a volcano) and exposure (the people and property at risk from the volcanic phenomena).

Ash from nearby volcanic eruptions is likely to be carried away from the proposed project site by the prevailing winds, which trend toward the east and northeast. Some ashfall could reach the project site, but would not likely occur in significant quantities (Washington Military Department 2012).

Landslides

Figure 3.1-4 Landslide Susceptibility

Landslide hazards occur in areas where there is a risk of the downward movement of soil, rock, and debris. Most landslides that take place in the Puget Lowland are shallow slope failures that commonly turn into debris flows, which are a moving mass of loose mud and soil (Harp et al. 2006). The occurrence and severity of landslides is generally dependent on the slope gradient, slope shape, surface and subsurface materials, precipitation, surface and subsurface water conditions, vegetation, and seismic events. According to Skagit County's Potential Landslide and Erosion Areas map, no part of the proposed project or wetland mitigation sites is susceptible to landslides (Skagit County Geographic Information Services 2016). In Department of Ecology's Slope Stability Maps – Coastal Zone Atlas for Skagit County (Ecology 1979), an area along South March's Point Road southeast of the proposed project site near the Anacortes Subdivision is identified as "intermediate" with respect to slope stability. The map shows this area adjacent to slopes that have been modified. There is also a borrow pit in that area, which may have resulted in the modified slope designation and intermediate stability.

Shallow landslides commonly occur in weathered glacial deposits and colluvium on Puget Sound bluffs after periods of relatively heavy rainfall or snowmelt (Baum et al. 2002). On the BNSF Railway main line south of the Anacortes Subdivision between Everett and Seattle, frequent landslides have occurred during the wet winter season, causing damage to rail facilities and resulting in service interruptions (Figure 3.1-4). For example, during 1996 and 1997, landslides in this area blocked one or both tracks in about 100 places and came close to the tracks in about 30 more locations. Although most landslides that temporarily blocked the tracks did not collide with trains, one large slide derailed part of a train and caused significant damage (Baum et al. 2000).

In the past decade, more than 200 slides have occurred along the coastline between Everett and Seattle (LaBoe 2015). In December 2012, a freight train was derailed near the Port of Everett when it was struck by a landslide. An Amtrak train was partially derailed by a landslide near Everett in April 2013. These and other landslide incidents along the rail corridor in this area have led to a growing public concern for the safe transport of hazardous material by rail, as evidenced in scoping comments on this EIS.

> The probability of a landslide or other accident causing derailment and the release of crude oil from a tank car is examined in detail in Chapter 4 – Environmental Health and Risk.

Record numbers of passenger rail service interruptions during the 2012–2013 winter season prompted a collaborative effort among Washington State Department of Transportation (WSDOT), BNSF Railway Company (BNSF Railway), Sound Transit, Amtrak, and stakeholders to address the issue of landslides in the corridor between Everett and Seattle. This effort led to the development of the Landslide Mitigation Action Plan (WSDOT 2014), a report that quantifies landslide-related impacts, identifies the primary factors within the corridor that contribute to landslides, and provides mitigation strategies to reduce their occurrence and impact.

While targeted to passenger rail service, the landslide mitigation strategies identified in the report would also benefit the movement of freight. The report notes that it is virtually impossible to predict the location and impacts of a single event within such a long landslide-prone corridor, given the wide range of potential factors that influence the initiation of landslides; e.g., slope, subsurface materials, precipitation, vegetation, and surface materials. The report does not identify vibration or weight from train traffic as a contributing factor to landslide potential). The report acknowledges that reducing landslide-related impacts to rail service in the Everett to Seattle corridor will require “substantial investments in capital improvement projects” such as drainage improvements and stabilization (WSDOT 2014). It goes on to state, “Depending on the financial resources available, as well as factors such as permitting, design, and construction scheduling, the time required to achieve significant reductions in landslide-related service interruptions will likely take one or more decades” (WSDOT 2014).

WSDOT is spending $16.1 million in federal funds on landslide management projects to help shore up slopes along rail lines (WSDOT 2015). Work is being conducted at six sites (four sites west of Mukilteo, one site west of Everett, and one site north of Everett) and includes building retaining walls and slide detection fences (for early landslide warning), slope stabilization and erosion control, and drainage system improvements. The current BNSF Railway hazard mitigation process serves to detect landslides with trip wires and halt all subsequent passenger trains for 48 hours following a slide. Freight trains are allowed to resume operations as soon as the debris has been cleared from the tracks (WSDOT 2014).

Soils

The soils at the proposed project and wetland mitigation sites, and along the Anacortes Subdivision, are predominantly gravelly loam, gravelly loamy sand, and silt loam. They tend to be very deep, somewhat poorly drained soils. They formed in gravelly glacial drift over glaciolacustrine deposits (derived from glaciers and deposited in glacial lakes) and volcanic ash. These soils have low permeability and a seasonal high water table.

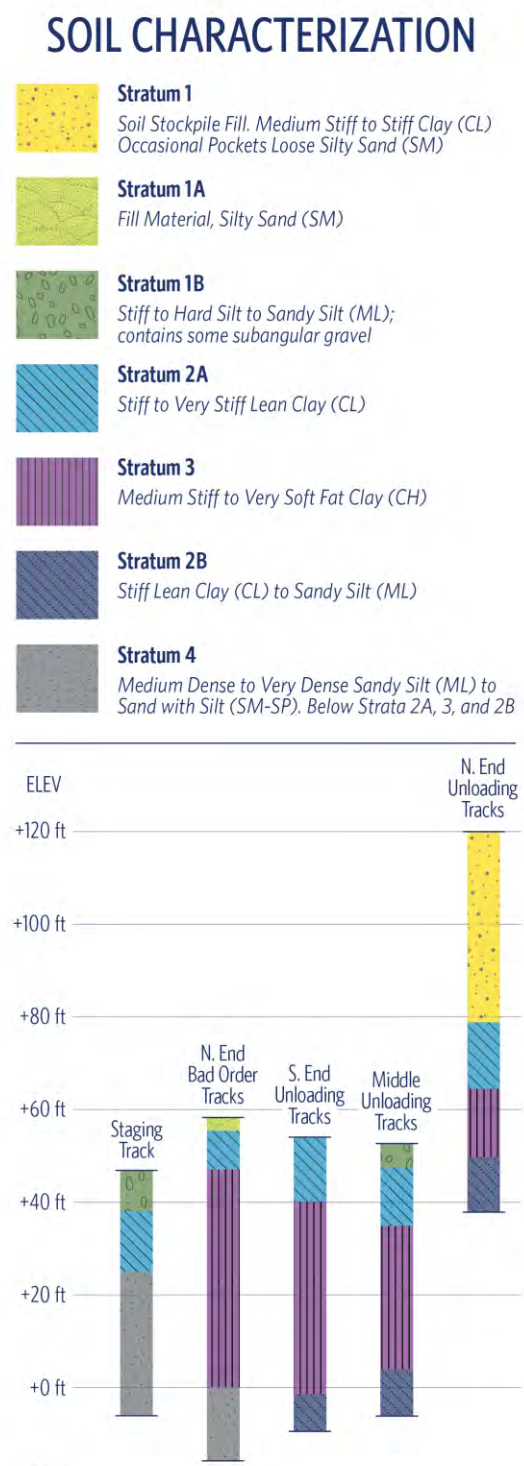
Soils at the proposed project site have been characterized by recent geotechnical investigations (URS 2014a; URS 2014b), and further classified along the rail alignment (from shallow to deep) into the following components (shown on Figure 3.1-5):

- Stratum 1 – Soil Stockpile Fill: Medium Stiff to Stiff Clay (CL), Occasional Pockets Loose Silty Sand (SM).
- Stratum 1A – Fill: Silty Sand (SL).
- Stratum 1B – Stiff to Hard Silt to Sandy Silt (ML).
- Stratum 2A – Stiff to Very Stiff Lean Clay (CL).
- Stratum 3 – Medium Stiff to Very Soft Fat Clay (CH).
- Stratum 2B – Stiff Lean Clay (CL) to Sandy Silt (ML).
- Stratum 4 – Medium Dense to Very Dense Sandy Silt (ML) to Sand with Silt (SM-SP).

The general soils profile along the project alignment varies substantially, as depicted in Figure 3.1-5. The northern end of the proposed unloading track alignment has a soil stockpile of stiff clay and pockets of loose silty sand (Stratum 1, CL and SM) created from materials excavated at various locations around the Shell Puget Sound Refinery (PSR) throughout its development. The depth of the soil stockpile ranges from about 29 to 46 feet. Additional fill material composed of silty sand (Stratum 1A, SL) is located near 4th Street (near the terminal end of the bad order tracks) and is generally 2 to 5 feet deep.

The shallowest native deposit is silt to sandy silt (Stratum 1B, ML) and is frequently encountered just below the topsoil layer south of, and occasionally north of, 4th Street. This stratum is typically 3 to 5 feet deep and contains some subangular gravel.

Figure 3.1-5 Soil Characterization



Lean brownish yellow to brown Clay (Stratum 2A, CL) is consistently present beneath Stratum 1B or at the surface (where Stratum 1B is not present), and varies in depth from approximately 6 to 25 feet.

Fat gray clay (Stratum 3, CH) underlies Stratum 2A throughout the proposed project site, although it was absent along the southern half of the rail alignment. Stratum 3 ranges in depth from approximately 15 to 48 feet.

Lean clay (CL) to sandy silt (ML) (Stratum 2B) was encountered underneath Stratum 3 and was generally absent in portions of the southern half of the alignment, where Stratum 3 was also absent. Stratum 2B is similar to Stratum 2A with stiff clay, is generally gray in color and medium stiff to stiff in consistency, and frequently contains traces of sand and fine gravel.

Brown and gray sandy silt (ML) to sand with silt (SM-SP) (Stratum 4) was the deepest soil stratum encountered. The depth of this stratum was not determined. Stratum 4 was encountered below Strata 2A, 3, and 2B.

Soils at the proposed project site are considered prime farmland, meaning they have the best combination of characteristics for agricultural production, but only if drained (USDA-NRCS 2016). Currently, the depth to groundwater is too shallow for agricultural production. The soils also have some shrink-swell properties associated with the clay component, which limits development unless the soils are properly drained. The soils can be muddy when moist and unsurfaced roads are sticky and slippery to the point of being impassable.

At the northern-most terminus of the proposed project site, the soils have been heavily altered: there is a substantial depth of fill that includes a significant thickness of silt and clay underlain by dense sand and gravel. These materials were excavated from various locations in the surrounding area during development. Dark organic material, grass and grass roots, and woody material are intermixed with the soil material (URS 2014a).

The soils at the wetland mitigation site are mostly hydric (66-99 percent), and were likely converted from entirely *hydric soils* following drainage and diking to provide land for cultivation (USDA-NRCS 2016) (Figure 3.1-6).

Hydric soils are formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions (i.e., without oxygen) in the upper part.

Soil erosion is a continuing natural process that can be accelerated by human disturbance. Factors such as soil texture, structure, slope, vegetative cover, rainfall intensity, and wind intensity can influence the degree of erosion. No soils at the proposed project and wetland mitigation sites, and along the Anacortes Subdivision, have been identified by the USDA-NRCS Soil Survey of Skagit County as having severe soil erosion potential. Along the BNSF Railway main line south of the Anacortes Subdivision between Everett and Seattle, sections of the coastline are classified as having moderate to severe erosion potential. The severe classification indicates that erosion is very likely and that erosion-control measures, including revegetation of bare areas, are advised. The soils at the proposed project and wetland mitigation sites, and along the Anacortes Subdivision, have a high potential for restoration under ordinary climatic conditions (USDA-NRCS 2016).

There are no soils at the proposed project and wetland mitigation sites, and along the Anacortes Subdivision, that have been identified by state or local agencies as rare or unique, or in other ways important for their economic or cultural value. All of the soils have low resistance to compaction. There is no known frost action in the soils at the proposed project and wetland mitigation sites or along the Anacortes Subdivision.

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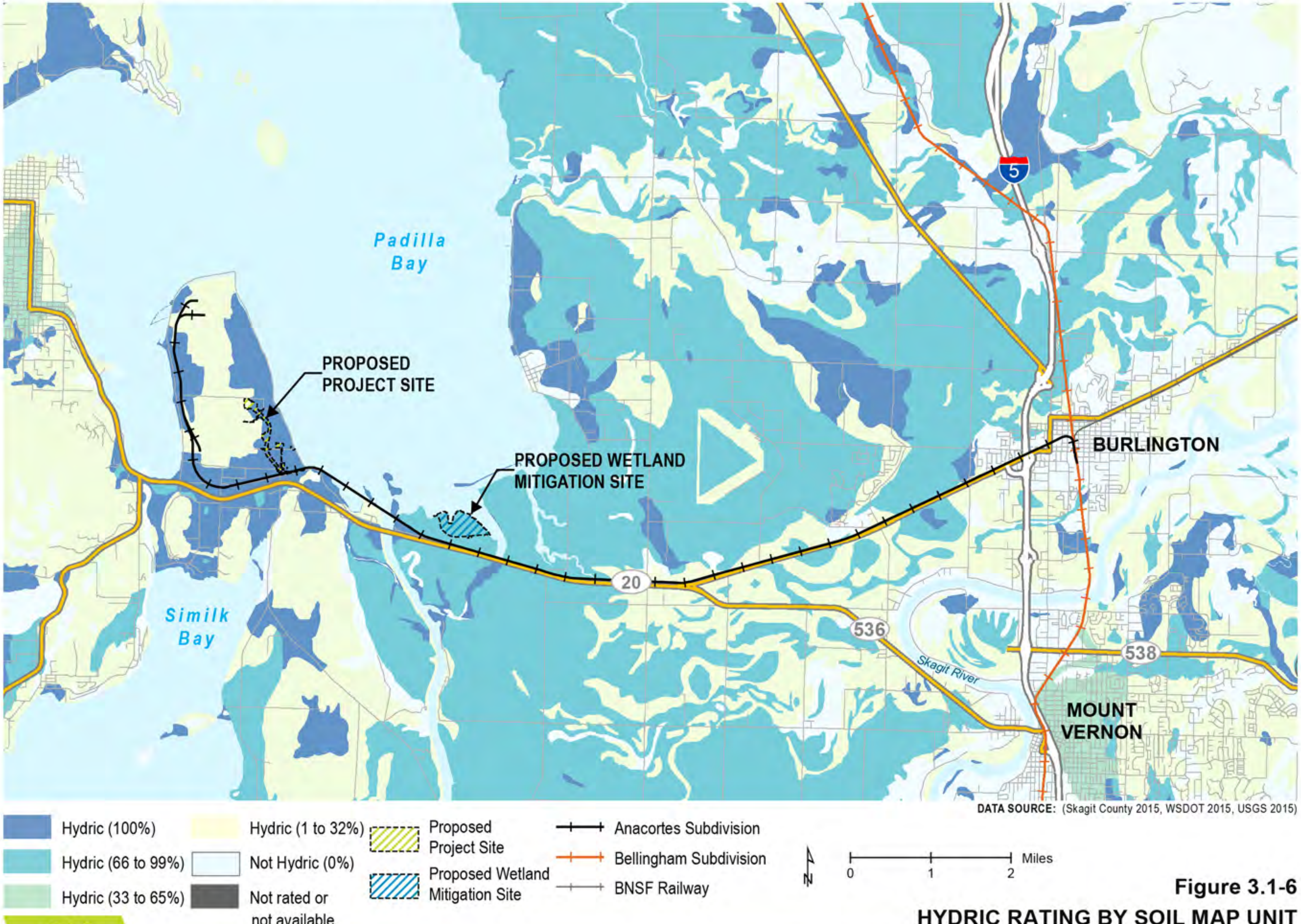

Figure 3.1-6
HYDRIC RATING BY SOIL MAP UNIT

ENVIRONMENTAL IMPACTS

No Action Alternative

Because no construction or operation would take place under the no action alternative, there would be no impacts to geology, topography, or soils. Existing conditions would remain the same unless affected by other projects in the future. The potential for geologic hazards, including seismic hazards, ground motion/shaking, soil liquefaction, tsunamis and seiches, volcanic activity, and landslides, still exists under the no action alternative.

Proposed Project

Potential impacts to earth resources would be largely attributable to the direct impacts caused by construction activities at the proposed project and wetland mitigation sites. Such activities would alter topography, soils, and, in some locations, the underlying sedimentary materials. Project operations and long-term use of the proposed project and wetland mitigation sites would have limited impacts on these earth resources. Impacts related to geologic hazards, while not considered an environmental consequence of the project, are noted in this chapter to describe potential conditions that could affect project facilities and operations.

Direct Impacts

Construction

Direct construction impacts would result in permanent changes to the surface geology, topography, and soils. For example, soil removal, grading, and clearing necessary to complete construction of permanent facilities would cause permanent alterations to earth resources. No impacts are anticipated on mineral resources of economic value as none are found in the study area.

The proposed project would require alteration to 47.1 acres of ground surface, with additional temporary ground disturbance to 25.7 acres. Approximately 1.1 million cubic yards (cy) of material are anticipated to be excavated during construction activities. An existing soil stockpile that contributes to steep slopes at the northern end of the proposed project site would be excavated and graded. Excavated material would be tested for any contamination. If contaminants were found, the materials would be removed from the proposed project site and disposed of in accordance with state and local regulations. Potential spoil disposal sites are identified in Chapter 2 – Proposed Project and Alternatives, Figure 2-11. The transport of spoils material is discussed in Chapter 3.16 – Vehicle Traffic and Transportation.

The topography of the proposed project site would be altered during construction. The proposed project would require a gentle and even grade for rail operations. Soil grading is required for site development and would include a modest increase in grade (up to 10 feet) and more extensive lowering (cutting) of grades (up to 70 feet) for acceptable rail elevations at the northern end of the proposed rail spur (URS 2014a). Because much of the area already has been altered by development, the changes from the proposed site development and soil grading would not significantly alter the natural landscape.

Approximately 400,000 cy of clean soil removed from the proposed project site would be placed at the wetland mitigation site to restore surface elevations to what existed prior to agricultural use. Preliminary investigations estimate a typical fill depth of 3 feet would be sufficient for the creation of wetland conditions. Fill would be placed at higher elevations on the perimeter of the site and at lower elevations along the banks of new channels. Regrading low-lying areas would allow tides to inundate the site. This would modify the soil chemistry of imported soils to facilitate development of salt marsh vegetation. Preliminary geotechnical analyses performed by Shell (AECOM 2016) indicate there may be settlement of approximately 0.5 foot after placement of fill material. The wetland mitigation site would be graded to slope gently toward the designed channels to allow for drainage and prevent ponding.

The primary concerns with respect to construction impacts on soils are erosion, loss of topsoil, soil compaction, soil mixing, construction suitability, revegetation, and changes to groundwater hydrology (for groundwater hydrology, see Chapter 3.2 – Groundwater). Construction of the proposed project would cross three soil types; the wetland mitigation site would encompass two soil types.

The soils at the proposed project and wetland mitigation sites are classified as having slight water erosion potential, meaning that little or no erosion is likely. A small area in the southeastern-most part of the project footprint is classified as having moderate water erosion potential where some erosion is likely. These classifications are based on existing slopes, which are relatively flat. Some steep slopes would be created as part of the proposed project, which could increase the susceptibility of these areas to erosion; however, erosion and sediment control measures would be put in place to stabilize slopes and control construction stormwater runoff.

Operation

No grading or re-grading is planned during operation; therefore, surface geology and topography would not be affected at the proposed project site. Changes in site elevations during construction would be long term and persist through the operational phase. Minimal settlement of the underlying soils is expected (1 to 2 inches over 30 years). At the wetland mitigation site, it is anticipated that suspended sediments would be retained from the mudflat, thereby increasing the elevation of the site slowly over many years.

After the proposed rail unloading facility is operational, impacts to soil resources would be negligible. Soil contamination from increased train emissions is not expected, based on the findings in the air quality analysis (see Chapter 3.10 – Air Quality and Greenhouse Gases). Following construction, exposed ground surfaces would be stabilized in accordance with the methods described in the construction Stormwater Pollution Prevention Plan (Wilson and Company 2014). Operation and maintenance of the proposed project would not require additional excavation or disturbance of ground surfaces.

Indirect Impacts

Construction

The proposed changes to the surface geology, topography, and soils could result in indirect impacts to earth resources. Installation of drainage infrastructure would result in a lowering of the water table, thereby drying the soils to some degree. Soils would be converted from those that support native vegetation to soils more suited for industrial uses. Removal of large soil volumes would effectively remove the soil's capacity to support native vegetation or future agricultural uses. Unsuccessful or slow revegetation could lead to increased erosion on bare soil surfaces. Erosion would lead to a long-term loss of soil productivity in discrete locations.

Operation

A long-term or permanent loss of soil productivity and quality would occur in association with permanent project facilities and infrastructure. Installation of drainage infrastructure would change the depth to groundwater at the proposed project site. The soils in the study area have no economic or productivity value as a local or state resource.

Potential Impacts Resulting from Geologic Hazards

Geologic hazards would not be affected by the proposed project; rather the potential for these hazards to affect construction and operations would need to be considered. Geologic hazards would be present during construction and operation activities and include seismic hazards, ground motion/shaking, soil liquefaction, tsunamis and seiches, volcanic activity, and landslides. Such hazards are discussed in relation to the project components.

Seismic Hazards

There is the potential for earthquakes in the study area. The proposed project site does not cross any known faults, but many small and large faults exist nearby, such as the Darrington-Devils Mountain Fault. The geotechnical investigation of the proposed project site concluded that there was no potential for ground-surface rupture should a major earthquake on the Darrington-Devils Mountain fault zone occur (URS 2014a). The unconsolidated, deep soils present at the proposed project site may somewhat amplify ground motion and shaking during an earthquake. The potential for such an occurrence is greater at the wetland mitigation site where the soils are looser and wetter. Seismic design standards and building codes would be applied to minimize the likelihood of negative impacts from ground motion.

Seismic hazard impacts along the Anacortes Subdivision could vary from negligible to moderate. The potential for moderate seismic activity capable of disrupting rail transportation is considered particularly high within Washington State as a whole, which includes possible derailment.

The potential for impacts from soil liquefaction at the proposed project site is low because of the density of the underlying soils. At the wetland mitigation site, the hazard is considered moderate-high to high because of the looseness of the soil and the potential to alter site topography. Soil liquefaction could cause the wetland mitigation site to lose elevation and become inundated. However, no significant impacts are anticipated because the site would be used for wetland mitigation purposes and have no permanent structures.

Tsunami or seiche inundation is considered unlikely at the proposed project site; however, large, unusual, and unexpected tsunamis have been known to occur around the world. The wetland mitigation site and a portion of the Anacortes Subdivision have been identified as tsunami inundation areas with a potential to experience between 0.5 to 2 feet of water. Heavy inundation at the wetland mitigation site has the potential to wash away backfill and accumulated sediments. Seiches that occur after an earthquake could result in damage to shoreline areas that are outside of the tsunami inundation area; however, the risk is considered low as there are no historical records of seiches in Skagit County.

Volcanic Activity

While ashfall from a nearby volcanic eruption would most likely be carried eastward with the prevailing wind, some ashfall could reach the proposed project site, wetland mitigation site, and Anacortes Subdivision, but not likely in significant quantities. At the proposed project site, impacts from ashfall could include ash accumulation on structures and infrastructure; disabling of certain electronics, machinery, and filters; suspension of abrasive fine particles in the air; and ash accumulation on transportation routes and vegetation. In the event of a large eruption, implementation of on-site emergency plans could significantly reduce the impacts of ashfall. Ashfall could disrupt operations along the Anacortes Subdivision, but any impacts would likely be temporary. No significant impacts of ash on the wetland mitigation site are anticipated.

A lahar moving down the Skagit River Valley could reach the Bellingham Subdivision and the eastern edge of the Anacortes Subdivision. A lahar of that extent could affect rail operations along those corridors.

Landslides

The potential for landslides is considered negligible or nonexistent at the proposed project and wetland mitigation sites due to the relatively flat topography and the stiff, dense, and/or cohesive soils present. Slopes steeper than what currently exists at those sites would be created during grading activities and could increase the risk of slope failure; however, numerous retaining walls would be constructed and appropriate erosion and sediment control measures would be in place at the proposed project site to minimize the risk of slope failure. No permanent clearing or creation of steep slopes would occur at the wetland mitigation site, so the potential for slope failure would be minimal.

Ecology (1979) maps a slope stability concern along the Anacortes Subdivision, which may be related to an old borrow pit. A more recently published map by Skagit County (2016) does not indicate a landslide hazard in the project area. Landslides are a frequent occurrence along the BNSF Railway main line between Everett and Seattle. A landslide could result in rail closures and emergency activities that disrupt freight and passenger rail service. However, the risk of a landslide occurring that results in a train derailment would be extremely low. Further, independent of any activities related to the proposed project, WSDOT, in coordination with BNSF Railway, is making improvements along the main line to minimize the potential for landslides and their associated impacts.

Cumulative Impacts

As described above, construction and operation of the proposed project could result in impacts to earth resources. Since 1958 (the beginning of the timeframe for the cumulative impact analysis), there has been significant agricultural, industrial, commercial, and residential development in the study area. It is assumed that with this growth, earth resources have been affected to accommodate new construction. Construction and operation of the proposed Tesoro Clean Products Upgrade Project (Tesoro 2015) (see Table 3.0-2 in Chapter 3.0 – Introduction, for additional project details) has the potential to impact these resources. The Tesoro project and the proposed project could have cumulative impacts on earth resources. These impacts would be minimized by construction BMPs and localized to the Tesoro Anacortes Refinery site and the proposed project and mitigation sites.

MITIGATION MEASURES

Avoidance and Minimization

Impacts to earth resources would be minimized by implementation of the *best management practices* (*BMPs)* required as part of the National Pollutant Discharge Elimination System (NPDES) Construction Stormwater Permit, Clean Water Act (CWA) Section 404 Individual Permit, Skagit County Grading Permit, and Shoreline Substantial Development Permit. For example, as described above, soils would be tested for contamination and disposed of properly per Skagit County's grading permit. In addition, to minimize disturbance during construction, Shell PSR would mark the boundaries of the project ahead of time and maintain those boundaries throughout construction. These "no work" areas would be off limits to construction personnel during nonwork activities (e.g., breaks and walks). Construction workers would receive "Environmental Awareness Training," emphasizing the avoidance of adjacent natural areas (i.e., no-work areas).

> Specific best management practices (BMPs) and minimization measures would be developed during the preparation of the permits required for the project.

Mitigation

No additional mitigation measures are proposed beyond the avoidance and minimization measures that would be developed and enforced as part of the permitting process.